Australian Society of Exploration Geophysicists
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PREVIEW

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FRONT COVER

Some of the participants in the first online ASEG AGM. See the *Executive brief* in this issue for more information about the AGM.

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Editor's desk

Our "best of" series, marking the 50th anniversary of the establishment of the Australian Society of Exploration Geophysicists, continues in this issue. John Denham, who was Editor of *Exploration Geophysics* from 1994 - 99 makes his selection. Again, you will have to flick through to the feature pages to find out what it is!

We also have a second feature; Kim Frankcombe must have had time on his hands during lockdown because he has finally delivered on a promise to write up some work he has done on approximating magnetic response from topography *(Magnetics in the mountains*). If you are processing magnetic data acquired in topographically challenging environments, this article is definitely one you will want to bookmark.

David Denham (*Canberra observed*) reflects ruefully on 2020 – a year that is only half over. He also directs us towards some interesting reports that have recently released, including a CSIRO report on hydrogen as an energy source. Michael Asten (*Education matters*) considers the impact of COVID-19 on geophysical teaching and research. Mike Hatch (*Environmental geophysics*) has used some of his time-out to resume his quest to improve the interpretation of data collected using ground conductivity meters. Terry Harvey (*Mineral geophysics*) offers sage advice about survey design. Mick Micenko (*Seismic window*) puts on his beer googles. Tim Keeping (*Data trends*) revisits ASEG GDF2, and Ian James (*Webwaves*) warns us to check up on our privacy.

The State, Territory and Federal geological surveys continue to deliver new data (*Geophysics in the surveys*) and promise more. I, for one, am finding it hard to keep up. So much data to review, so many webinars to attend! I have observed that lockdown has sorted us, the great unwashed, into those who are busier than ever, and those who are twiddling their thumbs. I know I have been busier than ever, but I suspect that has had something to do with sharing lockdown with my grandchildren my grandchildren.

Please stay safe and, importantly, stay cheerful!

Lisa Worrall
Preview Editor
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Yes, I drew the short straw, and my office was my bedroom for the duration of lockdown. In common with many working parents and grandparents, I was being closely supervised by children - a two year old in this case!

Letter to the Editor

Dear Lisa

I liked reading Ken Witherly's history of Hans Lundberg in the February issue of *Preview* (*Preview* **204)**. Ken and I have corresponded on the history of geophysics for at least 20 years, and he is a keen member of the ASEG History Committee - the only non-Australian currently on that Committee.

The text of this paper has large similarities with Ken's paper in the *SEG Newsletter* (**119**) of October last year, but is supplemented with more illustrations, including a figure showing measurements by Lundberg in 1926 of equipotential surveys at Buchans lead-zinc mine, plus four more photos than one common to both papers, plus a poem. Also new is a recent photo of Ken and a few Canadian geophysical colleagues "celebrating Lundberg's induction into the Canadian Mining Hall of Fame" in 2020. Ken has not referred to the YouTube video on Lundberg, which may have not been available at the time of publication. See CMHF 2020 – Hans Lundberg tribute video.

Lundberg's name was known in Australia from 1925, through the writings about the Lundberg-Nathorst method by E. C. Andrews, the then Government Geologist, and others.

Ken's claim that Lundberg might be the World's first mineral geophysicist, as well as Canada's, is worth considering. Certainly, I am not aware of any earlier minerals geophysicist with such a broad range of involvement spread over a period of five decades. As Ken details, Lundberg's first written work was his thesis in 1917, and his last in 1960. Conrad Schlumberger made electrical measurements earlier than Lundberg with equipotential readings in 1912, and reported for the first time on the electrical I.P. and S.P. effects and recognised electrical anisotropy all in 1913. His company, which included his brother Marcel and his son-in-law Henri Doll, founded what was to become the biggest well-logging company in the world, Schlumberger-Doll, in 1926. However, Conrad was unfortunately no match for Lundberg's longevity, as he died of a heart attack in 1936 at the age of 58.

Another member of the Canadian Mining Hall of Fame, also appearing in *Preview* (**142**) was Dr Anthony Barringer. Barringer is another prodigious inventor, holder of 60 patents on new ideas and methods, and author of 80 papers who also spent equal time with geochemical pursuits such as Airtrace. His legacy is, therefore, in many ways similar to Lundberg's, but about 30-40 years later.

Roger Henderson
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President's piece

Being elected to the Presidency of the ASEG is a rare honour, and in the ASEG's 50th year, rarer still. It is humbling to recall my immediate (Ted Tyne, Marina Costelloe) and historical (https://www.aseg.org.au/history/historical-federal-executive-committees) predecessors, and I realise that there are some particularly large shoes to fill.

At the time of writing, the ASEG has had its first electronic AGM, which was attended by 30 Members from all states and territories. Although an electronic AGM was required by the COVID-19 pandemic, general feedback has been that it was a seamless and valuable experience, and I hope that future AGMs, when the current pandemic has tailed off, can include an electronic component.

I would like to thank your new Federal Executive for volunteering. Danny Burns will continue as Treasurer and Leslie Atkinson has stepped into the Secretary role. I am delighted to announce that Kate Robertson is now President Elect. Marina Pervukhina and Tim Dean will continue in Professional Development and Education roles respectively. Mark Duffett will continue as Technical Standards liaison, and Ian James as Webmaster. Ted Tyne remains on the executive as the immediate Past President and Lisa Worrall and Mark Lackie will continue as Editors of *Preview* and *Exploration Geophysics* respectively.

New to the 2020 Federal Executive are Yvette Poudjom Djomani as Branches liaison, Suzanne Haydon as Memberships Chair, and Millicent Crowe as Communications Chair, and I hope that they find their experience as valuable and enjoyable as I have over the past few years. I would also like to thank Marina Costelloe and Megan Nightingale for their sterling service as Secretary, President and Past President (Marina) and Secretary and Young Professionals liaison (Megan). Volunteer roles can require significant time input and, on behalf of the Executive, I would like to thank our employers for this time. Leslie Atkinson's *Executive brief* in this issue contains far more detail on the 2020 Federal Executive and comings and goings, and contains a screen-shot of the final moments of the AGM.

But 'time and tide wait for no man', much less the ASEG. The AGM is a month past at the time of writing. Three webinars have been held, attracting around 30 international participants, and more are planned over the year. True, online webinars cannot replace monthly branch meetings. However, they offer a flexible opportunity to reach a wider audience, both immediate - as webinars can be scheduled independently of monthly meetings and anyone can watch and ask questions - and later, as presentations are published on YouTube through the ASEG's channel (which should be subscribed to in order to receive up to date notifications). Indeed, it is hoped that, post-COVID-19, branch meetings will be routinely recorded and published to a broader temporal and spatial audience. Readers interested in presenting material are welcome to contact Kate Robertson (president-elect@aseg.org.au) who has taken the initiative in this space.

In its 50th year, it is appropriate to examine the ASEG in some detail. The ASEG conducts business in a number of areas including the organisation of conferences and various courses. We have also developed two high-quality publications in our scientific journal; *Exploration Geophysics,* and our magazine; *Preview*. We publish a monthly newsletter and maintain a website that routinely supports more than 1000 visitors a month, more when each edition of *Preview* is released online. All of this for the benefit of ASEG Members, and it is ASEG membership that forms the basis for the rest of this piece.

Slightly before the 2020 AGM, the ASEG had 732 Members as students, associates, retired, honorary and institutions (corporate partners). By far the majority (70%) are Active Members. Figure 1 shows the change in ASEG membership composition between 2015 and 2020. It is immediately apparent from Figure 1 that there was a larger proportion of active and student members in 2015. As befitting an organisation in its 50th year, the relative proportion of retired and honorary members has increased over time.

Figure 2 shows the membership distribution by state as a function of membership decade. Several points are immediately apparent. Firstly, a significant number of Members might be regarded as young, in that they have been Members for less than 10 years. Membership decreases with "age" as Members move through their careers as, unfortunately, it is a cyclic industry. Members may be encouraged to learn that if they can navigate industry cycles, exploration geophysics offers a long career. It is also apparent that the largest number of Members call WA home, and that the second largest "branch" comprises international Members; in its 50th year, the ASEG is an international society. The relatively-large number of long-term Members calling NSW home

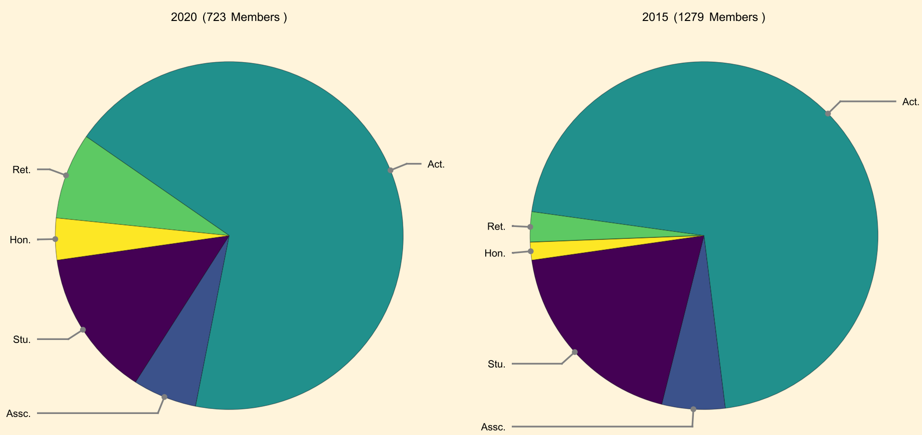

Figure 1: *Comparison of the ASEG's membership by type in 2020 (left) and 2015 (right). The number of Members has fallen so that current ASEG membership is only 57% of the 2015 membership. Proportions of Retired and Honorary Members have increased in 2020, as the proportion of Active Members has decreased.*

ASEG news

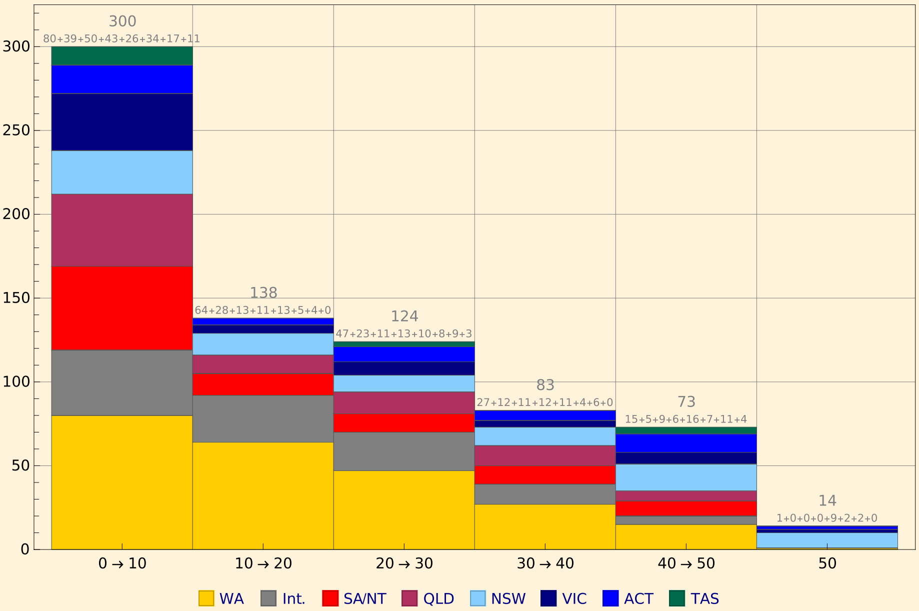

Figure 2: *Comparison of the ASEG's membership in March 2020 by state as a function of decade of membership. The large numbers atop each bar indicate the total number of Members in each decade, while smaller numbers indicate the numbers from each state. In its 50th year, the ASEG can be considered a 'young' society, with many new Members.*

may well reflect ASEG's origins when exploration companies were based on the east coast of Australia. Figure 2 also raises questions about conferences and opportunities for mentorship. These topics, and more, may be discussed in future President's pieces.

To summarise then, in its 50th year, the ASEG is in excellent shape. It is an international organisation with two high-quality publications as well as a regular newsletter. It operates a modern responsive website, which is evolving to meet Member's needs. It is a tripartite partner in the Australian Exploration Geoscience Conference, a world-standard conference evolving to meet the needs of the exploration geoscience community. I look forward to the challenge of Presidency.

David Annetts
ASEG President
president@aseg.org.au

Executive brief: 2020 AGM

The Annual General Meeting of the ASEG was held on 7 April 2020. Due to the impact of the global COVID-19 pandemic on Australia, we were unable to hold our Society's AGM in the usual format this year. The ASEG Federal Executive, instead, held a highly successful AGM via online videoconferencing, including online voting. The event was well attended with 27 attendees after receiving 31 registrations from Members. That is an 88% turnout rate, which is fabulous. The outcome was very favourable, and the general consensus is that future AGMs should include an online presence, while also returning to the face-to-face format. Some of the happy faces that attended can be seen in Figure 1.

The planned talk by Graham Heinson, Professor of geophysics at The University of Adelaide, titled "Training the next Generations of Geophysicists: Challenges and Opportunities" unfortunately was unsuitable for the online format, but we hope to get Graham back at a later date to give his talk in person.

The event saw the election of some new ASEG office bearers for 2020, and the departure of others. Dr David Annetts assumed the position of President for 2020. David has already made a big impact on the Federal Executive in his role as President Elect over the last 12 months, and he has some great ideas to further progress the ASEG. We look forward to the next 12 months under the stewardship of David, and the development of our Society.

We wish to extend an enormous thank you to our immediate Past President, Dr Ted Tyne. Ted's tenure as President has been somewhat difficult at times, navigating the move to Taylor & Francis as the new publishers of *Preview* and *Exploration Geophysics*. The process has not been without its difficulties, with some substantial delays seen in the publication of *Preview*. However, Ted has put an enormous amount of effort into achieving a great outcome for our Society and our publications. Under Ted's leadership we saw new collaborative agreements with the Society of Exploration Geophysics (SEG) and the South African Geophysical Association (SAGA). Ted also initiated the ASEG's 2020 50th anniversary celebrations, including overseeing the production of Doug Morrison's book "Measuring Terrestrial Magnetism - A History: The evolution of the Airborne Magnetometer and the first anti-submarine and geophysical surveys operations – People, Places and Events 1100 – 1949", which will be released as a special ASEG 50th anniversary publication. He has also had enormous input into the AEGC 2021 conference to be held in Brisbane in 2021. Thank you again, Ted.

Danny Burns will continue in his role as Federal Treasurer. We thank Danny for his ongoing contribution to the Federal Executive Committee. Dr Kate Robertson and Leslie Atkinson move into new roles on the committee as President Elect and Federal Secretary, respectively, and ASEG Directors. Thank you also, to returning members of the

Some of the participants in the online AGM.

ASEG news

Federal Executive: Dr Marina Pervukhina (Professional Development Committee Chair Dr Mark Duffett (Technical Standards Committee representative), Ian James (Web Committee Chair) and Dr Tim Dean (Education Committee Chair). Thank you for your efforts over the last 12 months, efforts that have also contributed to the Society's successful year.

This year we welcome Dr Yvette Poudjom Djomani (State Branches representative), Suzanne Haydon (Membership Committee Chair) and Millicent Crowe (Communications Committee Chair) to the Federal Executive. Photos and short biographies of these new members will appear in the next issue of *Preview*.

With huge thanks and appreciation, we farewell past President Marina Costelloe, who steps down from the Federal Executive. Marina has made enormous contributions to the ASEG in her six years on the committee, and we would like to extend a huge thank you to her for her contribution; she will be sadly missed.

This year we saw the resignation of Megan Nightingale who has made a huge contribution as Federal Secretary and with the Young Professionals Network. We would like to extend an enormous thank you to Megan for her contribution over her three years on the committee.

Our last farewell is to Dr Jim Austin, who oversaw the Conference Advisory Committee. Thank you to Jim for his efforts over the past 12 months. Jim's role will be assumed by David Annetts for the current year.

The day after the AGM is usually followed by a strategy day where the Federal Executive, editors and representatives from the Secretariat, The Association Specialists (TAS), meet to discuss the short- and long-term issues facing the Society. The 2020 strategy day was cancelled due to COVID-19 restrictions, but the Federal Executive is committed to the continued improvement of our Society and will continue to discuss these issues at their monthly meetings.

The mission of the Society is to provide an environment for the science of applied geophysics to grow for the benefit of its Members and the wider community. Our aims are:

- to promote the science of geophysics, and specifically exploration geophysics, throughout Australia
- to foster fellowship and co-operation between geophysicists
- to encourage closer understanding and co-operation with other earth scientists
- to assist in design and teaching of courses in geophysics and to sponsor student sections where appropriate

The ASEG, in line with its aims and the activities defined in the Constitution, has adopted several aspirational strategic goals for 2018–2023 to ensure that the Society retains vitality and relevance in an exploration industry that is continually changing. During 2019 and 2020 so far, the ASEG Federal Executive has continued to progress these strategic goals in the following ways:

- Continuing community engagement with webinars during the COVID-19 pandemic in a time when face-to-face meetings were unavailable. This has made monthly state meetings available to the entire geophysical and wider community, and the Federal Executive has agreed this would be beneficial beyond the current crisis. Webinars and presentation recordings will be made available on the ASEG website and on our YouTube Channel.
- Increasing our online presence including social media posting on LinkedIn, Facebook and Twitter, and the ASEG monthly newsletter.
- Improve interaction with our international Members

The Federal Executive would like to thank TAS for organizing and facilitating the 2020 AGM.

Leslie Atkinson
ASEG Secretary
fedsec@aseg.org.au

Welcome to new Members

The ASEG extends a warm welcome to four new Members approved by the Federal Executive at its April and May meetings (see Table).

First name	Last name	Organisation	State	Country	Membership type
Mazifi	Adamu	Federal University Lafia	Plateau	Nigeria	Student
Nelson	Kuna	CSIRO Oceans and Atmosphere	TAS	Australia	Active
Anna	Petts	Department for Energy and Mining	SA	Australia	Active
Grace	Smith	The University of Adelaide	SA	Australia	Student

ASEG Research Foundation: Grants awarded in 2020

Applications for ASEG Research Foundation 2020 grants closed at the end of February 2020. Eight applications were received from five Australian Universities. There were three in the Minerals category, two in the Petroleum category and three in the Engineering/Environmental category. The applications were assessed, using the grant criteria, by the three relevant sub-committees.

Four applications were successful, taking into account the availability of funds. One was for honours, one for masters and two for PhD degrees. The total amount committed for this year's round was $46 220. We express appreciation to ASEG for a contribution of $45 000 for this year.

A brief summary of the four successful applications follows:

University	Supervisor	Student	Degree	Field	Years	Subject
University of Western Australia	Prof Mike Dentith	Natalia Delgado	MSc	M	1	Geophysics in precision agriculture: Mapping soil properties to guide amelioration practices in the WA wheatbelt
Curtin University	Prof Brett Harris	Fionnuala Campbell	BSc(Hons)	M	1	Comparison, evaluation, and optimisation of the portable near surface Loupe TEM system for underground Nickel sulphide detection
University of Adelaide	A/Prof Simon Holford, A/Prof Ros King and Dr Mark Bunch	Monica Jimenez Lloreda	PhD	P	2	Controls on gravity-driven normal fault geometry and growth in stacked deltaic settings
Flinders University	Dr Ian Moffat	Andrew Frost	PhD	E	3	Assessing a multi-modal approach in the location of unmarked graves under various seasonal conditions

Doug Roberts
ASEG Research Foundation Secretary
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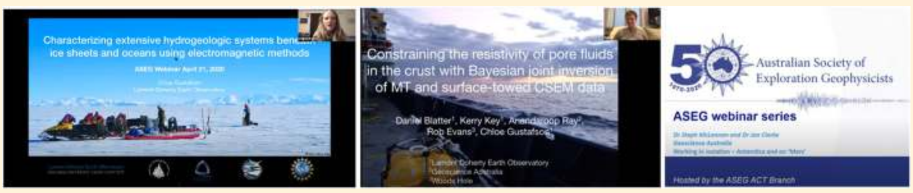
ASEG Professional Development Committee: Events in 2020

Unfortunately, we have not been able to enjoy the many excellent presentations by national and international speakers scheduled for our regular ASEG branch meetings in the first half of 2020. Most of these meetings were cancelled, and most of our ASEG Members have been working from home for the last couple of months. The ASEG Professional Development Committee has been working to continue to engage with our Members, and to give them the opportunity to grow their skills and extend their professional network by attending virtual/online lectures and courses.

The lack of face-to-face professional interaction has led to greatly increased online activity and we are trying to ensure that ASEG Members benefit from this. Presentations planned as presentations to regular branch meetings, as well as presentations by international speakers have been delivered via our newly developed ASEG webinar series. These webinars have been broadly advertised by email and by social media to ensure that ASEG Members from all around the world can benefit from them. Recordings of these presentations are freely available on our website and YouTube.

Other geophysical societies have also increased their online presence, offering complimentary virtual lectures that are based on the presentations made at recent conferences. We are pooling this information and notifying our Members about upcoming events by email on a regular basis.



Three excellent presentations that are now available on our website at https://www.aseg.org.au/aseg-videos.

Regrettably, all the SEG Honorary and Distinguished Lectures that were advertised at the beginning of this year have been cancelled. Despite still being advertised on the SEG website, the 2019 Distinguished Instructor Short Course by David Monk "Survey Design and Seismic Acquisition for Land, Marine, and In-between in Light of New Technology and Techniques," will not be run in Australia this winter, although, it might be delivered as a virtual course at a later date. The EAGE conference has been postponed for six months and will take place 8 - 11 December 2020. The AEGC 2021 conference has also been postponed and will now take place 15 – 20 September 2021. These are just a few of the event changes that are affecting our professional life.

Marina Pervukhina and Kate Robertson
ASEG Professional Development Committee
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ASEG Young Professionals Network: Update

The ASEG Young Professionals Network, like so many groups, is undergoing a little bit of change at the moment. The COVID-19 pandemic is obviously limiting networking opportunities, however, in its place we are experiencing an abundance of seminars and low-cost training opportunities. Mentoring should be continuing much as it did before, unless you are feeling burnt out from videoconference and phone call overload!

The other change is that the co-chair of the YP group, Megan Nightingale has stepped down, leaving me (now a not so young professional) at the helm. I'd like to thank Megan for her efforts over the past few years in providing federal oversight of the YPN, and wish her the best for future endeavours. Over the coming weeks I'll make contact with state representatives of the YPN and try to reboot things a little so that the Federal committee can best support the YP activities that mostly happen at the branch level.

Looking back at 2019, as this is my first column for the year, I want to acknowledge the comprehensive efforts made by Cameron Adams and his sub-committee at the AEGC conference in Perth. These were beautifully documented in a previous edition of *Preview* and have set a high-water mark for the next AEGC in Brisbane (assuming it goes ahead). Mentoring programmes were continued in four states, typically paired with other societies. I'll come back with more information on these programmes, and a refreshed local contacts list, as soon as possible. Two YP-focussed training courses were run in Melbourne along with regular evening seminars, thanks to the efforts of Daniel Thompson.

Looking ahead, the changes to our working environment in 2020 have encouraged new ways of working. We are witnessing an explosion in the number of geoscientists sharing their work via online seminars and online training courses. Many are keen to promote their businesses in the downturn because their usual marketing methods are currently not allowed. It could change the way we do business, and market goods and services, for much longer than the pandemic lasts. I'd encourage the YPs to take full advantage of this moment to bolster their learning and networks.

Marina Pervukhina recently collated many of the online learning opportunities in an email sent to ASEG Members. Please don't hesitate to forward her links to relevant seminars coming up so that she can build further momentum in the area of online learning for the benefit of everyone when better times return.

Jarrod Dunne
Acting Young Professionals Network Chair
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ASEG Honours and Awards Committee: Nominations open for the 2021 ASEG Honours and Awards

To be presented in conjunction with the AEGC 2021, 15-20 September 2021, Brisbane, Australia.

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

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

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

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

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

ASEG Branch news

Victoria

A god-fearing comrade recently asked me whether I thought the apocalypse could be upon us, like that described in the book of Revelation. Curious, I responded with a raised eyebrow and asked him whether the final showdown between God and Satan, if this were indeed the final days of mankind, would be shown on Netflix tonight. He did not take my response too kindly. I acquiesced. I then asked him to which cryptic symbol in the scriptures of Christianity was he referring? Armageddon? The armed forces of many countries have been deployed to render humanitarian aid. They're putting their efforts into saving lives, not necessarily preparing for war. Was it the Antichrist, I asked? Trump is certainly doing a fine job so far. I believed he once responded to a reporter, "God, who? Never heard of her". Or perhaps it was the Rapture, I inquired? Many airlines have been placed into administration, with bankruptcy their only protection. It would be rather difficult to obtain sufficient altitude, at the preferred cloud level, to meet the Lord at the present time. It was at this point, my comrade decided he had had enough of my wicked attitude. John and I are no longer friends. I have always been mistrusting of John's Revelations ☺. If this were the End of Days, I would be very disappointed. I have placed a very large sum of money with the TAB betting that the Apophis asteroid would strike the Earth on 13 April 2029.

In branch news, the Victorian chapter of the ASEG entered early hibernation in 2020. It will be a long, long winter, I suspect. While the committee continues to siphon the remaining funds entrusted to us by treasury, I can only hope life will swiftly return to normality for the sake of geoscientists Australia over. Take care out there. We hope to see you all very soon. All donations to our beer fund are greatly appreciated.

Thong Huynh
vicsecretary@aseg.org.au

Western Australia

Well, during these trying times, no news is good news. And, that's what we have in WA for this period. Perth CBD remains a ghost town, but the number of reported WA COVID-19 cases are staying low, so the policies are working!

That being said, there are two items worth mentioning from here in Perth. Firstly, due to COVID-19's impact, we've extended the application period for our Student Awards until the end of July. Please pass this information along so that we can ensure everyone in SFH (Study From Home) groups are all aware of this extension! Secondly, due to the nearly complete lack of (ASEG WA) costs since the lockdown(s), we have decided to extend our sponsors' period right through to the end of the year (i.e., we've added a grace period from the usual June 30). We do this in great appreciation for their support for the past years, and also to help them with their bottom line right now.

Lastly, I do know that the lockdown policies are being relaxed across Australia, but please remain vigilant, and stay safe everyone!

Todd Mojesky
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Australian Capital Territory

The ACT Branch offered the wider membership a webinar on 29 April. This webinar entitled "Working in isolation – Antarctica and 'on Mars'" was presented by Dr **Steph McLennan** and Dr **Jon Clarke** (both from Geoscience Australia) and hosted by **Marina Costelloe**.

Steph McLennan is a geoscientist and communicator working to understand environmental impacts on ice-free areas of Antarctica. These environments are particularly vulnerable to damage from infrastructure development and tourism. Steph joined Geoscience Australia as a graduate in 2015 and received her PhD in environment geoscience from the University of Adelaide in 2016. She has worked on sedimentary basins and landscape evolution in eastern and northern Australia, as well as periglacial landscapes in East Antarctica. Dr McLennan is a super star of STEM https://scienceandtechnologyaustralia.org.au/what-we-do/superstars-of-stem/

Jon Clarke graduated as a palaeontologist, moved into petroleum and coal geology, and undertook a PhD in carbonate sedimentology and palaeoecology. He has worked on marine surveys in the Southern and Indian Oceans, explored for base metals, nickel and gold in Archaean and Proterozoic terranes in South and Western Australia, the Northern Territory and Queensland, as well as for gold and copper in the Philippines and Chile. Jon has a keen interest in Mars and has been studying terrestrial analogues of Martian landscapes and developing exploration strategies for human missions to Mars. His expertise also covers exploration strategies for human missions is through integrated field research of instruments (spectrometers, data capture, geophysical tools), methodologies (scouting, navigation), exploration technologies (suits, living modules, rovers, field robotics), at appropriate levels of simulation fidelity. www.marssociety.org.au

This amazing webinar is available on the ASEG YouTube channel for you to watch now https://www.aseg.org.au/aseg-webinar-act-branch-29-april-2020-dr-steph-mclennan-dr-jon-clarke

Marina Costelloe,
actpresident@aseg.org.au

New South Wales

In 1964 Bob Dylan famously sang "the times they are a changin", and these words still resonate today, perhaps now more so than ever. In this different world no-one (including ASEG NSW) has been spared … as such, it has been a relatively quiet couple of months on the NSW Branch front.

We have cancelled our regular monthly meetings and we are looking forward to re-commencing when we are able – hopefully sooner rather than later. Thankfully, we were still able proceed with awarding a scholarship. In April we awarded the 2020 ASEG NSW scholarship to **Xueyu (Tom) Zhao** from UNSW for his project on "Machine learning of EM and gamma-ray data for the lime application on the farmland". We wish Tom well with his project and look forward to his presentation later in the year.

We trust all the ASEG Members are virus free.

Mark Lackie
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Stephanie Kovach
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Queensland

Well 2020 has so far been quite a unique leap year. It had 29 days in February, felt like 300 days in March, and five years in April.

Queensland has been very quiet since our State Government declared a public health emergency on the January 29. As with other states, closure of businesses, restrictions on travel and home confinement (anyone-else starting to get a tan off the light in the fridge?) has taken its toll on our industry during the COVID-19 pandemic. Despite all the disruption, it has been good to see exploration activity continue in some areas, and we're looking forward to restrictions easing in the coming weeks and months.

Early in May the Queensland Government released a support package for the exploration sector. It included:

- a 12-month waiver of rent on exploration due between 1 April and 1 September 2020
- a freeze on fees and charges until 1 July 2021
- release of approximately 7 000 square kilometres of land for gas and mineral exploration
- bringing forward $2.8 million in grant funds for innovative exploration in the North West Minerals Province.

I hope all our fellow ASEG Members are well and continue to stay that way.

Ron Palmer
qldpresident@aseg.org.au

James Alderman
qldsecretary@aseg.org.au

South Australia & Northern Territory

Hi everyone

Face-to-face branch meetings are still suspended but, as we are seeing restrictions start to ease, we are hopeful that we will be able to resume technical meetings at some point in the second half of 2020.

Hopefully, also, you have found the ASEG webinars of interest, don't forget you can find the recordings of these on YouTube. The SA/NT Branch will be hosting Dr **Ian Moffat** for a webinar on 'Searching for the Beaumont children and other adventures in unmarked grave detection.' His presentation on June 2 will review a number of grave detection projects, including the search for the Beaumont children and mapping WWII graves from the Battle of Tarawa, and will discuss current best geophysical practice in this field. Ian was scheduled to present at our Branch AGM before it had to be moved to a virtual AGM, so we are delighted that Ian has agreed to speak in this new format that will be open to everyone.

Stay safe!

Kate Robertson
ASEG SA/NT Branch committee member
Kate.Robertson2@sa.gov.au

Ian Moffat in the field

Tasmania

All Tasmanian face-to-face branch meetings are currently on hold. When restrictions are eased, it is expected that meetings will resume in the CODES Conference Room, University of Tasmania, Hobart. Meeting notices, details about venues and relevant contact details can be found on the Tasmanian Branch page on the ASEG website. As always, we encourage Members to also keep an eye on the seminar/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.

Mark Duffett,
taspresident@aseg.org.au

ASEG national calendar

Date	Branch	Event	Presenter	Time	Venue
All ASEG Branch face-to-face meetings have been cancelled until further notice. Some branches have been hosting webinars, and some of these can be viewed on the ASEG website https://www.aseg.org.au/aseg-videos. Please monitor the Events page on the ASEG website for information about upcoming webinars and other on-line events					

Kate Robertson reports on US study tour

The potential of magnetotellurics (MT) as an exploration tool is still to be fully realised, but the technique is capable of imaging deep conductive signatures of mineral systems across metres to hundreds of kilometres; highlighting prospective regions. The Australian lithospheric architecture magnetotelluric project (AusLAMP) is an exciting project, which will eventually result in deep sounding MT sites being located across the entire continent, and potentially across the continental shelf. The Geological Survey of South Australia (GSSA), along with collaborators, is using the currently available 3D modelling codes, to provide unprecedented views of the entire lithosphere beneath SA, down to ~200 km. However, these codes assume that the electrical conductivity, the property we are imaging, is constant in all directions - a scalar quantity. However, many geological processes cause preferred orientations of geological structures or anisotropy. There are no currently available 3D inversion codes that consider anisotropy.

The building in which I was working at the Lamont Doherty Earth Observatory, Columbia University, New York.

Some of the large pool of marine MT instrumentation at Scripps Institute of Oceanography.

In December 2019, I visited a research group at the Lamont Doherty Earth Observatory, Columbia University in New York led by Associate Professor Kerry Key, who is in the final stages of developing a 3D magnetotelluric modelling code, MARE3DEM, that can model complex anisotropic conductivity structure. During this visit we applied the new software to our South Australian AusLAMP MT data, and our higher resolution (1.5 - 5 km site spacing instead of 55 km site spacing of AusLAMP) Olympic Domain MT array in a project that we will continue to develop. We look forward to presenting results at the GSSA's Discovery Day 2020 and AEGC 2021 in Brisbane.

The Mare3DEM software is also suitable for modelling 'amphibious' (part land, part sea based) MT data, which will be useful for the MT data acquired in November 2019 across the Spencer Gulf in SA by the GSSA, SCRIPPS Institute of Oceanography, AuScope, University of Adelaide and Geoscience Australia. These data were acquired to better delineate the southern extent of the large crustal conductor that extends down the eastern edge of the Gawler Craton. This conductor can be observed in AusLAMP models and previous MT surveys, and correlates to surface occurrences of copper and gold. A visit to Professor Steve Constable at Scripps Institute of Oceanography, whilst in the US, enabled further discussion and planning on future workflows for the recently acquired marine MT data.

Also, while I was in the US, I attended the 2019 AGU Fall Workshop in San Francisco - the world's largest gathering of geophysicists. The workshop gave me personal development and networking opportunities, along with the opportunity to promote the work we are doing at the GSSA. I focused on sharing our understanding of the deep mineral systems signatures within South Australia, derived from our AusLAMP MT models.

My trip was co-funded and supported by the Australian Geoscience Council, a 34th IGC travel grant and the South Australian Department for Energy and Mining. I am very grateful for this support. The trip will enable vast improvements in the accuracy of Australian conductivity models, which are critical for the quantitative interpretation of Australian MT data, and evaluation of implications for mineral potential analysis.

Kate Robertson
Geological Survey of South Australia
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Phillip Wynne awarded GA 2020 Australia Day Achievement Medallion

Phillip Wynne, a long standing ASEG Member and contributor, was awarded Geoscience Australia's Australia Day Achievement Medallion earlier this year.

The award was made by James Johnson, GA's Chief Executive Officer. James read the following citation that was put together by Phillip's colleagues – who clearly value his contribution to their workplace.

"Phillip has shown himself to be a team player that team leaders long for: a quiet achiever, always contributing, prepared to lead when asked and never flustered when confronted with extra work. He builds positive organisational culture by getting on with the job but operating with open arms when the opportunity to collaborate is presented. He mixes experience of the role, his intimate knowledge of Geoscience Australia (GA) and the geophysical acquisition and processing (GAP) function with an underlying hunger to innovate and build better ways of doing things. Phillip works with other GA sections and State agencies to ensure all newly acquired gravity data is properly levelled, reduced, archived and calibrated to the Australian Fundamental Gravity Network (AFGN). Spanning the entire continent and all of the respective states and territories, Phillip provides a single point of accountability.

Phillip is also the long-standing coordinator of the State and Territory Government Geophysicists, and there are many examples of how this working group have made innovative improvements and resolved issues early in a safe and calm environment. Phillip is attuned to the needs of GA, MRB and the GAP team; always contributes, is prepared to lead, a can-do operator that always treats other people's ideas with respect and sensitivity. Phillip is the only person working on ground gravity datasets for the States and national compilations for the last 10 years, maintains the AFGN network and was the Health and Safety Representative (HSR) for the floor for 10 yrs. Most recently he has been asked to lead some additional projects which in each case, are taken on as enthusiastic challenges and not burdens on an already full plate. The GAP team are very grateful to have Phillip as a long-standing team member.

Phillip has been with Geoscience Australia 26 years."

Next generation of magnetic resonance tools

Readers of *Preview* who work with groundwater may be interested in two next generation Magnetic Resonance (MR) tools. These are Vista Clara products, so, in the spirit of full disclosure, I should say that I have been working as Vista Clara's sales and equipment representative in Australia since 2017. Vista Clara is a US-based company exclusively focussed on MR instrumentation for geophysical applications. Among the many advantages of the MR technique are non-invasive measurements, and direct measurement of the presence of water in the subsurface.

The new tools are 1) The "GMRFlex", a new, more compact, surface NMR system (Figure 1), and 2) the Javelin® "Slim" a new integrated borehole wireline tool (Figure 2). Both of these tools represent the next generation of smaller, and easier to use tools that will be of use on many groundwater investigations that were not possible previously.

The GMRFlex uses a combined transmitter-receiver loop (similar to an exploration-style TEM survey) that produces a data sounding providing information on both water content and porosity distribution from near the surface down to about 75 m or so with the new compact system. If you have used or seen Vista Clara's workhorse GMR system, you will realise that what it makes up for in increased depth-of-investigation, is traded off against ease of use and portability. The new GMRFlex system is quite capable of being run with only the transmitter unit, a laptop, a pair of 12V batteries and transmitter cables. This means that it can be run from smaller vehicles - even a quad bike equipped with a small trailer.

The "Slim" is a more compact version of the original Javelin wireline system. The original Javelin system is built with the high-powered transmitting electronics on the surface, using a specialised winch (requiring non-standard winch cable) to carry the high-current transmitter signal to the probe. The new system runs on a standard four-core winch cable, removing the need for the special winch, making borehole NMR accessible to more users. The probe is separated into two parts: the top half houses the electronics and power supply, while the bottom half is the "sensor" part of the probe. The top comes in two sizes, either a 2.38" (60 mm) "Slim" version, or a 3.5" (90 mm) "Max" version. The Slim can be paired both with 2.38" (60 mm) or 3.5" (90 mm) sensors. The Max can be paired with both 3.5" (90 mm) and 5.25" (135 mm) sensors. In either case the entire probe weighs between 30 and 45 kg for the Slim (up to 85 kg for the Max), depending on which probes are used. Being modular the probe can be built "on the hole" by one or two people without the need for an overhead winch. As an option, these probes can be set up to read natural gamma simultaneously with the NMR. Like the GMRFlex surface system they are available for purchase or hire, and are offered with a full suite of processing software as well as support from Vista Clara to help with training, processing, and interpretation.

Figure 1. *The full FlexGMR system, including transmitter, laptop, connectors and transmitter cables. Also shown are the optional DC Capacitor expansion module and tuning expansion module.*

Figure 2. *The Javelin Wireline Slim probe including surface unit and both the 2.38" and 3.5" inch sensors. The system shown is also able to collect natural gamma delta data.*

Mike Hatch
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Geoscience Australia: News

Despite many new barriers to completing long-running projects, the geophysical teams at Geoscience Australia continue to deliver on new pre-competitive resource datasets, interpretations and methodologies. In collaboration with State Agencies of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania, the last quarter has seen a number of substantial projects reach projects reach closure and data release, as outlined in Figure 1 and the tables in the section on geophysical survey progress that follow.

While our acquisition programs are suspended, a number of collaborative agreements have been signed to see significant airborne programs re-commence in the forthcoming financial year, including AusAEM20, the first of hopefully many new airborne programs throughout Tasmania, and additional EM surveying in western NSW. A June update on releases is as follows.

2019 Cobar AEM data and inversion models

Acquired in collaboration with the Geological Survey of NSW and the MinEx Cooperative Research Centre (MinEx CRC), this 5900 line km survey covers nearly 20 000 km^2 in the Cobar–Lake Cargelligo area of Central West New South Wales. In conjunction with the technique's utility to help delineate water resources under cover, the program focusses on a portion of western NSW considered highly prospective for metallic minerals. Along with the located data set, both the contractor's and GA's in-house inversion are available for download via GA's online catalogue system: http://pid.geoscience.gov.au/dataset/ga/135557 under "MinEx CRC Cobar Airborne Electromagnetic Survey, NSW, 2019: XCITE® AEM data and conductivity estimates".

South West McArthur Barkly Gravity Survey

Last month also saw the release of the South West McArthur, Barkly Gravity Survey data; jointly funded under Geoscience Australia's (GA) Exploring for the Future program and the Northern Territory Geological Survey's (NTGS) Resourcing the Territory 2018-2022 Initiative. The survey was designed to aid in the resource potential mapping of the Barkly Tablelands and infills existing 4 km gravity coverage to 2 km coverage. This is the second part of the Tennant Creek Mount Isa (TISA) Gravity Surveys, P201901, the first being the East Tennant Gravity Survey P201901, NT, 2019. Acquired by Atlas Geophysics, the new package consists of 3303 gravity stations as a point located data and grids. The data are available for free download from http://pid.geoscience.gov.au/dataset/ga/132968.

New groundwater AEM data releases

Data from four SkyTEM® helicopter EM surveys flown over Western Australia, Northern Territory and Queensland have been finalised and will be released via GA electronic catalogue on 30 June, 2020 (see Figure 1). Approximately 10 929 line km of transient electromagnetic (TEM) and magnetic data were acquired between 2015 and 2018 to support basin-focussed investigations of regional groundwater systems and assist with more sustainable utilisation.

Mike Barlow
Geoscience Australia
Mike.Barlow@ga.gov.au

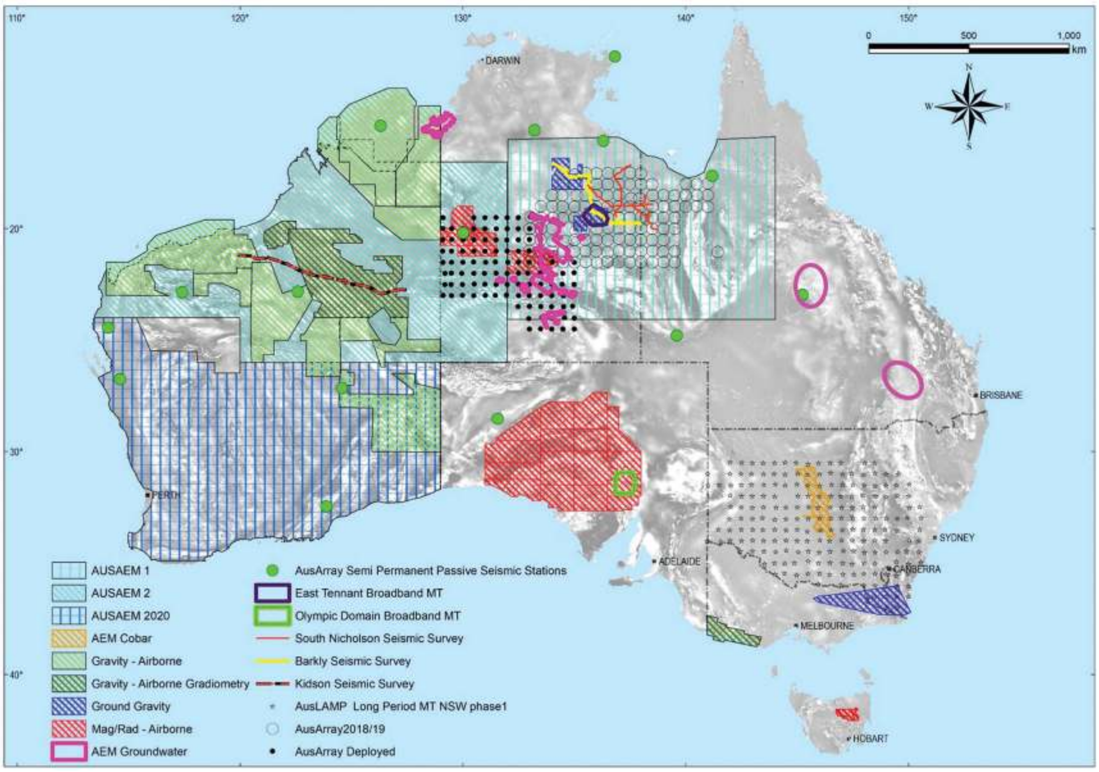

Figure 1. *2018-2020 geophysical surveys – completed, in progress or planned by Geoscience Australia in collaboration with State and Territory agencies*

Update on geophysical survey progress from Geoscience Australia and the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania (information current on 10 May 2020).

Further information about these surveys is available from Mike Barlow Mike.Barlow@ga.gov.au (02) 6249 9275 or Marina Costelloe Marina.Costelloe@ga.gov.au (02) 6249 9347.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Line spacing Terrain clearance Line direction	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Tasmanian Tiers	MRT	GA	TBA	Q3 2020	Up to an estimated 66 000	200 m 60 m N–S or E–W	11 000	End of 2021	TBA	TBA	TBA
Gawler Craton	GSSA	GA	Various	2017	1 670 000	200 m, various orientations depending on structure	294 000	26 Jun 2019	Aug 2019	http://www.energymining.sa.gov.au/minerals/geoscience/pace_copper/gawler_craton_airborne_survey	Released
Tanami	NTGS	GA	Thomson Aviation	14 Jul 2018	275 216	100/200 m 60 m N–S/E–W	48 267	2 Dec 2018	Jun 2019	195: Aug 2018 p. 16	Released
Mt Peake	NTGS	GA	MAGSPEC	10 Jul 2019	136 576	200 m N-S	24 748	Oct 2019	Feb 2020	Aug 2019	Released

TBA, to be advised.

Table 2. Ground and airborne gravity surveys

Survey name	Client	Project management	Contractor	Start survey	Line km/ no. of stations	Line spacing/ station spacing	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Kidson Sub-basin	GSWA	GA	CGG Aviation	14 Jul 2017	72 933	2500 m	155 000	3 May 2018	15 Oct 2018	The survey area covers the Anketell, Joanna Spring, Dummer, Paterson Range, Sahara, Percival, Helena, Rudall, Tabletop, Ural, Wilson, Runton, Morris and Ryan 1:250 k standard map sheet areas	Expected release before the end of Jun 2020
Little Sandy Desert W and E Blocks	GSWA	GA	Sander Geophysics	W Block: 27 Apr 2018 E Block: 18 Jul 2018	52 090	2500 m	129 400	W Block: 3 Jun 2018 E Block: 2 Sep 2018	Received by Jul 2019	195: Aug 2018 p. 17	Expected release before the end of Jun 2020
Kimberley Basin	GSWA	GA	Sander Geophysics	4 Jun 2018	61 960	2500 m	153 400	15 Jul 2018	Received by Jul 2019	195: Aug 2018 p. 17	Expected release before the end of Jun 2020
Warburton-Great Victoria Desert	GSWA	GA	Sander Geophysics	Warb: 14 Jul 2018 GVD: 27 Jul 2018	62 500	2500 m	153 300	Warb: 31 Jul 2018 GVD: 3 Oct 2018	Received by Jul 2019	195: Aug 2018 p. 17	Expected release before the end of Jun 2020

(*Continued*)

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

Survey name	Client	Project management	Contractor	Start survey	Line km/ no. of stations	Line spacing/ station spacing	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Pilbara	GSWA	GA	Sander Geophysics	23 Apr 2019	69 019	2500 m	170 041	18 Jun 2019	Final data received Aug 2019	The survey area is in the Pilbara region in the northwest of Western Australia. Data acquired will be compiled into an update of the gravity anomaly map of Western Australia	Expected release before the end of Jun 2020
SE Lachlan	GSNSW/ GSV	GA	Atlas Geophysics	May 2019	303.5 km with 762 stations	3 regional traverses	Traverses	Jun 2019	Jul 2019	See Figure 1 in previous section (GA News)	Set for incorporation into the national database by Jun 2020
TISA	NTGS	GA	Atlas Geophysics	2 Jul 2019	5719	2 km × 2 km grid	31 285	Sep 2019	Nov 2019	See Figure 1 in previous section (GA News)	Released

TBA, to be advised

Table 3. Airborne electromagnetic surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Surat-Galilee Basins QLD	GA	GA	SkyTEM Australia	2 Jul 2017	4627	Variable	Traverses	23 Jul 2017	Nov 2017	188: Jun 2017 p. 21	To be released by 30 June at: http://pid.geoscience.gov.au/dataset/ga/121991
Stuart Corridor, NT	GA	GA	SkyTEM Australia	6 Jul 2017	9832	Variable	Traverses	12 Aug 2017	Nov 2017	188: Jun 2017 p. 22	eCAT release http://pid.geoscience.gov.au/dataset/ga/131098
Ord-Bonaparte, WA	GA	GA	SkyTEM Australia	18 Oct 2015	2784	Variable to 500 m		4 Nov 2015	May 2016	See Figure 1 in previous section (GA News)	To be released by 30 Jun at http://pid.geoscience.gov.au/dataset/ga/135452
Daly River, NT	GA	GA	SkyTEM Australia	9 Jul 2017	3378	Variable 1-2 km	Traverses	24 Aug 2017	Feb 2018	See Figure 1 in previous section (GA News)	To be released by 30 Jun at: http://pid.geoscience.gov.au/dataset/ga/122012
AusAEM2, NT-WA	GA	GA	CGG Tempest	May 2019	73 005 with areas of industry infill	20 km	1 074 500	~ May 2020	~ Jun 2020	201: Aug 2019 p. 16	72% complete. Acquisition suspended. Acquired portion will be released in Jun 2020
AusAEM20	GSWA	GA	CGG & SkyTEM	2020/ 2021	24 000 km as Phase 1	20 km	480 000	Dec 21	TBA	See Figure 1 in previous section (GA News)	TBA
Cobar	GSNSW	GA	NRG Xcite	30 Sep 2019	6701 with areas of industry infill	2.5 and 5 km	19 145	19 Oct 2019	Jan 2020	201: Aug 2019 p. 17	Released
Howard East	GA	GA	SkyTEM Australia	23 Jul 2017	2073.6	Variable to 100 m	Traverses	8 Aug 2017	Feb 2018	See Figure 1 in previous section (GA News)	eCAT release http://pid.geoscience.gov.au/dataset/ga/132400

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	367 stations deployed in 2018-19	50 km	Long period MT	The survey covers areas of NT and Qld. *Ongoing*
AusLAMP NSW	GSNSW/ GA	NSW	AusLAMP NSW	270 stations deployed in 2018-19	50 km	Long period MT	Covering the state of NSW. *Ongoing*
Southeast Lachlan	GSV/GSNSW/ GA	Vic/ NSW	SE Lachlan	Deployment planned to commence in Oct 2020	~4 km	AMT and BBMT	~160 sites in the Southeast Lachlan
AusLAMP TAS	GA	TAS	King Island MT	4 sites completed	<20 km	Long period MT	Covering King Island. Acquisition completed.
East Tennant	GSQ/GA	NT	East Tennant MT	131 sites completed	1.5 – 10 km	AMT and BBMT	Released
Cloncurry	GA/GSSA/ UoA/AuScope	QLD	Cloncurry Extension	200 stations have been acquired	2 km	AMT and BBMT	Approximately 500 sites planned in the northern Cloncurry. Data acquisition will be restarting in late Mar 2020.
Spencer Gulf		SA	Offshore marine MT	12 stations completed	10 km	BBMT	This is a pilot project for marine MT survey

TBA, to be advised

Table 5. Seismic reflection surveys

Location	Client	State	Survey name	Line km	Geophone interval	VP/SP interval	Record length	Technique	Comments
South East Lachlan	GSV/ GSNSW	Vic/NSW	SE Lachlan	629	10 m	40 m	20 s	2D - Deep crustal seismic reflection	This survey covers the Southeast Lachlan Orogen crossing the Victorian-NSW border. Data acquisition was completed in Apr 2018. Raw data and processed seismic data has been released and are available via Geoscience Australia and State Geological Surveys.
Kidson	GA/ GSWA	WA	Kidson Sub-basin	872	20 m	40 m	20 s	2D - Deep crustal seismic reflection	Within the Kidson Sub-basin of the Canning Basin extending across the Paterson Orogen and onto the eastern margin of the Pilbara Craton. The survey completed acquisition on 8 Aug 2018. Data released in May 2019.
Barkly/ Camooweal	NTGS	NT	Barkly sub-basin	812	10 m	30 m	20 s	2D - Deep crustal seismic reflection	Acquisition of 2D land reflection seismic data to image basin and basement structure in the Barkly region of the Northern Territory. Data acquisition was completed in Nov 2019. The data is expected to be released first half of 2020.

Table 6. Passive seismic surveys

Location	Client	State	Survey name	Total number of stations deployed	Spacing	Technique	Comments
Northern Australia	GA	Qld/NT	AusArray Phase 2	About 135 broad-band seismic stations	50 km	Broad-band 1 year observations	The survey covers the area between Tanami - Tennant Creek –Uluru and West Australian Border. The first public release of transportable array data is expected by end 2019. See location map in in *Preview* 201: Aug 2019 p. 16
Northern Australia	GA	QLD/WA	AusArray	3 high-sensitivity broad-band seismic stations installed in Oct 2019	~1000 km	Broad-band 4 years observations	Semi-permanent seismic stations provide a back-bone for movable deployments and compliment the Australian National Seismological Network (ANSN) operated by Geoscience Australia, ensuring continuity of seismic data for lithospheric imaging and quality control. Associated data can be accessed through www.iris.edu

Geological Survey of South Australia: A new way to access geophysical data on SARIG

Thousands of geophysical surveys have been acquired over South Australia. Many hundreds of these are airborne surveys, notably magnetic, radiometric, and electromagnetic surveys. In the past the government of South Australia has presented the survey boundaries of all these surveys on a single map of the state. They are now also visible on SARIG (https://map.sarig.sa.gov.au/) via a time slice tool, grouped together in blocks of surveys acquired in five-year intervals.

There are four main options to download survey data and grids. The first way involves using the "Spatial Search" option and selecting "Active layers" from the drop-down menu (ensuring first that "Geophysical Surveys" is an active layer). Use the "Draw Area" tool to draw a box on the survey you're interested in, and a pop-up window will emerge from the bottom of the screen. The pop-up window will include a link to the survey data and metadata. Clicking the link will take you to a Geonetwork page, which includes a blue "Download data package" button. Surveys downloaded using this option will contain all of the company supplied and GSSA processed data, grids and contractor reports in a single download. These data packages are stored on the Cloud using Amazon Web Services.

The second method involves using the "Spatial Search" option and selecting "Geophysical Data" from the drop-down menu. Again, draw a box in your area of interest but this time, click the Advanced Search option at the bottom left of the screen (you may have to scroll down) and follow the prompts. This second method will cookie-cut the survey to the box you drew on the screen, and has options for downloading multiple types of geophysical data in either grid or located data (ASCII format) for multiple surveys in your choice of coordinate system and datum. Additionally, this method will allow the user to download selected columns of ASCII data, and to resample grids to every 2^{nd} or 10^{th} grid cell.

This second method may struggle with larger downloads. Somewhere around 3GB our servers struggle with the processing load. If you've requested a download and haven't received an email within a few hours, please try another method or contact our customer services team.

The third method also involves a direct link to the data. From the initial SARIG screen, click on "Map Layers" and start typing "geophysical surveys" in the text box. Switch on "Geophysical Surveys" by clicking the box, and then select the Identify tool under Action in the middle of the screen. Click on the map at your area of interest and any surveys intersecting the clicked area will be listed on the left-hand-side of the screen. Expanding any of these items will reveal a hyperlink that will allow you to directly download the complete data package for that survey.

The geophysics team at the GSSA are routinely adding historic and more recent surveys to these layers. If you can't find a survey you know exists – or see no surveys in your area of interest – be sure to try a fourth method and check any open file envelopes in that area. One way to do this is to first determine any previous Exploration Licences in your area of interest using SARIG. Then click the burger menu in SARIG (the three horizontal lines near the top) and click on Georeference. Click on Advanced Search under Mineral company exploration reports, and type the Exploration Licence number next to "Tenements" (it should be in the format EL01234). Links to open file envelopes can be found on the results page. Many smaller surveys – including gravity and ground magnetics – are often simply paper clipped to the pdf, and have not yet made it to the spatial layers.

Many surveys remain that haven't yet been added to the various layers on SARIG but we are confident that there is ample information available on SARIG to hunt anything down. If you require assistance with downloading geophysical data on SARIG – please do not hesitate to contact Customer Services on resources.customerservices@sa.gov.au.

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Planned new seismic data acquisition

Illuminating the detailed 3D seismic velocity structure of the lithosphere was identified by the UNCOVER initiative as a key element for enhancing the probability of successful mineral exploration under cover. To this end, the GSSA is poised to deploy the AusArray SA broadband seismic array across the eastern-central Gawler Craton.

Existing broadband seismic data from sparse arrays in South Australia (e.g., SKIPPY, SOC, BILBY) illuminate lithospheric structure at a length scale of ~3° x 3°. However, this is insufficient to delineate the detailed lithospheric architecture (terrane margins, metasomatic fingerprints, trans-lithospheric faults, sutures and shear zones, etc.) needed for robust prospectivity mapping. Dense seismic arrays (WOMBAT) in the southeast of the state have helped to mitigate this deficiency, but the band-limited sensors were insensitive to the data-rich low frequency surface waves that are a mainstay of probing lithospheric velocity structure.

The AusArray SA seismic array is designed to acquire broadband data across the eastern-central Gawler Craton at the same station spacing (~0.5° x 0.5°) as the AusLAMP magnetotelluric (MT) array. The array will comprise 29 Nanometrics Trillium Compact 120s sensors (25 from ANSIR; 4 from GA) and 12 Trillium Compact 25s sensors (from ANSIR). These sensors will faithfully record ground motion at frequencies between 100 Hz and 120s, and between 100 Hz and 25s, respectively.

Given the relative seismic quiescence of the Australian continent, the tomography modelling will draw predominantly on two energy sources: (i) "ballistic" waves from distant (teleseismic) earthquakes, and (ii) the diffuse, ambient noise field.

Surface waves transit trapped near the Earth's surface and are dispersive, i.e., their velocity varies with frequency. Their dispersion is due to their increasing depth sensitivity with decreasing frequency (or equivalently, with increasing period). Surface (Rayleigh)

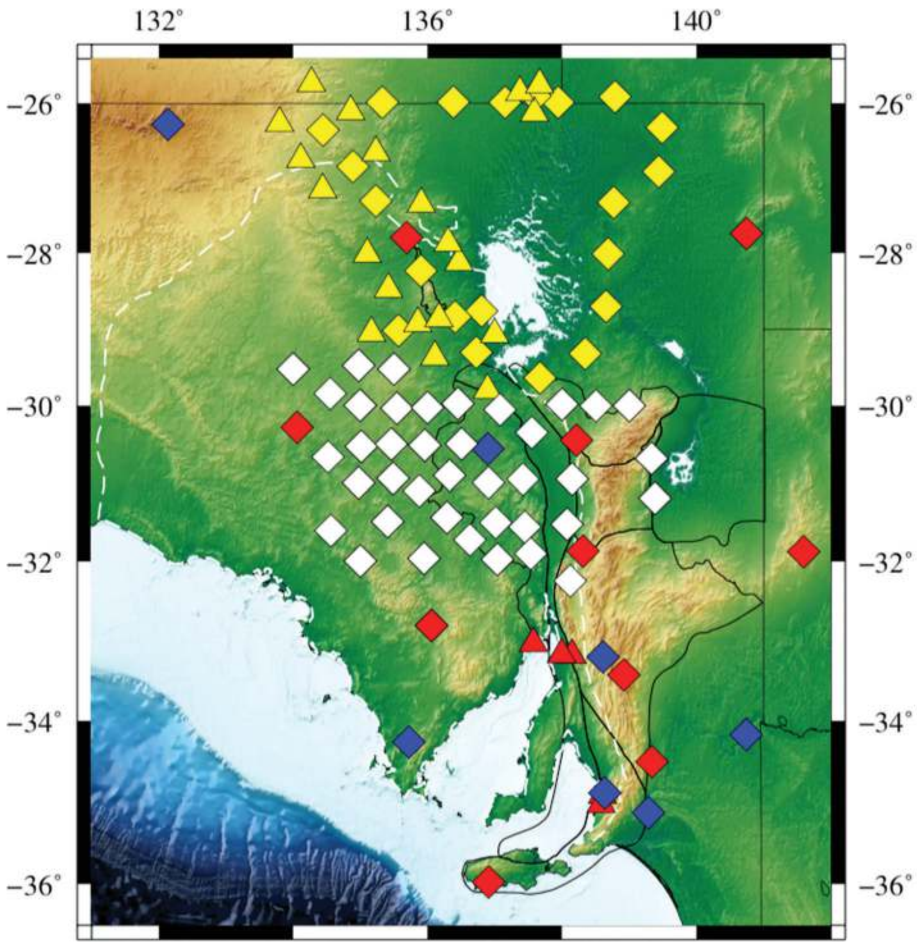

Figure 1. *The white symbols show the planned locations of the AusArray SA broadband seismic stations. Other seismic stations currently operating in South Australia include those of the Australian National Seismic Network (red), Australian Seismometers in School program (blue) and ANU's Lake Eyre Basin seismic array (yellow). Diamonds signify broadband stations, triangles short period stations.*

waves at periods of ~20-120s will be used to probe upper mantle structure, constraining absolute 3D velocity structure at length scales of many 10s to several 100s of km. Shorter period (typically less than ~20s) surface waves transiting in the more compositionally heterogeneous crust are subject to more scattering and attenuation; the longer the propagation path, the greater the wavefield complexity accrued - especially if terrane or plate boundaries are encountered. This renders teleseismic surface waves at periods less than ~20s difficult to interpret.

Ambient seismic noise refers to the diffuse energy field excited by ocean swells and infragravity waves interacting with the seafloor. Its spectral power is highest in the primary (~10-20s) and secondary (~5-10s) micro-seismic bands. Ambient noise correlation exploits the fact that the approximate impulse response of the Earth between two stations (i.e., the Green's function) emerges from the cross-correlation of the noise records. In effect, one seismic station serves as a local, virtual earthquake source for the other, and vice versa. In the case of Australia, this circumvents reliance on complex teleseismic surface waves for probing crustal structure. Ambient noise tomography will be used to constrain absolute 3D crustal velocity structure beneath the eastern-central Gawler at length scales of several 10s of km (targeted, dense "Large-N" arrays of nodal seismometers can extend resolution of 3D upper crustal velocity structure to sub-km length scales).

Unlike surface waves, whose peaks and troughs can be readily tracked as they journey across a seismic array (thus facilitating measurement of absolute velocities), body waves from distant earthquakes arrive sub-vertically. Because we cannot (easily!) account for the absolute travel times of body waves plunging through the deep Earth along entire earthquake-to-station propagation paths, we'll rely on measurements of *relative arrival times* between stations rather than absolute travel times to model the local, sub-array 3D velocity structure. The cost of this normalisation is that only relative, rather than absolute, 3D velocity variations can be inferred. However, the higher frequency body waves resolve velocity structure at a length scale that the lower frequency surface waves cannot, so the additional information is extremely valuable. Superimposing the granular, relative velocity variations inferred by teleseismic body-wave travel time analysis upon the longer wavelength absolute velocity structure inferred by teleseismic surface wave and ambient noise analyses leverages both data types.

Because seismic and MT data have contrasting sensitivities to temperature and composition, the combination of these complementary data - at a similar resolution - offers the promise of distinguishing between thermal and compositional signals, something neither data set alone can rigorously accomplish. In particular, signatures of metasomatism and fluid pathways should be more readily identifiable, and these are of course primary indicators of mineral prospectivity. Along with MT model data, the seismic model data will ultimately be fed into the LitMod modelling formalism as part of the existing ARC Linkage grant "Illuminating AusLAMP: Thermodynamics inversion for mineral systems" to model the 3D thermochemical structure of the Gawler Craton based on probabilistic joint inversion of multiple geophysical observables.

Deployment of the AusArray SA seismic array was due to commence in April 2020, but this has been temporarily postponed in light of the COVID-19 pandemic. Once deployed, the array will record continuously for at least 15 months in order to record sufficient earthquake and noise data for modelling purposes. The raw seismic data will be housed on the AusPass passive seismic data server and the derived model outputs will be made available on SARIG.

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Geological Survey of New South Wales: New AusLAMP 3D conductivity model supports tectonic interpretation in New South Wales

The Geophysics and Modelling team at the Geological Survey of New South Wales (GSNSW) is playing a key role in the tectonic interpretation of the Tasmanides of eastern Australia through an ongoing program of geophysical data acquisition and interpretation and pro-active collaboration with academia, industry, other state surveys and Geoscience Australia (GA). Current tectonically focussed geophysical studies at GSNSW include long-period

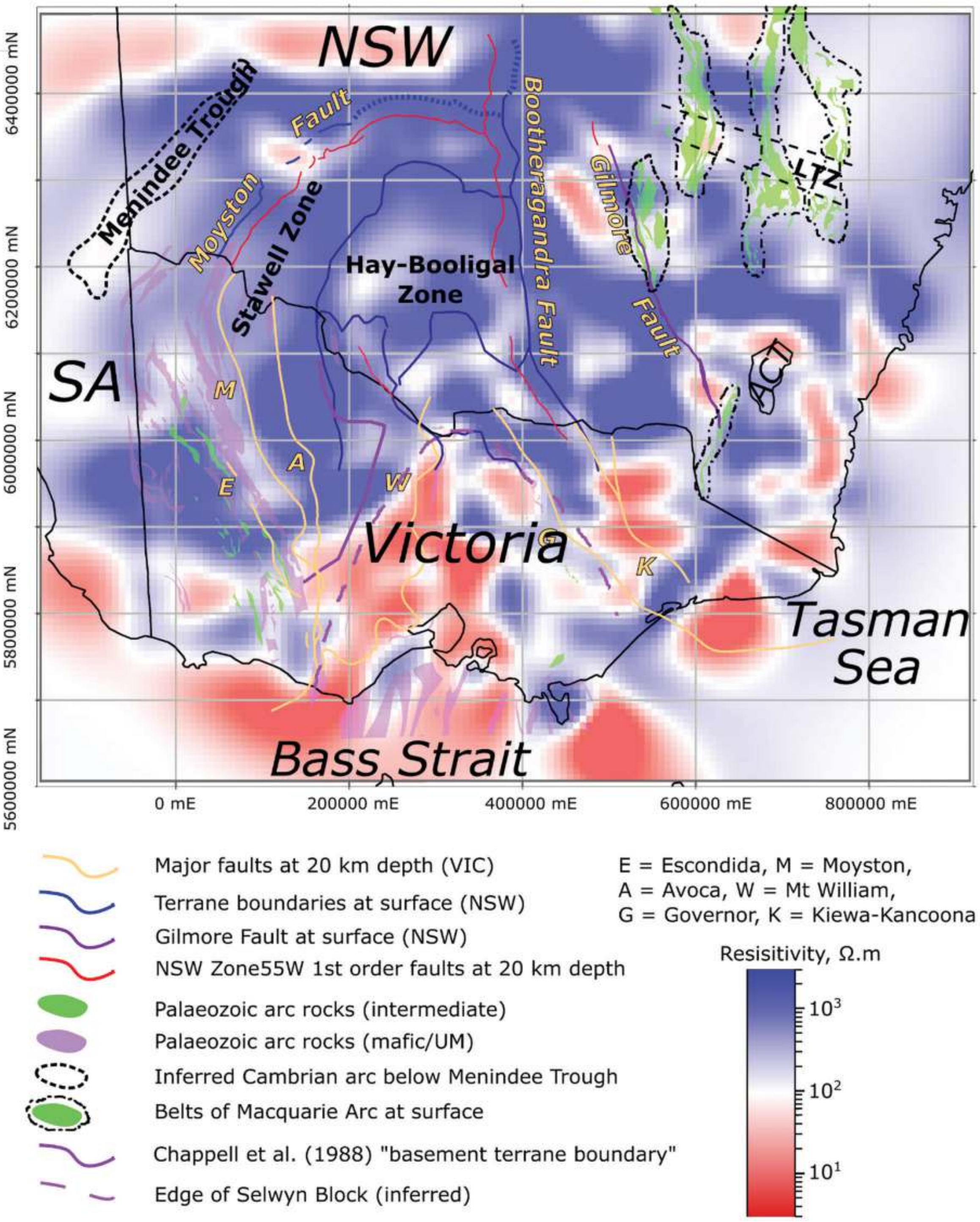

Figure 1. *A 20 km depth slice from preliminary AusLAMP MT 3D conductivity model for southern NSW and Victoria. Also shown are tectonic zones and boundary faults, Palaeozoic arc rocks, and the inferred position of major faults at 20 km depth. NSW terrane boundaries are after Hallett et al. (2005) and Musgrave et al. (2008). Projections of faults at 20 km are derived from the NSW Statewide 3D Fault Model (Spampinato 2018) and the Geological Survey of Victoria 3D Victoria Project (Rawling et al. 2011), the latter courtesy of Phil Skladzien. Arc rocks in Victoria are from the 2014 edition of Seamless Geology Victoria (Welch, Higgins, and Callaway 2011). Macquarie Arc and Gilmore Fault are from the Eastern Lachlan Orogen Geoscience Database, version 2 (Glen, Dawson, and Colquhoun 2007).*

magnetotelluric surveys, deep seismic reflection (collaboratively with Geological Survey of Victoria and GA (Haydon 2019)), and palaeomagnetic and petrophysical studies (Musgrave 2018).

The Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP) is a collaboration between the State and Northern Territory geological surveys, universities, AuScope and other research organisations. The NSW component of AusLAMP, which commenced in 2016, has to date completed 224 of a planned 320 sites in NSW. Long-period MT data have been recorded at a 55 km spacing in a rolling deployment. The array is sensitive to variations in electrical conductivity over depths from about 10 to 130 km. A model derived from these data combined with AusLAMP data from Victoria (Duan and Kyi 2018) and the eastern part of the Flinders Ranges in South Australia (Robertson, Heinson, and Thiel 2016) is beginning to address a wide range of fundamental tectonic questions (Figure 1). Geoscience Australia has released the NSW–Victoria resistivity model (http://pid.geoscience.gov.au/dataset/ga/131889) and the results are described in detail in Kirkby *et al* (submitted). Results from AusLAMP data acquired to date in New South Wales can now be downloaded from the GSNSW MinView portal (minview.geoscience.nsw.gov.au) and include station locations, EDI files, 3D model grids, and depth-slice images and grids.

The depth range of AusLAMP allows geologists to track major boundaries into the lower crust and lithospheric mantle. Curvature of the upper crust in the Stawell Zone can be traced to the base of the lithosphere – a key test of the Lachlan Orocline hypothesis (Cayley, Musgrave, and Preiss 2012; Moresi et al. 2014; Musgrave 2015). The Palaeozoic arc systems – the Cambrian Mount Wright Arc and its continuation under the Menindee trough, and the highly prospective Ordovician to Silurian Macquarie Arc – can likewise be traced into the middle crust. Cross-cutting conductivity structures under the Macquarie Arc align with the belt of major Cu – Au porphyries defining the Lachlan Transverse Zone (LTZ – Glen and Walshe 1999). A curved conductor within the enigmatic Hay – Booligal Zone matches predictions that the zone includes the southern continuation of the Macquarie Arc, detached and bent during development of the Lachlan Orocline.

AusLAMP fieldwork in NSW has been disrupted by travel restrictions due to COVID-19. GSNSW plans to complete all AusLAMP measurements in NSW within six months of restrictions being lifted and will release an updated dataset and conductivity model shortly afterwards.

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3D wireframe model of New South Wales

The Geological Survey of New South Wales (GSNSW) has followed a state wide approach to 3D modelling since 2014, building regional-scale models of basins, major faults and depth of cover. The first version of an integrated 3D model of the state has now been drafted and will be released in mid-2020.

The geological evolution of NSW is very complex and spans almost two billion years of Earth history. East of the Proterozoic Curnamona Craton, the Neoproterozoic to Cambrian rocks of the Delamerian Orogen record the break-up of the super-continent Rodinia, followed by the growth of orogenic belts along the eastern margin of Australia, forming most of the Phanerozoic rocks of NSW, which are collectively known as Tasmanides (Glen 2005). Overlying these basement rocks are a series of Palaeozoic (e.g. Darling Basin), Mesozoic (e.g. Eromanga–Surat Basin, Sydney–Gunnedah Basin) and Cenozoic (e.g. Murray Basin) basins interspersed with widespread sequences of basaltic volcanic rock.

There is extensive evidence of the geological evolution the state, however most data are collected from outcropping rocks or those near surface (Glen 2005; Gray et al. 2006; Spampinato et al. 2015). Currently, almost all of the known metal resources and occurrences in NSW occur in areas of outcropping or sub-cropping geology (Hough, Bierlein, and Wilde 2007). This reliance on surface and near-surface data places a significant limitation on the understanding of the state's geology as well as the ability of explorers to find new resources.

Understanding geology in three dimensions is a key factor for exploration planning and estimating mineral resource potential, particularly in areas where prospective geology is obscured by younger, un-prospective rocks and soil. The GSNSW modelling program is developing a series of interlocking 3D models to better represent the state's geology and improve visualisation and understanding of the relationship between the different elements of the crust. These 3D models have widespread applications, including for land-use management, mineral and energy resource exploration, scientific research, water resource management, civil engineering and waste management.

As a part of its 3D modelling program, the GSNSW will soon release a 3D wireframe model of the state (Figure 1). The model illustrates the nature and tectonic setting of outcropping and concealed basement rocks (Figure 2) and their relationship to overlying basins. The 3D wireframe model of NSW incorporates:

- three-dimensional surfaces representing crustal-scale structures that exert major control on the geological architecture

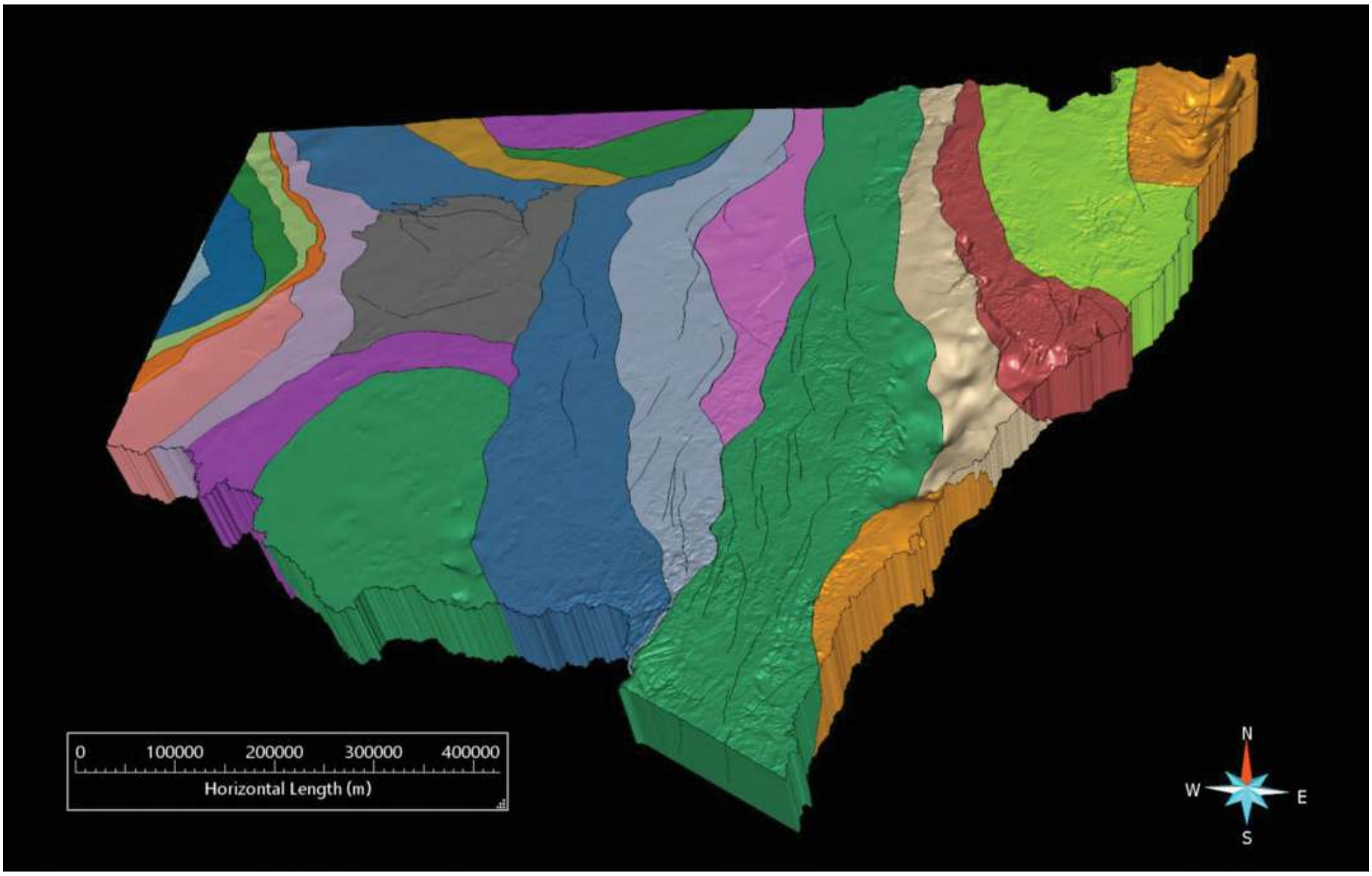

Figure 1. *Preview of the 3D wireframe model of NSW (basement geology) with colours highlighting the different pre-Carboniferous tectonic zones. Image has a 4× vertical exaggeration.*

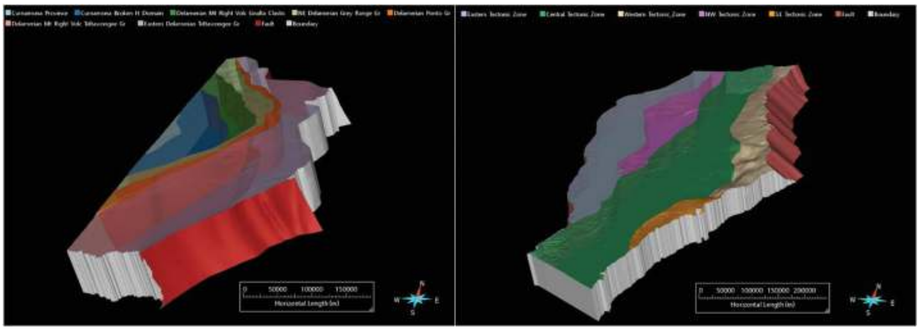

Figure 2. *Details of the Curnamona Province and Delamerian Orogen (left) and eastern Lachlan Orogen (right) from the 3D wireframe model of NSW. 30% transparency has been applied to the basement units. Images have 3× vertical exaggeration.*

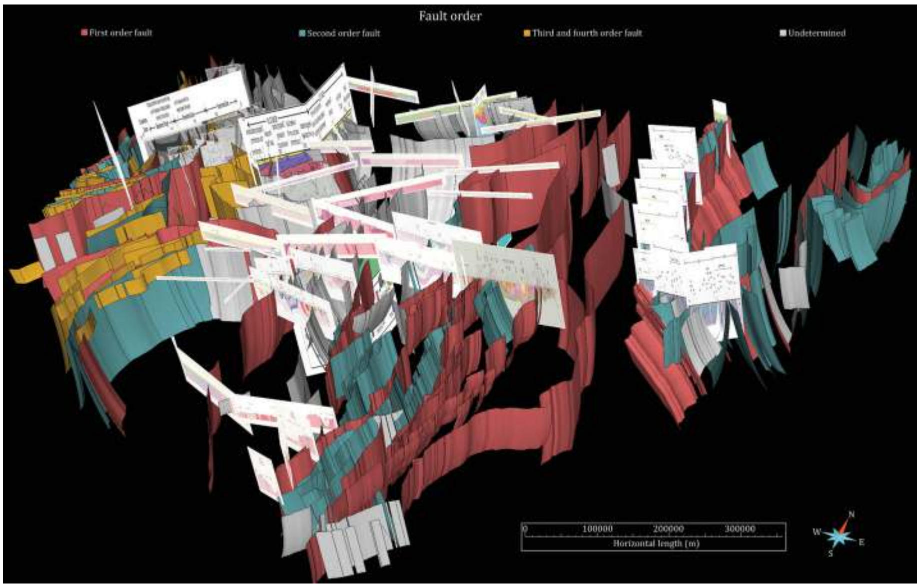

Figure 3. *3D fault model of NSW. Surfaces are coloured by the interpreted fault order: first order (red-brown), second order (blue-green), third and fourth order (mustard) and undetermined (light grey).*

- volumes illustrating the surface distribution and undercover extensions of the major Pre-Carboniferous tectonic subdivisions of NSW
- embedded sedimentary basins that include all the major stratigraphic units and basin-scale structures
- digital terrain, basin and basement interfaces.

Constraining data for the 3D modelling includes geological maps and cross-sections, seismic sections, drillholes (petroleum, minerals, coal and water bores), structural measurements and gravity and magnetic data.

The 3D wireframe model of NSW follows the completion of the NSW Seamless Geology dataset (Colquhoun et al. 2018) and the Statewide 3D Fault Model (Spampinato 2018). The NSW Seamless Geology dataset provides a statewide compilation of the best-available mapping data in an internally consistent format. The Statewide 3D Fault Model integrates all available geological and geophysical data to determine the geometries of faults and structures that define the architecture of the orogens (Figure 3).

The 3D wireframe model of NSW has drawn together and consolidated previous large-scale structural interpretations and extended faults mapped in the NSW Seamless Geology to crustal-scale depths. The model contributes to a better understanding of the tectonic setting and distribution of geological terranes of eastern Australia and will inform new mineral exploration as well as government land-use decisions.

The 3D wireframe model of NSW also provides a geological framework for future detailed modelling. The 3D data integration highlights gaps in data and geological understanding that will focus future GSNSW work. The model is dynamic and will be updated as new data are collected.

The 3D wireframe model of NSW will be released as Geoscience ANALYST project, GOCAD® and DXF compressed files and will be available online through MinView in mid-2020.

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Canberra observed

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Fire, smoke, hail and now COVID-19, welcome to Canberra

Welcome to 2020 in Canberra. What a year it has been; and we are only about halfway through it.

The devastation from the bushfires around Canberra was shocking. Fortunately, our city was spared the disaster of the 2003 fires, but the claustrophobic smoke we endured for days on end was enervating. It is estimated that more people (over 400) died in Australia from smoke inhalation than from fire (https://onlinelibrary.wiley.com/doi/full/10.5694/mja2.50545). In Canberra it is estimated there were 31 excess deaths, 82 cardiovascular hospital admissions, 147 respiratory admissions and 89 asthma related attendances from the smoke haze.

The bushfires were followed on 20 January by a gigantic hailstorm. The total damage in Canberra was more than half a billion dollars, and that includes over 7000 vehicles written off. Homes are still being repaired from the hail-damage.

Finally, the apocalyptic COVID-19

But these events were nothing compared to what we are experiencing from COVID-19, which is affecting the whole country. At the time of writing (11 May), the number of confirmed cases in Australia is 6948, we have 97 deaths, an 89% recovery rate and a fatality rate of only 1.4% (https://epidemic-stats.com/). A much better record than countries such as the USA (5.9%), UK (14.7%), Canada (6.9%) and Italy (13.9%).

Furthermore, the rate of increase in the number of confirmed cases is decreasing so that we might only have at most about 8000 cases, and a maximum of about 120 deaths. Compared to the 1918 Spanish flu, when approximately 13 500 Australians died, the present numbers are particularly good.

The State, Territory and Federal Governments have worked together to provide this excellent health outcome. But this is only the beginning. The socio-economic disruption from COVID-19 will be massive and affect everybody. Ironically, this is because we are a very wealthy nation.

Consequently, a large percentage of our jobs are not essential for providing our basic needs. We do not need so many sporting events, gambling facilities, restaurants, coffee shops, beauty parlours, gyms, concerts, or tourist attractions to survive. And yet, these activities are worth billions in terms of providing jobs, and are an integral part of our culture.

Should we have been better prepared?

Ross Garnaut, in 2008, forecast that, because of climate change, fire seasons would start earlier, end later and be more intense. He also said, "This effect increases over time, but should be directly observable by 2020". SARS and MERS gave us ample warning of the risk of new corona viruses. Why weren't we better prepared?

How does COVID-19 affect resource industries and exploration?

There are three main affects. The first is that the demand for many commodities falls along with their prices. The second is we are not able to travel; this affects exploration as well as tourism. The third is that the number of unemployed rises and consequently there is less money available and whole economy of the nation shrinks. When we are living in lockdown, we don't spend much, we use fewer resources and we survive - without the luxuries we used to enjoy.

The collapse of the oil price following domestic and international travel bans was spectacular. Figure 1 shows the daily prices of West Texas Intermediate (NYMEX) Crude Oil from the start of 2019 until May 2020 (https://www.macrotrends.net/2516/wti-crude-oil-prices-10-year-daily-chart).

On Monday 20 April 2020, the price went negative, for the first time, as traders got caught in a flurry to sell their contracts before having to actually receive the oil. The speed of the decline in price was remarkable (Figure 1). It had been chugging along steadily between $US50-60/bl throughout 2019, and then COVID-19 struck.

The drop in price affects the whole petroleum industry from exploration through to less gas sold from the pumps. In other words, if you are an explorer or a producer your market has vanished, and if you do not have access to storage you are really in trouble.

Energy Minister Taylor organises storage of Australian oil – in USA!

The shortage of storage for oil didn't stop our Energy Minister, Angus Taylor, announcing on 22 April that the Australian government is to spend $94M to begin building up a stockpile

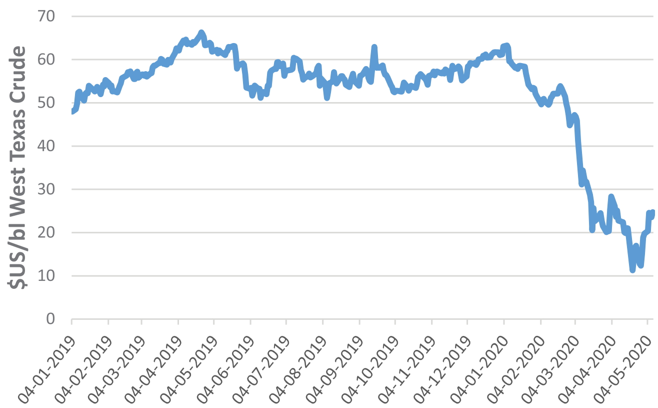

Figure 1. *Daily oil price of West Texas Intermediate (NYMEX) Crude Oil from the start of 2019 in $US/bl. The lowest daily price was $11 on 21 April 2020.*

of crude oil – that will initially be in the United States.

Under International Energy Agency rules, each country has an obligation to hold emergency oil stocks equivalent to at least 90 days of net oil imports as part of planning to avoid a hit from any major disruption to oil supplies. The oil will be purchased now when the price is exceptionally low, and stored in the US Strategic Petroleum Reserve caverns on the Gulf Coast.

Australia currently has sufficient oil for about 81 days, including 25 days of stocks in overseas ports and in transit to Australia, according to the Department of Industry, Science, Energy and Resources. Why we persist in storing our strategic oil resources overseas is very strange. Mr Albanese said he thought the decision was "rather bizarre" and did not protect Australia's national interest. I would say: it does not make any sense in the uncertain world we now live in.

CSIRO provides a National Hydrogen Roadmap

This report is a good read for anyone who wants to know more about hydrogen as a source of renewable clean energy. It was released earlier this year (https://www.csiro.au/en/Do-business/Futures/Reports/Hydrogen-Roadmap) and aims to set out what is needed to develop the pathways to an economically sustainable hydrogen industry in Australia. It summarises the options for production, storage, and transport (see the boxes below) and finally utilisation and the economics.

The thermochemical process would involve geophysical techniques, and technologies that have not been tested commercially. The electrochemical process would require large amounts of solar energy to be viable.

A test facility is being established at Port Lincoln in South Australia, at a cost of $117 million, and the outcomes from this will be critical if/when a hydrogen power source proceeds.

Hydrogen may be produced via two mature pathways:

Thermochemical: Uses a fossil fuel feedstock to produce hydrogen. This process must be paired with carbon capture and storage (CCS) to produce clean hydrogen. Mature technologies include steam methane reforming (SMR), which relies on natural gas as an input, and coal gasification.

Electrochemical: Involves the use of an electrical current to split water into hydrogen and oxygen. Requires the use of low or zero emissions electricity to produce clean hydrogen. Mature technologies include polymer electrolyte membrane (PEM) and alkaline electrolysis (AE)

Hydrogen storage technologies can be broadly classified as:

Compression: Gaseous hydrogen stored at higher pressures to increase volume. Includes large scale underground storage (e.g. salt caverns) and 'line packing' in gas pipelines.

Liquefaction: Pressurising and cooling hydrogen to -253°C so that it is in a liquid state.

Chemical: Molecules such as ammonia, metal hydrides and toluene that carry hydrogen. All retain an additional energy penalty and cost associated with the recovery of hydrogen prior to use.

CSIRO confirms hydraulic fracturing safe in Surat Basin

The results of a three-year study by CSIRO's gas industry social and environmental research alliance (GISERA) into the air, water and soil impacts of hydraulic fracturing in Queensland has found there is little to no impact on air quality, soils, groundwater and waterways. It was released in April 2020 (https://gisera.csiro.au/wp-content/uploads/2020/04/Water-12-Milestone-7-final-report.pdf).

As part of the study, CSIRO analysed air, water and soil samples taken before, during and up to six months after hydraulic fracturing operations at six coal seam gas wells in the Surat Basin. It found current water treatment technology used for treating water produced from coal seam gas wells is effective in removing hydraulic fracturing chemicals and naturally occurring chemicals to within relevant water quality guidelines.

The Minister for Resources, Water and Northern Australia, Keith Pitt, said "The CSIRO report should pave the way for further investment in gas exploration and development across Australia. It found that best practice fracking operations that have been adopted in the Basin had little to no environmental impact, even water produced directly from the wells showed no chemical residues above normal background levels within 40 days of the fracking operation taking place."

There will now be clearance to expand gas exploration and production in the Surat Basin.

Water for coal mining and coal-fired power production in NSW and Qld equals domestic use by 5.2 million people

Finally, a Water for Coal report produced by Ian Overton for the Australian Conservation Foundation (https://www.acf.org.au/water_for_coal) claims that the water used by coal mining and coal-fired power production in New South Wales and Queensland is equivalent to the domestic use of 5.2 million people. This assumes that the average person uses about 73 000 L/a.

The largest annual withdrawal of freshwater is for coal-fired power stations amounting to 2129 GL/a. Coal mining itself withdraws approximately 225 GL/a. Coal-fired power stations withdraw about 157 000 L/MWh, gas-fired power stations 50 000 L/MWh and nuclear power stations 10 L/MWh.

The report is an interesting read and it is to be hoped that when governments assess which way to move forward in power generation the cost of water is considered.

Education matters

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Geophysics in a COVID-19 world

I have spent some months since last year preparing a conference paper on evidence for 6000-year natural cycles of climate change over the past 20 000 years (a fourth paper of mine on natural cycles of climate change over the past four years). The conference has now been and gone, and I have a grand total of three short online text questions, and one correction to my terminology, to show for it. No networking, no faces to remember, or contacts for further discussion. Is this the future of scientific research?

I don't think so – I certainly hope not – but it epitomizes the remarkable road-blocks to our work introduced by the presence of the COVID-19 virus.

The conference I speak of is the European Geophysical Union annual meeting in April-May in Vienna. The organisers were faced with an especially difficult time frame for decision making when lock-downs and bans on international travel commenced, well after the majority of 18 036 intended attendees had registered and lodged their accepted conference abstracts. To their credit, the conference organisers put science before profit and set up an online conference format, while refunding all conference registration fees.

The online conference used sendbird software (sendbird.com) so that each scheduled session could proceed at the allocated time, with session convenors moderating online statements and Q&A. However, the text-based chat meant that no online visual presentation or face-to-face discussion (in the ilk of a Zoom meeting) was available. Presenters were encouraged to upload a presentation or poster that appeared via a link with each online abstract, thus it was possible for a viewer to read and gain some in-depth understanding of the scope of a paper. However, only 61% of presenters acted to post a presentation. The resultant sessions, limited to text Q&A and the inevitable time delays produced by typing and reading between the Q and the A were, in my view, disappointingly shallow - especially in the context of the huge effort by presenters, conveners and organisers to arrange one of the largest Earth Science conferences on the globe. But, viewing the cup as half-full not half-empty, those presentations are now online permanently as part of the body of non-peer-reviewed scientific literature.

The EGU meeting is only one of hundreds of scientific conferences affected by the now-infamous virus. Our own Australian Exploration Geoscience Conference (AEGC 2021) scheduled for next April has been postponed to September 2021 (see announcement elsewhere in this issue) in the hope of dodging the worst of the virus-induced limitations in travel mobility and creativity. After much internal consultation our societies have decided on the delay of 6 months, followed by continuance of a delayed 18-month AEGC conference cycle. Thus our professional activity, publication and exhibition opportunities will lock in a 6-month dead-period in 2020; we hope that dead period will not prove to be any longer.

Four other disrupted conferences which will affect many of our constituency are:

- The **International Geological Congress** in Delhi, which has been delayed from March 2020 to November 2020. It is hard to see how this conference can survive given the expected continuing restrictions on international travel.
- The **6th International Archean Symposium (6IAS),** which was scheduled for Perth in July 2020 has been postponed for "at least 12 months".
- The 17th **World Congress on Earthquake Engineering**, Sendai Japan, which has been delayed from September 2020 to September 2021.
- The flagship conference of our international partner, the **Society of Exploration Geophysicists**, which is still scheduled for Houston Texas in October 2020. At time of writing the SEG is wrestling to find the best (or least-worst) option in order to go ahead with this meeting. Many countries (definitely Australia) will *not* permit air-travel in this calendar year for intending delegates. The SEG is also feeling the COVID-19 crisis in its general operations and financial support, including having to enact forced redundancies on a quarter of its head-office staff in Tulsa.

Meanwhile, universities worldwide are suffering acute contraction pains triggered by workplace lockdowns and travel restrictions. A major causative factor is the very large growth of foreign student enrolments in the past decade, income from which has cross-subsidised many university research and teaching activities. Timothy Devinney (University of Manchester) and Grahame Dowling (University of NSW) writing in the *Times Higher Education Supplement* (https://www.timeshighereducation.com/features/crisis-higher-education-needs-have) take a sometimes harshly critical view of university management both in Australia and overseas. Time will tell if they are being wise after event of the unpredictable calamity of COVID-19, or whether the virus merely triggered a problem already in the making. What is undeniable is that current students, research students and early-career researchers, regardless of nationality, are hugely impacted by the loss of the "university experience" of networking and mentoring as we endeavour to offer geoscience lectures and practical classes via online formats.

Among Australian universities, the University of NSW has a forecasted budget shortfall of $650M, and my own workplace, Monash University, is posting an expected $350M contraction. Achieving necessary savings in my own School has resulted in a freezing of most research expenditures, a ban on travel and restriction of field programmes to single-day outings – rather a challenge for geoscientists studying the rocks of our wide brown land. Bureaucrats have helpfully added additional advice that on those outings we should take our own sandwiches rather than patronizing take-away outlets.

A return to academic normality is likely to be slow. Our Faculty Dean at Monash points out that the need for social distancing may extend many months until a COVID-19 vaccine becomes available, and that a continuance of distancing rules severely restricts any normal practical classes in our laboratories. The Vice-Chancellor of Monash University and Chair of Universities Australia, Prof Margaret Gardner, was quoted in *The Australian* saying with reference to the loss of income from foreign students this year, and the flow-on effects into enrolments in future years, "the nation has seen only the start of the crisis. Conditions will worsen next year and could even be worse in 2022."

One good result sponsored by the lockdowns is that online seminars for both casual meetings and formal seminars have become routine. While they lack some of the personal interactions we value in such meetings, they have also made available a wider set of informative talks for all students. Thus we see off-campus university seminars being advertised as available to our home institutions in online visual and interactive form via Zoom. We also see ASEG branch meeting online talks being advertised nationally for all interested Members. As we take a breath after the initial shocks of the past two months, we must regularise these features and ensure that our wider geophysical education efforts reach as many as possible. Our students and colleagues deserve every effort on our part to widen the opportunities for professional contacts and inspiration.

The ASEG in social media

Have you liked/followed/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 Millicent Crowe at 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

YouTube: https://www.youtube.com/channel/UCNvsVEu1pVw_BdYOyi2avLg

Instagram: https://www.instagram.com/aseg_news/

Environmental geophysics

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Improving interpretation of ground conductivity data

Welcome readers to this issue's column on geophysics applied to the environment. I wasn't going to write about COVID-19, so I won't, other than to comment that I don't get out much, and therefore this month's column is even more "in my space" than usual. In this column I am going to continue in my quest to improve our (my?) ability to interpret data collected using Ground Conductivity Meters (GCM). Specifically, I am most interested in instruments like the GF Instruments CMD or the DualEM 421 that collect data using a combination of frequencies and/or transmitter-receiver separations so that data are collected at a number of depths.

As most of you will know, it irritates me that a) these data are still presented using the LIN approximation (see, for example, my diatribe on this in *Preview* **191** - December 2017), and b) that the data are usually presented using Excel (don't get me wrong, Excel is fantastic), with each conductivity data set presented on a graph with labels like Shallowest Data, Medium Depth and Deepest Data (Figure 1a) and then some estimate of depth given based on the instrument's manual – come on folks, we can do better than that. These data can be inverted and the results are improved when this is done. The problem is that data collected using a GCM usually need to be calibrated. This became very obvious to me a number of years ago when a colleague tested a GCM against some just-drilled (and logged) shallow bores in an area where we had some shallow time-domain electromagnetics (TEM) data that had been collected a number of years before the drilling. Interestingly, the (uncalibrated) GCM inverted results were just a bit off, while the far older TEM data appeared to do better. Ever since then, I have been hoping to have an opportunity to see if I could come up with some calibrates for the GCM. And finally, I have started making some progress in this space - after almost five years.

The methodology that I am about to describe is inspired by a number of articles (e.g. Davis *et al,* 2010 and Foged *et al*, 2013) along with conversations with the various authors and others on a simple (too simple?) way to calibrate this type of data.

In this exercise, a few of us from the University of Adelaide collected a line of shallow resistivity over a project area in the Riverland of South Australia. The data were collected using a ZZResistivity 64-channel system, using 3 m station spacings. These data were inverted using ZZResistivity's ZZResinv64 2.5D program. The next day we collected GCM data over the same line using Flinders' University's GF Instruments CMD Explorer (many thanks to Flinders University for use of the instrument).

The inverted resistivity results were then treated as individual soundings at each station on the line. I ran a search to find the GCM readings that were within 0.5

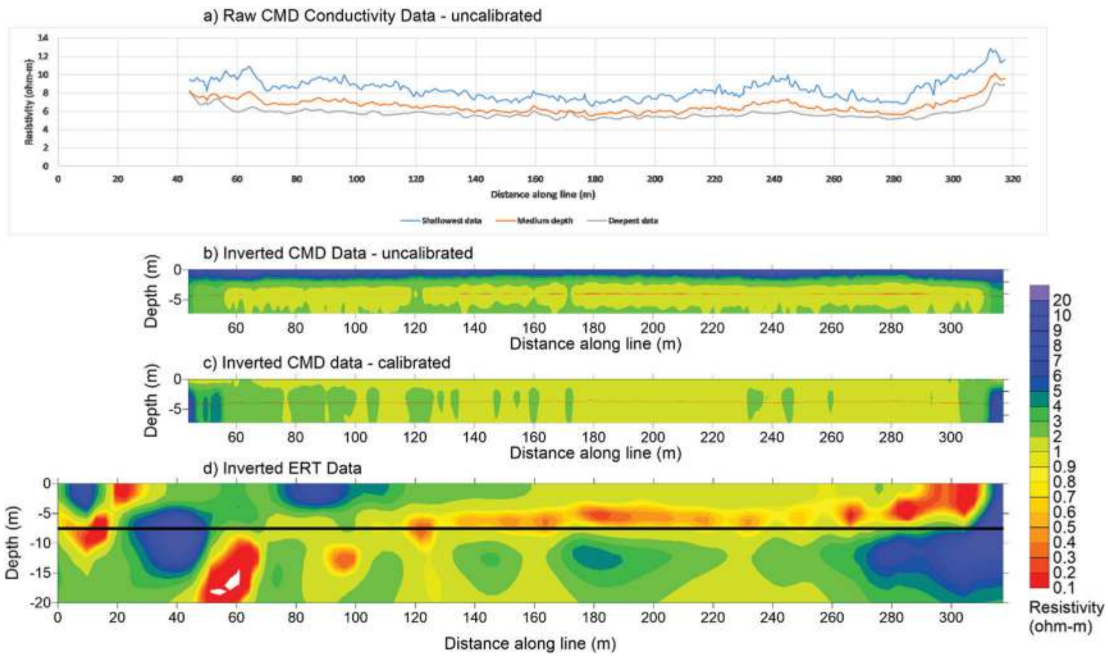

Figure 1. *Comparison plot showing various representations of GCM data. a) uses Excel to plot data for each transmitter - receiver separation; b) inverted section using uncalibrated data; c) inverted section using calibrated data; d) ERT data used as calibrate "known". Red lines in b) and c) indicated approximate depth of investigation for these GCM inversions. Black line in d) delineates depth extent shown in b) and c).*

m of a resistivity sounding (only 28 of 314 readings qualified). These inverted resistivity sounding became the forward model for simulated CMD data. In this step I forward modelled CMD Explorer data using Aarhus University's Aarhusinv 1D modelling program (Aarhusinv is the "engine" that runs Aarhus GeoSoftware's Workbench). I then calculated the ratio between the observed GCM data and the calculated (forward modelled) data at each location. The average ratios and their associated standard deviations, for each transmitter-receiver separation, are shown in Table 1. Note that while I ran the forward models on both the in-phase and out-of-phase data, I only used the out-of-phase results, as that has a relatively direct link to conductivity/resistivity (McNeill 1980). These ratios were then used as the correction factors to calibrate the CMD readings on two lines of data collected during this field stint. Figures 1 and 2 compare various representations of the CMD data collected over the two lines and compares them with the resistivity survey data that were collected on the same line.

At first I started writing in some detail to describe the results and compare them but, as always, that is largely unnecessary as the pictures speak for themselves. Instead, I will note a few things that I think are interesting (and may still be very obvious). First off, observe that I have added a red line to each of the CMD inversions to show where the inversion has estimated the depth-of-investigation (Christiansen and Auken, 2012). Some of what is interesting in the resistivity section is often below that depth in the CMD, and may explain some of the differences. More interestingly, the world as described by the resistivity is far more interesting than the relatively uninteresting versions portrayed by the CMD. In general, the CMD and the resistivity are finding similar resistive features toward the ends of the lines, although the resolution of the shallowest resistive units in the CMD appears less than what is resolved with the resistivity (assuming that the resistivity inversion is the "truth").

Table 1. Ratios of observed data to modelled data for each CMD transmitter - receiver separation.

	Input data/modelled data		Standard deviation	
	In-phase	Out-of-phase	In-phase	Out-of-phase
Shortest separation	0.853	0.401	0.566	0.135
Mid separation	0.569	0.517	0.342	0.137
Longest separation	0.583	0.845	0.300	0.142

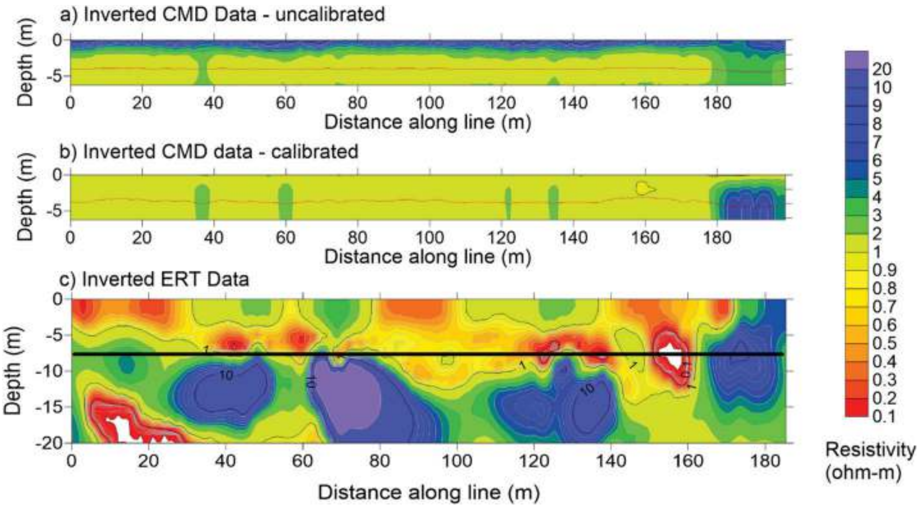

Figure 2. *Comparison plot showing various representations of GCM data. a) inverted section using uncalibrated data; b) inverted section using calibrated data; c) ERT data used as calibrate "known". Red lines in b) and c) indicated approximate depth of investigation for these GCM inversions. Black line in d) delineates depth extent shown in b) and c).*

Again, more interestingly, the CMD is not resolving any features that are more conductive than about 1 ohm-m, while it appears that the resistivity is making claims in that ultra-conductive space. While we are no longer limited by the LIN approximation with this GCM, I wonder if we are hitting some sort of a low-limit related to LIN. Or is it something that I have done, in my rush to get this article to press (late again Mike)? Obviously, a) I need to check my work, and b) I need to experiment with the forward modelling to see what it tells me. I am hoping to do both faster than the five years it took me to get here. And I would love to hear advice and input into this problem. Do any readers have another set of data, in a different (maybe not quite so conductive) setting that I can play with? No time guarantees.

Stay healthy!

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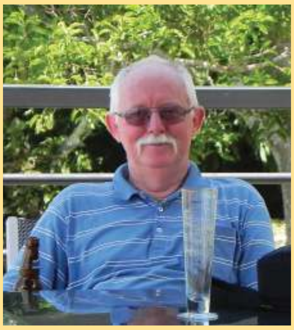
Minerals geophysics



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Factors in survey design

How do you go about undertaking a geophysical survey? You identify which technique and what survey parameters you need to employ, estimate how much it is going to cost, decide on the contractor and the timing, and commission the work. Unfortunately, it is rarely that simple!

Here's the scenario. The exploration team has identified an area of interest and come up with a target style. This should give you some parameters to work with. First of all, what is the relevant petrophysical property that you can utilise to identify your target? Then there is the expected size of the target, or perhaps the minimum size that the team is interested in. What about the required depth of investigation – how deep is too deep? So far so good. With enough information, you may be able to model some expected geophysical responses to back your judgement that your survey can do the job.

Now, what about the near-surface environment. Any nasties there? Do you have to contend with deep and severe weathering? Large and erratic density variations within the weathered zone can cruel a gravity survey (unless they relate to a near-surface expression of what you are after). Are there unfavourable rock types at shallow depths between you and the potential targets – a magnetic basalt (for aeromagnetics), surficial maghaemite (for ground magnetics), highly resistive silcrete (for IP-resistivity), conductive transported cover (for electromagnetics and IP-resistivity), etc.?

And what about the geological environment itself? Is it benign or malign? Graphitic, carbonaceous and pyritic rock types can be a graveyard for electrical and electromagnetic exploration. Are there rock types that will complicate magnetic or gravity responses, rendering the expected target anomaly just one of a multitude of similar style targets?

Maybe you'll have to do subsidiary surveys to fine tune the interpretation. Perhaps passive seismic to map depth to basement to help discriminate between basement topography effects and genuine in-basement gravity responses, or IP-resistivity surveys to identify which of the potential field anomalies have sulphidic source material.

Then there is the access for the survey itself. Are there environmental issues that limit what you can do in the way of ground preparation and track clearing? It may not be realistic to plan a high power ground electromagnetic survey if access restrictions limit you to hand-carrying everything for kilometres just to get on to site. You may have to use airborne access to the site, or look to using an airborne method.

What about man-made features? Power lines, earthed fences and the like can play havoc with electrical and electromagnetic surveys. Mine sites can be a difficult place to undertake geophysics, although gravity may offer possibilities, but only if it is appropriate to your target. Also, are there flying height restrictions and no-go areas for airborne surveys because of topography, residential areas, power lines, etc.?

Having selected your method, there will be other considerations. Cost and timing are the two most obvious.

Do you have the budget for this? If necessary, can you reasonably compromise survey design parameters to reduce the survey expenditure; does it really have to be the Rolls Royce of geophysical surveys? Perhaps there is enough flexibility with survey timing to opportunistically take advantage of the presence of a survey crew already in the area and share mob-demob costs.

More rarely, you may have the luxury of a potential underspend. Have you compromised too much? Does reducing the risk of missing something warrant an upgrade in survey parameters and an increase in survey expenditure? Are there other concomitant benefits to be had in spending more, such as tenure expenditure requirements? Could you sensibly increase the extent of the survey (access permitting); would interpretation benefit from more extensive coverage? Are there other adjacent areas worth investigating? Can you take advantage of this survey to commission additional work, perhaps undertaking other small surveys which by themselves would be uneconomic?

We once commissioned a helicopter electromagnetic survey with lines spaced closer than that normally considered necessary for 100% coverage. We considered this would give us more confidence to site drill-holes directly from the airborne survey results without the luxury of ground survey confirmation, which would have been difficult in the rugged topography of the survey area. A secondary benefit was that the extra line kilometres required for the closer line spacing took us over the threshold for a lower per line kilometre rate. We got significantly more data for not much more expenditure. Yes, we did spend more on the survey, but we got an arguably more appropriate product. And we did successfully intersect all the targets.

There can be non-technical factors, too. Prevailing attitudes for example. Is there pressure to use a particular technique because it is currently in vogue, or because someone has had past success or even just has some familiarity with it? Conversely, is there an aversion to using a particular technique because of past bad experiences? At one stage there was resistance to the re-introduction of one technique into our geophysical exploration arsenal because of previous issues where the benefits of the method had been oversold.

If your recommendations stack up technically and financially, and it is prudent to do so, back your own judgement! And good luck!

Seismic window

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Nostalgia isn't as good as it used to be

Well, it's six weeks into isolation and working from home and the deadline for submitting an article is rapidly approaching. Fortunately, I received fan mail. That's right, after 20 years I have had two responses from readers so that the total letter count since my first article is now approaching double figures. Neither of these replies were to claim the prize offered in the last issue, which is still available (I could interpret this as the readers' dislike of competitions or red wine but it may indicate a lack of readers.) Here are the letters:

Hi Mick,

Just read your Preview *article. So true, but you forgot to mention that although we had lots of TA, secretarial and drafting support, we had to do the complete range of actions involved in the seismic workflow from instrument testing, supervising micro arrays in the field for noise analysis to decide on the geophone array, acquisition QC (both offshore and onshore), static modelling, processing QC (including your own velocity picking) before we finally got to interpretation. These days all I do is decide on the area of interest, sit in on the processing meetings, and interpret the final data before, as you say, make copious PowerPoint displays and presentations.*

Finally, I agree with your final assessment of FWI (and I would add tomography) along with anisotropic input has changed the game significantly.

With all this it never ceases to surprise me how robust the method is.

Craig Dempsey
Principal Geologist
BHP Petroleum

Hi Mick,

Enjoyed your reminiscing about 40 years ago in the latest Preview.

I'm not after the bottle of red but thought you'd be interested in the list of companies involved in the commemorative wine and beer that was issued celebrating the liquids project in the Cooper Basin and first oil from Harriet, respectively.

The wine bottle is empty (it leaked through the cork and became 'shitty') but the beer can still holds the original beer!

Enjoy!

Cheers

John Hughes

Geophysical Operations Adviser

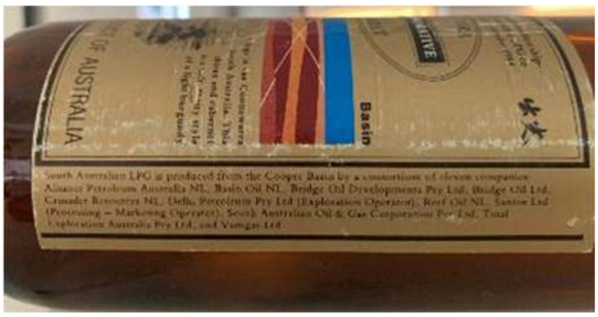
John R Hughes Geophysical Pty Ltd

The concept of commemorative beverages must seem strange in these days of alcohol free work places.

I'm not a fan of off wine or 35 year old beer, but the labels are interesting as they show the huge number of companies involved in the industry last century. I think most of them were absorbed by Santos, the most recent being Quadrant, a direct descendent of Bond Corporation – makers of the commemorative beer.

Craig brings up an interesting point. The seismic method is robust and it is remarkable how well it works despite all the assumptions and approximations. Sure, the end product is better if we are more accurate in the assumptions we use, but it is incredible how a seismic source that can be barely felt when standing 20 m away can provide details about the geology 4 km or more below the earth's surface. Perhaps this will be discussed in the next issue.

Note: Photographs supplied by John Hughes



Data trends

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Splitting strings over ASEG GDF2 files

In the column I wrote for the February issue of *Preview* (**204**), I identified problems in ASEG GDF2 datasets that confused my attempt at a parser. The standard is quite freeform and customisable, which results in a complex beast for all those trying to capture it. I have communicated with experts and re-read David Pratt's 2003 publication, available from the Technical Standards page of the ASEG website, (https://www.aseg.org.au/technical/aseg-technical-standards). Light was shed and some ambiguities were set straight, while others became existential.

The definition file

This first file created for a GDF2 dataset is the definition file (.dfn) which makes the data both computer and human readable. It provides the field information for data import that make GDF2 more efficient to read than a single file such as xyz or csv. It also cleverly provides enough information to treat the text data file (.dat) as a binary file.

String splits and regular expressions

Let's start with the generic syntax of each part of a .dfn line and a typical line.

DEFN [continuation] ST=RECD,RT=[name]; {<field definition>}; *{<field definition>}; etc*

DEFN 5 ST=RECORD,RT=DATA;FIDUCIAL:f 12.1:NULL=-999999.0,NAME=fiducial

Lines should split on the semi colons (;) to isolate the record type and each defined field. Then split on colons (:) and commas (,) to isolate values inside a field. There can be many fields on one line, but this is not recommended since one of the points of GDF2 is to be human readable. The above example would clearly become unreadable fast.

Misuse of the punctuation marks creates havoc. Colons associate with the bare bones data type, and commas with the optional parameters. The hierarchy of splitting relies on this.

No "DATA" in the data file

It is common for each line in the data file to start with "DATA". Or not, and the difference is in the record type (RT). The record type setting directs which file the line refers to.

DEFN ST=RECORD,RT=**COMM**;RT:A4

Each line in the description file (.des) will start with a four character record (A4), "COMM".

DEFN ST=RECORD,RT=**DATA**;RT:A4

Each line in the data file with start with the four character record "DATA". But what about the mysterious null record type?

DEFN ST=RECORD,RT=;RT:A4

As the bare minimum files in a GDF2 dataset are the .dfn and .dat, this defaults to RT=DATA.

Is this all worth worrying about? A more mechanical outlook was given as since this character field may or may not exist depending on the supplier, and has no impact on the data, some parser writers have learnt to detect but drop it. No harm is done. I hope this helps the other programmers trying to tame the GDF2.

Webwaves

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Reboot your privacy

The week of 4 - 10 May was Privacy Awareness Week 2020. As part of the week, the OAIC (Office of the Australian Information Commissioner) was running a campaign for people to 'Reboot your privacy and protect your personal information online'. This campaign consists of 10 topics to investigate to improve privacy. Here we look at the first 5 - for the complete list of topics and further information on privacy check out the OAIC website (https://oaic.gov.au/privacy).

1. Protect your accounts

Featuring in previous Webwaves columns including *Preview* **195** (https://www.tandfonline.com/doi/abs/10.1071/PVv2018n195p42) and *Preview* **199** (https://www.tandfonline.com/doi/full/10.1080/14432471.2019.1597401), protecting your accounts includes using multi-factor authentication, strong and unique passwords, and using reputable password managers to store credentials. Additionally, tools such as Have I Been Pwned (https://haveibeenpwned.com) allow users to check if they have been implicated in a data breach.

2. Detox your digital profile

While social media is a useful way to stay in touch, especially if one is in lockdown due to COVID-19, the privacy controls on your social media accounts should be checked. Limiting apps that have access to your social media accounts, and increasing privacy settings to control who can see posts, contact details and profiles is worth considering. Without appropriate and strict privacy controls in place, your content may be more visible than intended.

3. Be smart about connected devices

Smart devices are changing our lives. Have you stopped to think who owns the data and where it is going? Are some devices listening into your conversations all day? Do the manufacturers share your information with third parties? All of these points are worth considering for any smart devices in use. Online tools including *privacynotincluded from Mozilla https://foundation.mozilla.org/en/privacynotincluded/ provide information on how secure a device is and what is happening to your data.

4. Tracking your location

Tracking your location is multifaceted. There is your physical location that smartphones and apps may track. Have a look and think about which apps are able to track your location. There is also your web browser and tracking of your online location, or presence. Using a search engine like DuckDuckGo (https://duckduckgo.com) and clearing Cookies can help to prevent tracking of your online presence / usage.

5. Where's your data going?

Websites regularly use Cookies and other online identifiers to improve user experience. These can also be used to track movements across the web. Browsing the internet while logged into various platforms and social media sites can allow these companies to track a users activity across the web. It is recommended that users regularly clear caches/delete Cookies and do not browse the internet or shop online while logged into Google or social media accounts.

COVIDsafe tracking app

In Australia, the government is currently recommending that residents download the COVIDsafe app to track the COVID-19 pandemic and help to warn people if they have potentially become infected. This is how the COVIDsafe app works:

- Users download the app and enter their name, phone number and postcode. A unique, encrypted reference code is then created for each user.
- Users keep Bluetooth enabled on their phone and the COVIDsafe app running.
- When the user comes in close contact with another device running the COVIDsafe app, a note of the date, time, distance and duration of contact is logged. The current location is not logged.
- Logs of interactions are deleted on a 21-day rolling cycle (based on the incubation period of COVID-19).
- Should someone test positive, the logs on their device are decrypted and anyone they have been in close proximity to is informed that they may have been exposed.

Access to the information on a users' device is restricted to protect people's privacy. State and Territory health officials are permitted to access the information for contact tracing only. The COVIDsafe Administrator is allowed access only to ensure proper functioning of the app.

AEGC 2021 Postponement Notice

After careful consideration of the impacts related to the COVID-19 pandemic, we have made the difficult decision to postpone the 3rd Australasian Exploration Geoscience Conference.

AEGC 2021 will now be held on 15 – 20 September 2021 at the Brisbane Convention and Exhibition Centre.

AEGC 2021 is committed to delivering a world class forum to showcase the latest technical advances and applications in exploration across the minerals, petroleum and near-surface disciplines and we are eager to discuss sponsorship levels, exhibition options, or customised packages to suit your organisation's aspirations.

The Organising Committee of AEGC 2021 thank you for your understanding and support upon the need to take these steps and we very positively look forward to seeing you in Brisbane in September 2021 for this exciting event.

For any queries, please contact the AEGC 2021 Conference Managers via aegc@arinex.com.au.

Yours sincerely,
Rachel Kieft (PESA co-chair)
Eric Battig (ASEG co-chair)

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Magnetics in the mountains: An approximation for the magnetic response from topography

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Anyone who has spent time looking at high resolution magnetic data from modern volcanic terrains will likely have seen topographically induced magnetic anomalies. These are anomalies, not from a change in the magnetic properties of the ground but from the topography alone. This is illustrated in Figure 1, which shows two north-south sections through a mountainous area in Papua New Guinea (PNG).

These models were computed using UBC's MAGFOR3D. The modelling assumed an even susceptibility of 0.01 SI for the ground, an inclination of -28°, declination of 5.3° and field strength of 41,350 nT. The mesh size used was 100 x 100 x 50 m, which under-samples the topography. However, at the time this exercise was undertaken, in 2013, the best DEM available was the 90 m SRTM so the compromise was felt justified. Our current practice is to use the 30 m SRTM and 30 x 30 x 15 m voxels, unless a better DEM is available.

The field was computed at points in the centre of each voxel. The high values in air in the north (red) and low in ground in the south (blue) of the sections are edge effects due to not padding the model sufficiently in depth. This is in spite of the mesh extending 8500 m from the top layer at 3500 m. Padding extended for 2.5 km at each end, beyond the area displayed in the sections. The 50 m vertical mesh discretisation of the topographic surface introduced some noise to the profile, but, for our purpose, this can be ignored. For those familiar with the highlands of PNG, the range of magnetic values arising from the topography is comparable with observed magnetic values. Indeed, for this particular area, the measured magnetic field and computed field from homogeneous ground with topography looked very similar, even down to their amplitudes.

The importance of considering the topography in the interpretation is reinforced in Figure 2, which compares observed magnetic data against forward modelled topography from another project. The forward modelling was again done using UBC's MAGFOR3D.

The images have purposely not been interpolated to blur the pixel boundaries so that the resolution of the data can be more easily compared. The observed data were collected on 100 m spaced flight lines by helicopter with a 30 m terrain clearance (~60 m AGL in this area) and gridded at 20 m cell size. The forward modelled topography was computed on a 30 m grid with an observation height 60 m above the ground surface with a perfect drape (I=-30.7°, D=-0.1°, F=44300nT, k=0.01 SI). One could be forgiven for interpreting the observed data as dipolar anomalies from bodies with some depth extent. However, the forward model suggests that the same response could be caused by a flat sheet with steep sides superimposed on a flat surface. The correlation between the two is further illustrated in Figure 3, which shows a comparison between the two data sets along a NS trending profile. The forward modelled topographic response has been re-scaled by a factor of 13 times to enable it to share the Y axis with the observed data. The SRTM DEM topography is shown in blue for reference.

The shape and amplitude match between the two magnetic profiles is remarkable. In comparing the two magnetic profiles several things need to be remembered. Firstly the forward model assumes a perfect drape while the observed data were acquired with the pilot's best effort drape. Secondly, the SRTM

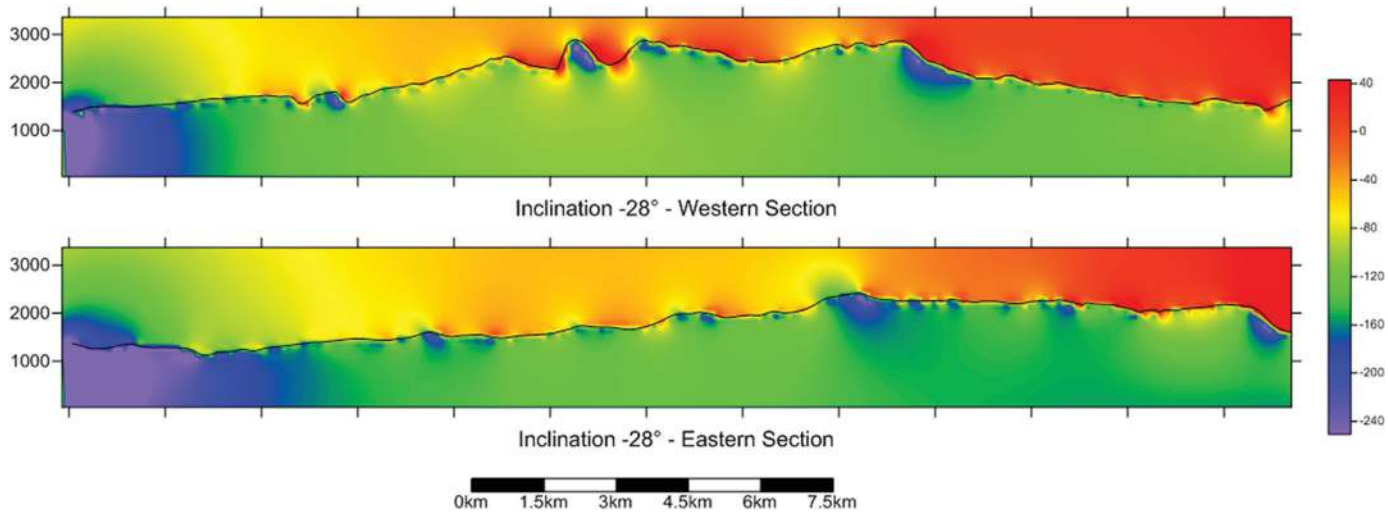

Figure 1. *Computed magnetic field on two south to north (left to right) sections through homogeneous ground. k=0.01 SI, I=-28 deg V:H=1.*

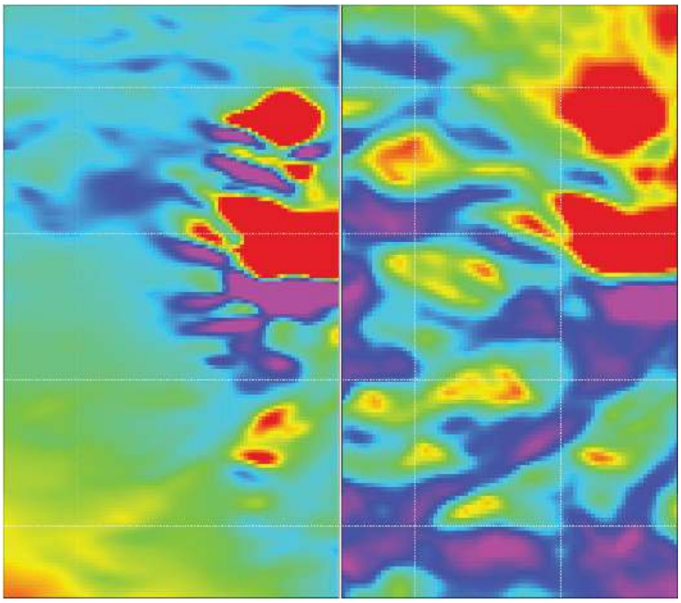

Figure 2. *Comparison of observed magnetic data (left) and forward modelled topography (right). Images use a linear colour stretch and the graticule has 1 km sides. The anomalies being discussed are truncated as they lie at the edge of the heliborne survey.*

DEM typically does a poor job of mapping the true shape of valleys, particularly where they are steep sided and finally, this is a profile through a three dimensional model so there will be contributions from off-profile sources.

Re-scaling the forward model by a factor of 13 implies a ground susceptibility of 0.13 SI, which is within the range of values we could expect for a recent andesite flow in this area.

As a result of this lesson, we always run a forward model of topography before interpreting new survey data in areas of high relief. Typically the run time for this might be of the order of a week to a month, which does not impact on overall production if the modelling starts at the same time as the survey design. However, a recent survey of over 45 000 line kms in Indonesia caused a rethink of this practice, as it was clear that it would take between 6 and 8 months to run the forward models, which would have to be run in panels because of the way the code uses memory.

Integral equation based methods such as used by Potent were of no assistance, and although Parker had published a Fourier based method to compute the magnetic response over topography, it required a plane observation surface, not a draped one. While that could have been extended to compute multiple plane surfaces and so build a draped surface

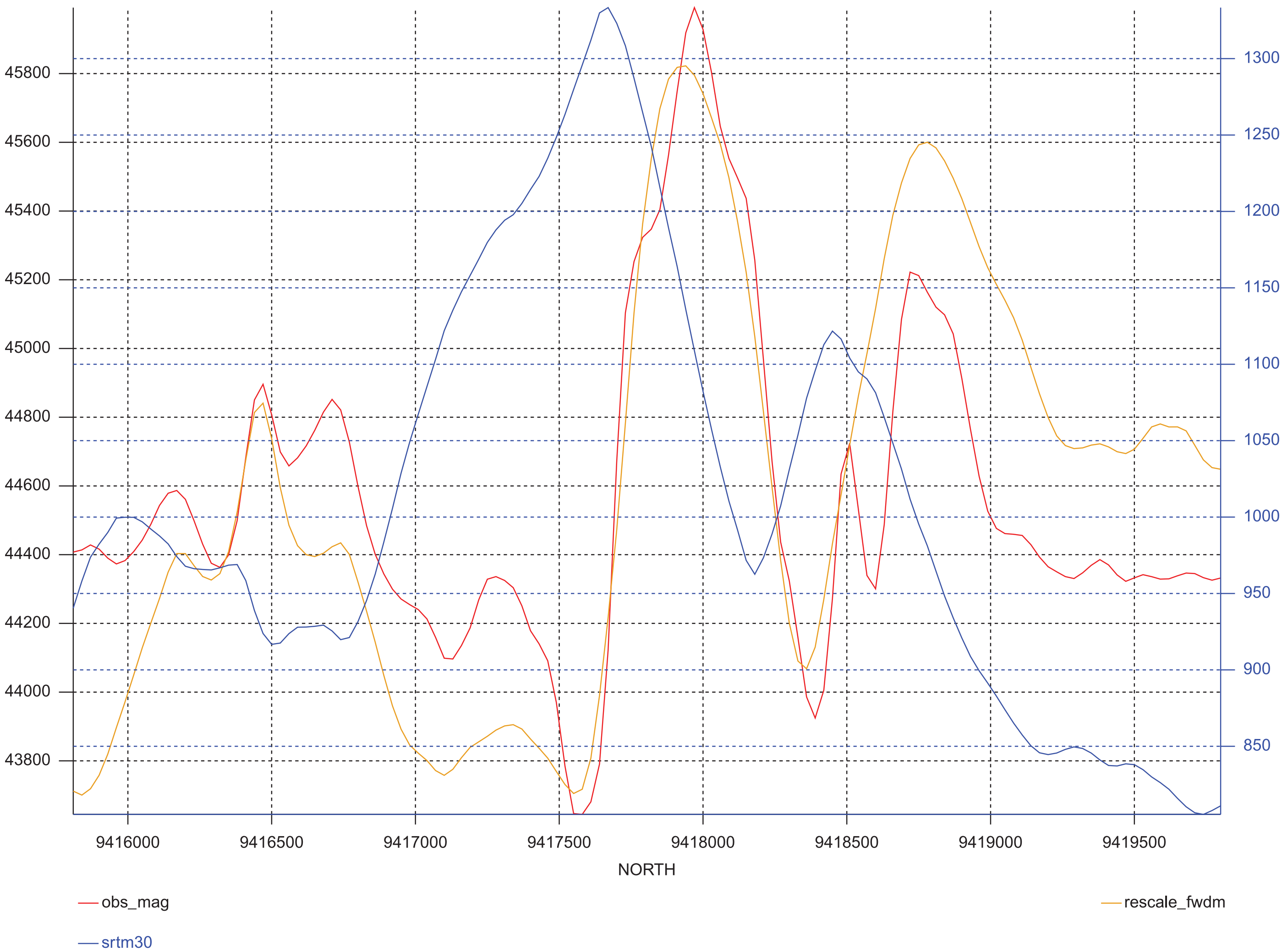

Figure 3. *Comparison of the two data sets in Figure 2 along a NS profile. Observed data (red) and re-scaled forward modelled topography response (gold), both on the left axis in nT, and SRTM topography (blue). Right axis in metres and X axis in metres*

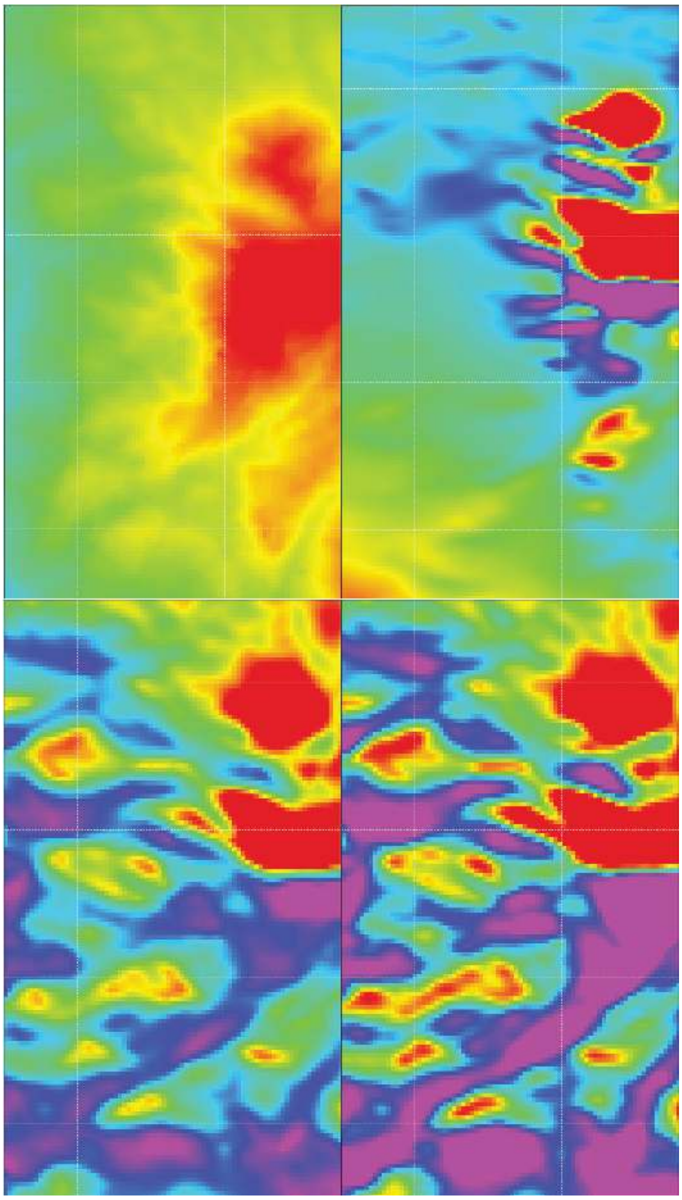

Figure 4. *Images from the study area of Figure 2 showing; top left, topography from SRTM30, top right , observed magnetic field, bottom left, calculated magnetic field using MAGFOR3D, bottom right, upward continued, pseudomag transformed topography. All images use a linear colour scale.*

from successive planes, it would fail once the plane hit the highest point in the survey as the observation plane had to be above the ground. It seemed that the only available empirical approach was with the finite element codes, which were going to take time. We could send the problem out to a bureau to run on a series of clusters, but not many clients are prepared to pay for this type of modelling, particularly at bureau rates.

One day, when looking at the sections in Figure 1 and others like them, it occurred to me that if I thought of the topographic surface as a gravity profile I could generate the modelled magnetic field by rotating the topography to an equivalent magnetic field using the reverse of Baranov's pseudo-gravity transform – the pseudo-magnetic transform.

Returning to the data set from Figure 2, I applied a pseudomag transform to the topography and upward continued it by 60 m to match the magnetic data and model. Figure 4 shows a comparison of the topography, observed magnetic data, forward modelled response from a uniform earth and the upward continued pseudomag transformed topography. Clearly the idea had merit as the pseudomag transformed topography image is very similar to the forwarded modelled response from a homogeneous earth with topography.

If we re-scale the upward continued, pseudomag transformed topography to the same range as the observed data and re-plot Figure 3 (see Figure 5) we see an excellent match, further supporting the potential of this as a fast approximation of the topographic response.

The relationship between the size of the topographic anomaly and its magnetic response is not always intuitive, and quite small hills or shoulders can result in significant magnetic anomalies.

As it appears that the pseudomag transform has been deprecated or is missing in at least one of the common commercial processing packages, it is worth pausing for a moment to describe it. The equation for the pseudomag transform is derived and given in Blakely (1995) (p347, Eq 12.47 and 12.48) and in full space form, with all the definitions on the same page in Li & Oldenburg (1998) (their Eq 1 and 2). For those who prefer to skip the technical part I have included an extract of the relevant parts from my source code in Appendix 1. There is also an older school F77 version in the excellent USGS Potential Field Software package contained in USGS Open-File Report 97-725. In their 1998 paper Li and Oldenburg describe a logical process to derive the conversion constant between gravity data and magnetic data. Knowing the conversion constant is only relevant in transforming the pseudomag units back to gravity units, as you would do after inverting a pseudomag gravity dataset to recover density from the pseudo-susceptibility. Prior to the Li and Oldenburg paper being published, I also thought that the magnetic inversion code might be used to invert gravity data, and so I wrote the pseudomag code. The choice of parameters for the conversion constant, while different to Li and Oldenburg, to my reckoning, followed an equally logical process. However, as the constant is applied to both the real and imaginary parts of the Fourier transform, it just becomes a constant offset in the space domain. When the transform is applied to topographic data we are talking about transforming meters to nanoTeslas. The physical relationship between the two escapes me, so until someone can link the two the value of the constant becomes academic.

Li and Oldenburg also discuss problems with noise generated by the pseudomag transform, which as you can see from the code snip combines a rotation with a power term which behaves in a similar way to a second vertical derivative. This noise is partially dealt with by the upward continuation to flying height, but can be almost completely removed with a Lanczos or Hanning filter while doing the FFT. I've included the Lanczos and Hanning code in Appendix 1 for anyone starting from scratch.

Moving back to the large survey area in Indonesia. Having established that the pseudomag transform produced a similar result to the forward model, I generated the transform for use in the interpretation. It took less than a minute to run the process on a 18034 x 7284 SRTM grid covering a much larger area than needed for the survey. As a fall back and final check, I also generated a forward model that, because of the size of the area, had to be broken into 5 blocks. The total mesh size was 5624 x 1701 x 144 with observation points at the centre of each voxel column. This was started

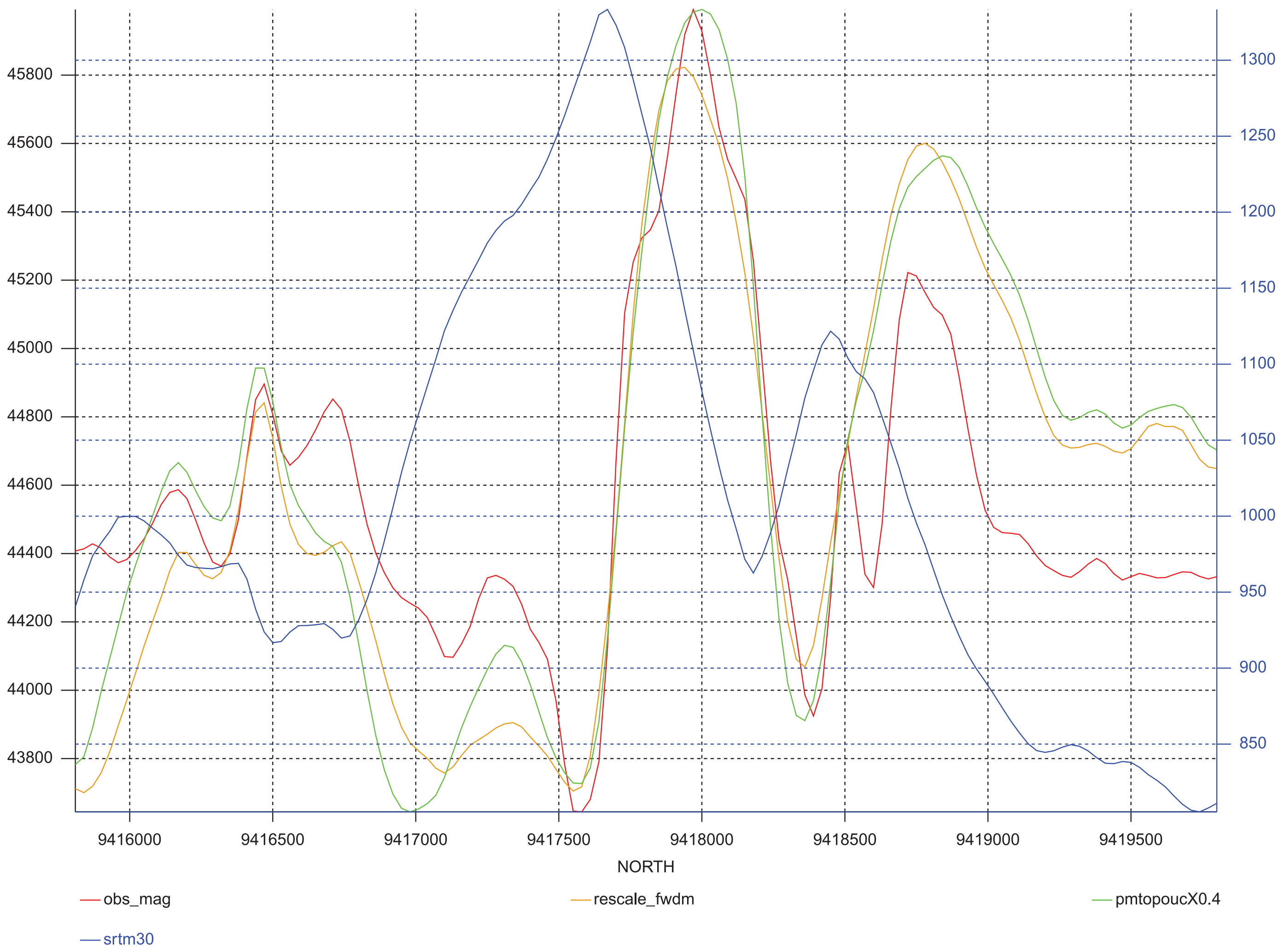

Figure 5. *North-south profile through the data sets in Figure 4: Left hand axis, observed magnetic data (red), forward modelled data (gold), upward continued pseudomag topography (green). Right hand axis; SRTM30 (blue).*

before flying commenced, and took eight months to run on a dual hexacore with 192 GB of RAM. It finished just as the final interpretation was being written up. Both processes used a 30 m x 30 m horizontal pixel/voxel size. The forward modelling used 15 m thick voxels down to the lowest point in the topography, then increased the voxel thickness by a factor of 1.1 with depth, to extend the mesh to 3.5 km below the lowest point in the topography. As I did not have accurate bathymetry, I allowed the model to assume that the sea surface was the land surface. Both assume a constant drape of 60 m above ground, which tallied with the flying height after tree height was added to the measured radar altimeter. For the rotated topography this was achieved by upward continuing the data by 60 m.

Figure 6 shows a comparison between the MAGFOR3D generated forward model of the topography for the survey block and a pseudomag transform of the 30 m SRTM. The panelling and edge effects in the south are evident in the modelled data but otherwise the two data sets correlate very well. Unfortunately I don't have permission to show you the real magnetic data here, but I can say that having the pseudomag transformed topography assisted greatly in the interpretation of the magnetic data.

In support of the correlation between the forward modelled data and the pseudomag transformed topography, Figure 7 shows a comparison between the two data sets along a NS trending profile through the data. The pseudomag transformed topography has been multiplied by 0.032 so that it can share an axis with the forward modelled response and allow the SRTM topography profile to be included on the right hand axis. The differences between the two "magnetic" data sets are of the order of a few nanoTeslas, which is well within the experimental error.

Because of the edge and panelling effects suffered by the forward model it could easily be argued that the transformed topography was a better data set to work with – at least from a subjective interpretation perspective. Because of the time taken to run the forward model in this case, it was the only data set to work with.

The re-scaling factor of 0.032 for the pseudomag transformed data was derived from a scatter plot of the two data sets – see Figure 8.

For the majority of mainland Australia, topography, at the scale where it becomes an issue for aeromagnetic interpretation, is largely absent. This is not the case for Tasmania, which has managed to retain some hills, particularly on the west coast. Figure 9 shows a comparison of elevation, from the SRTM 30, with observed magnetic data for an area just to the east of Waratah. The elevation range here is 900 m, while the range

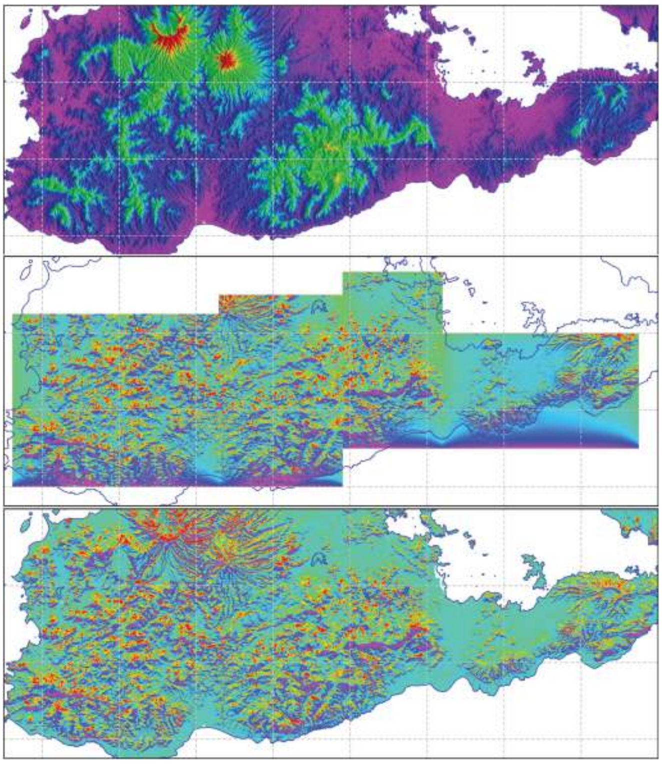

Figure 6. *Sun shaded image of topography that has a range of 1800 m (top), and comparison of the magnetic field computed from a homogeneous earth with topography using MAGFOR3D (middle), and upward continued pseudomag transformed topography (bottom). All images use a linear colour stretch. Graticule squares depicted are a 20 x 20 km grid.*

of magnetic values is just under 5000nT. The magnetic survey was flown with a terrain clearance of 80 m. Unfortunately the line spacing and flying height are not as tight as the previous Indonesian examples.

The stippled green area in the topographic image corresponds with Tertiary basalt, while most of the high points are Cambo-Ordovician sandstones. Points of interest are Mt Pearse, the arcuate ridge in the south west, and Valentines Peak and Companion Hill in the north. Mt Cripps is the V shaped edge to the plateau in the south east and the river cutting the plateau in the north is the Hellyer River. The infamous hairpin decent into the Hellyer Gorge is just off the image to the north east. Just to the south west of Mt Pearse the Hatfield and Coldstream rivers dig into the basalt sheet to create sharp breakaways. Each of those points of interest is associated with a corresponding pattern match in the magnetic data, and before drawing lines on an interpretation it would pay to understand what has a geological source and what is just topography.

Figure 10 shows the forward modelled magnetic data, assuming a constant 0.01SI susceptibility and the upward continued, pseudomag filtered topography. At the time of the survey, the magnetic field in this area had a declination of 13° and inclination of -72°. A field strength of 65000 nT was used for the forward model.

As we might expect from the previous example, the two data sets shape match very well. The forward modelled data shows fewer edge effects than the Indonesian example, perhaps because the core of the mesh is a little further from the coast in this example.

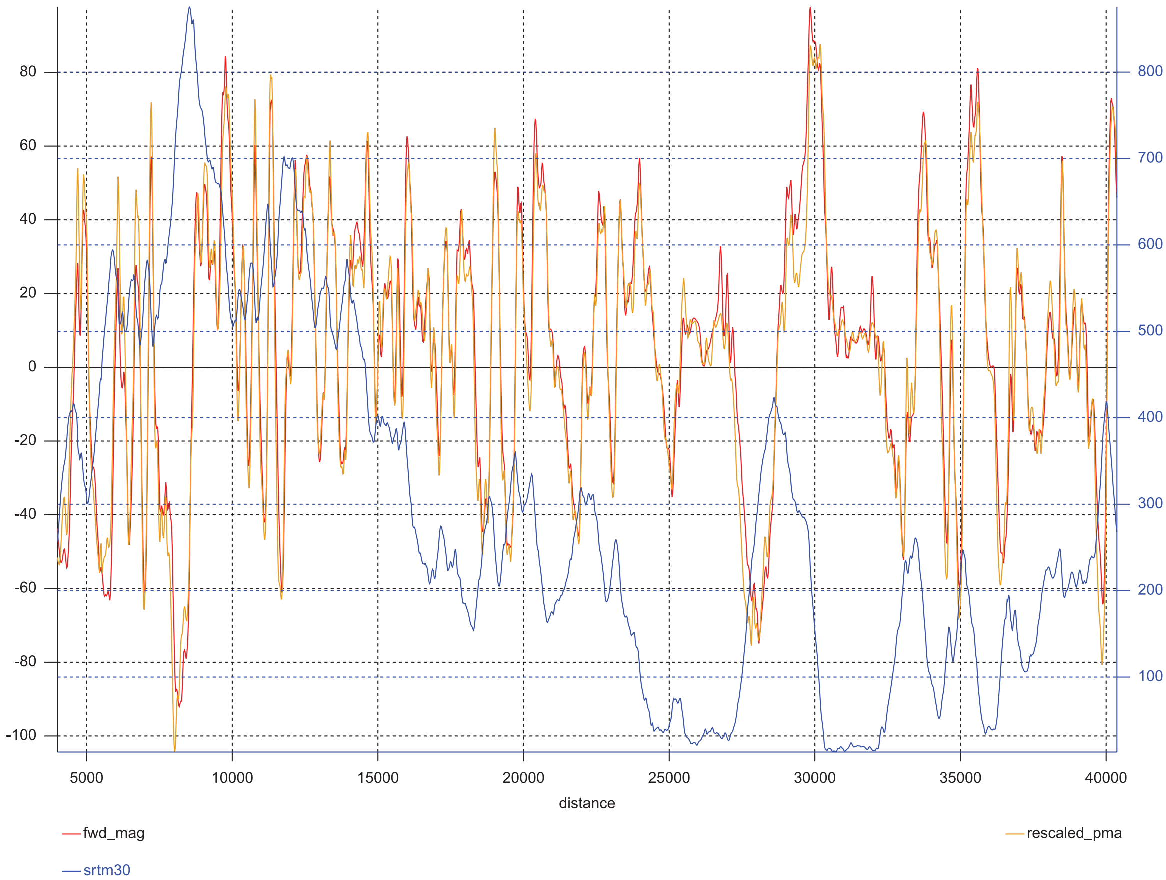

Figure 7. *Comparison of forward modelled topography using MAGFOR3D (red and left axis in nT) with re-scaled pseudomag topography upward continued (gold and left axis) and SRTM DEM (blue and right axis).*

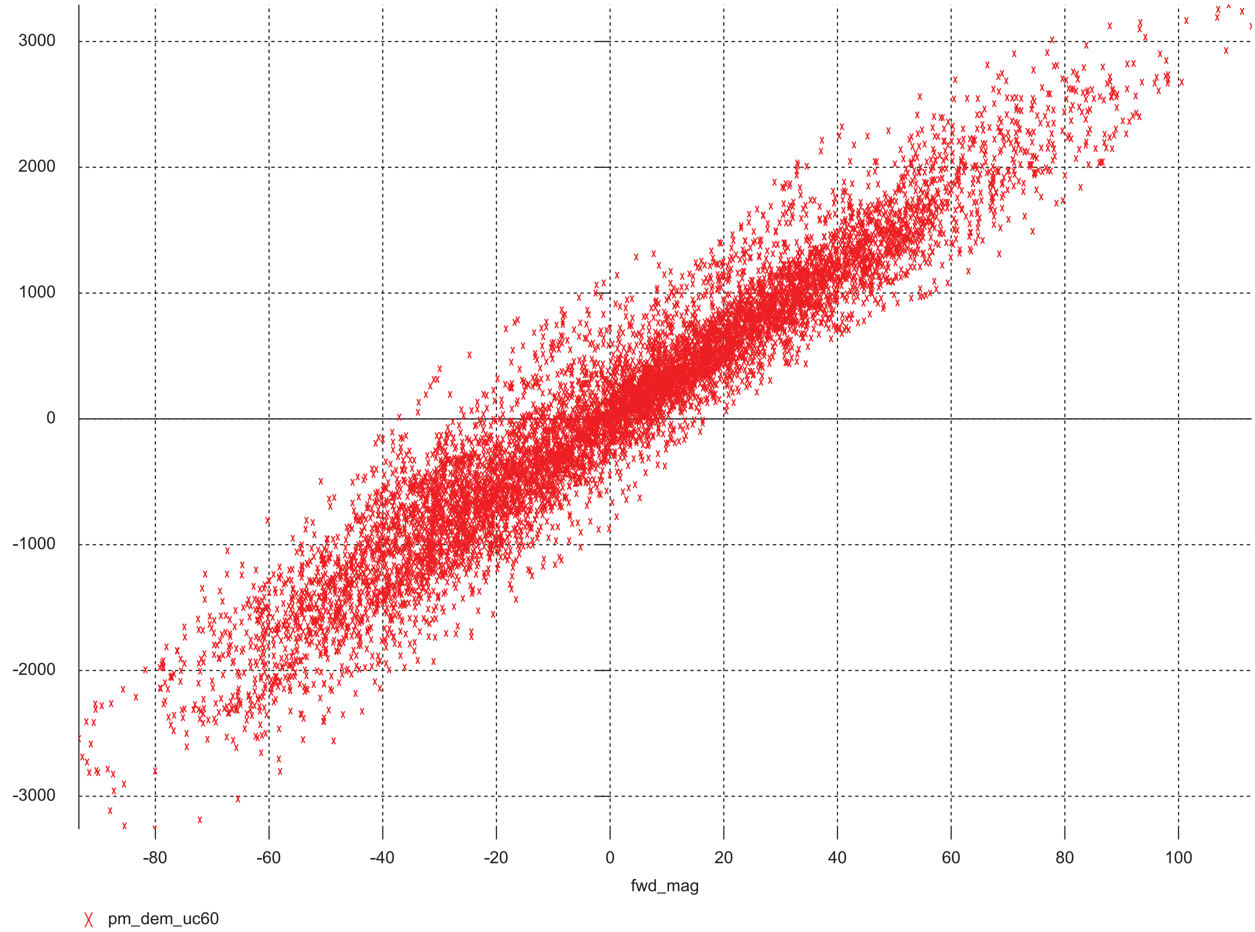

Figure 8. *Scatter plot of upward continued pseudomag transformed topography (Y) against forward mag model magnetic field in nT (X) for parts of the model not obviously effected by edge effects.*

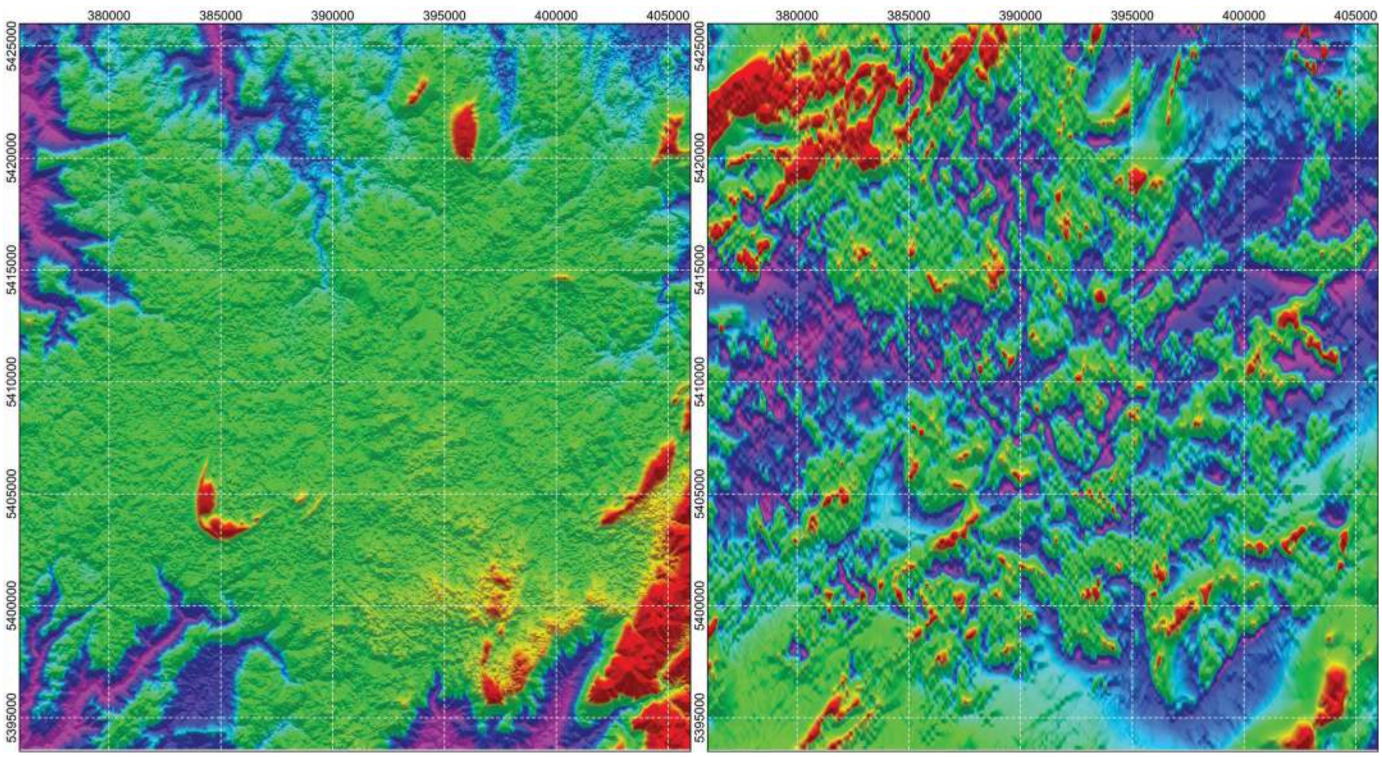

Figure 9. *Comparison of topography (left) with observed magnetic data (right). Both images use a linear colour stretch and are illuminated from the north. Magnetic data courtesy of MRT.*

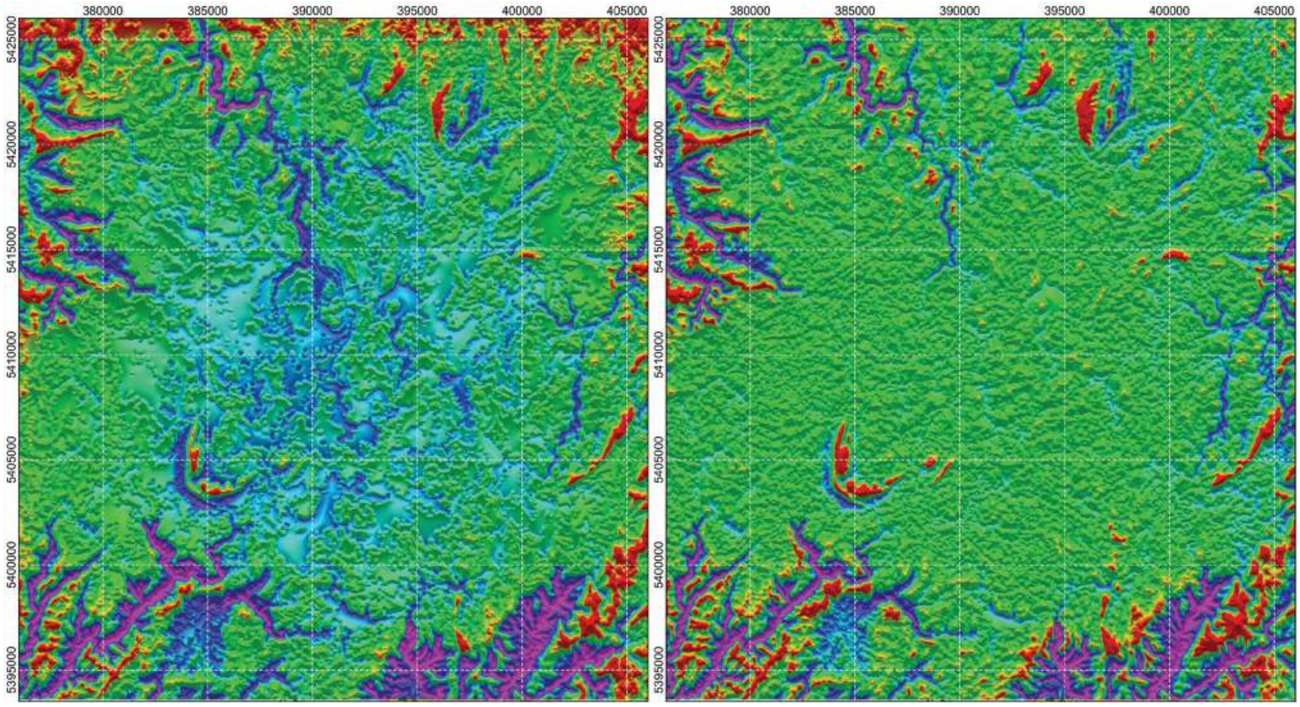

Figure 10. *Comparison between forward modelled topographic response with MAGFOR3D (left) and upward continued, pseudomag transformed topography (right). Both images have a linear colour stretch and are illuminated from the north.*

Figure 11. *East-west profile along flight line 11381 over the Hellyer River. Left hand axis; Observed magnetic data (red), forward modelled topographic response (gold) and upward continued pseudomag transformed topography response (green). Right hand axis; SRTM30 (blue).*

The modelled response over the mountains and peaks does not look like the observed response, which is both encouraging and not unexpected, given that they are sandstone. The gorges, however, show on both the observed magnetics and the modelled or transformed topography, so one would have to be careful in ascribing the magnetic patterns they create to changes in geology. This is illustrated in Figure 11 which shows an east west profile along flight line 11381 over the Hellyer River. Because of the coarse line spacing used for the survey, the observed data shown in Figure 11 is the line data, not the gridded magnetic data, while the other profiles have been extracted from grids.

The forward modelled response was multiplied by 4.09 to scale it to a similar range as the observed data, implying a susceptibility of 0.04 SI. This compares with the measured range of susceptibilities for the Tertiary basalt here of 0.0078 to 0.0215 SI (Duffett pers comm). However, the samples also showed a relatively high Königsberger ratio of up to 2 in a direction that was dominantly normal. A susceptibility of 0.04 SI is therefore not out of the question, although it seems more likely that the magnetic response here is a combination of changes in rock susceptibility and topography, which is probably a more general case.

The upward continued, pseudomag transformed topography was re-scaled to the same range as the observed data using a multiplier of 0.2. The modelled data sets contain a higher frequency content than the observed data, indicating that I have modelled the drape height too low or perhaps too exactly for this survey. In this case, the difference between flying height and model height might be explained by weathering, which will have the dual effect of increasing the apparent flying height and low pass filtering the topography. Nevertheless, the correlation between the observed, modelled and transformed data is impressive, even down to the small anomalies either side of the river valley. There are also correlations away from the river, which while not obvious in the images shown in Figure 10, would have a big impact on any interpretation of these data.

There may be a simple relationship between the value of pseudomag transformed topography and modelled response that will be dependent on the constant used in the FFT to compute the pseudomag transform, the susceptibility and field strength used in the forward model, and perhaps the field direction used in both. However, I'll leave that for others to solve. For any given area, the transformed data could be scaled based on some smaller blocks of forward modelled data or even on the observed data itself although that would not give you confidence that the susceptibility required to generate the anomaly was realistic for the environment being studied. While this transform does not replace more rigorous modelling, it does give the interpreter a very quick way of knowing whether or not topography is likely to be impacting on their data, and for very large areas may be the only practical way to evaluate the topographic response.

Hopefully this simple transform will improve your next magnetic interpretation in areas of strong relief.

References

Blakely, R, J. 1995 *Potential Theory in Gravity and Magnetic Applications*. Cambridge University Press.

Li, Y. and Oldenburg, D.W. 1988. 3-D inversion of gravity data. *Geophysics*, 63 (1), pp 109 – 119.

Appendix 1

```
SUBROUTINE INVF01
!
!-------------------------------------------------------------------------------------
!
! PERFORM THE SPECIFIED OPERATIONS
! - code originally written for a grid stored in row, column order. Converted to Surfer 7 column, row I/O but
! variable names not changed
! - note that X and Y are reversed relative to those given in Blakely - because of the way the fft is stored
!-------------------------------------------------------------------------------------
!
REAL, PARAMETER :: PI = 3.14159265
REAL, PARAMETER :: TWOPI = 2.0 * PI
REAL, PARAMETER :: DEGRA = PI/180.0
REAL :: DELWX,DELWY
REAL :: XLFAC,YLFAC
REAL :: AI,AD
REAL :: SINI,COSI,SIND,COSD
REAL :: WY,WX,WYSQ,WYSD,WXSQ,WXCD,YLANC,YARG,YHANN,WNUM
REAL :: XLANC,XARG,RLANC,XHANN,RHANN
REAL :: RPOLER,RPOLEI
REAL, PARAMETER :: CMTOG=53.0E-4 ! THIS IS A BIT ARBITRARY - EQUATION IS
   ! (G*dDEN)/(2PI*dMAG)
   ! WHERE G IS BIG g, dDEN= DENSITY CONTRAST, dMAG=MAG CONTRAST IN nT
   ! TO CONVERT PSEUDO SUSCEPTIBILITY INVERSION TO PSEUDO DENSITY
   ! STARTING WITH A BOUGUER GRAVITY GRID IN um/s⍰2, PSEUDOMAG AND INVERT USING A FIELD
   ! STRENGTH OF 60000 nT
   ! THEN MULTIPLY PSEUDO SUSCEPTIBILITY BY 188 TO GET DENSITY CONTRAST, ADD TO
   ! BOUGUER DENSITY TO GET PSEUDO DENSITY. FLIP THE PSUEDOMAG GRID AND INVERT TO GET
```

```
  ! THE NEGATIVE CONTRASTS. JAM KARAT
COMPLEX :: CPOLE
COMPLEX(SELECTED_REAL_KIND(15)) :: CFAC
COMPLEX(SELECTED_REAL_KIND(15)), ALLOCATABLE, DIMENSION(:) :: C1
INTEGER :: NXP, NYP
INTEGER :: NYQX,NYQY
INTEGER :: IFLAG,ICOL,IY,IROW,IX

! VALUES FOR LOP(I)
! 1 = LANCOZ
! 2 = HANNING
! 3 = REDUCTION TO THE POLE
! 4 = WITH LOW LATITUDE FILTER
! 5 = DIRECTIONAL FILTER
! 6 = UPWARD/DOWNWARD CONTINUATION
! 7 = VERTICAL DERIVATIVE/INTEGRAL
! 8 = BAND PASS FILTER
! 9 = NOTCH FILTER
! 10 = PSEUDO-GRAVITY TRANSFORM
! 11 = PSEUDO-MAGNETIC TRANSFORM
! 12 = Horizontal X derivative
! 13 = Horizontal Y derivative
! 14 = Horizontal slope
! 15 = Hilbert Transform
! 16 = REDUCTION TO THE EQUATOR
! set up FT parameters

! OPEN THE GRID CONTAINING THE FOURIER COEFFICIENTS
! ----> YOUR CODE
NXP = NYF          ! NUMBER OF ROWS IN GRID – GRID ARRAY STORED BY COLUMNS THEN ROWS
NYP = NXF/2        ! NUMBER OF COMPLEX ELEMENTS IN A ROW OF THE GRID
!ALLOCATE MEMORY
ALLOCATE(C1(NYP),STAT=IASTAT)
IF (IASTAT.NE.0) THEN
  IDUM=(2*NYP)*4
  WRITE (OUTMESS,'("PROBLEM ALLOCATING ",I15," BYTES OF MEMORY TO COMPLEX &
  &ARRAY")')IDUM
  CALL WERRORBOX(OUTMESS,OUTSUB)
END IF
!
! CHECK THAT IT IS A FREQUENCY DOMAIN GRID - 2nd VALUE IN FIRST COLUMN IS ALWAYS
! ZERO !!!!!
! READ A ROW FROM THE GRID INTO C1
! ----> YOUR CODE
IF (ABS(AIMAG(C1(1))) > EPSILON(AIMAG(C1(1)))) THEN
  WRITE(OUTMESS,'(A,G15.7)')TRIM(FILEFREQ)//' DOES NOT LOOK LIKE A FREQUENCY DOMAIN &
  & GRID. CHECK YOUR INPUTS DC IMAGINARY IS ',AIMAG(C1(1))
  CALL WERRORBOX(OUTMESS,OUTSUB)
END IF
NYQX = NXP/2 + 1
NYQY = NYP/2 + 1
DELWX = TWOPI/NXP
DELWY = TWOPI/NYP
XLFAC = PI/ NYQX
YLFAC = PI/ NYQY
!
! set operation constants
AI=0.0
AD=0.0
IF (LOP(10)) THEN
  AI = PINCL * DEGRA
  AD = (-PDECL+90.0) * DEGRA
ELSE IF (LOP(11)) THEN
  AI=PMINCL*DEGRA
  AD=(-PMDECL+90.0) * DEGRA
END IF
SINI = SIN(AI)
```

```
COSI = COS(AI)
SIND = SIN(AD)
COSD = COS(AD)
COSA = COS(AZIMR)
SINA = SIN(AZIMR)
! initialize operation factors
!
IFLAG = 1
CFAC = CMPLX(1.0_8,0.0_8,8)
!
! process each ROW
DO IROW = 1,NYF
  MODE=1
  CALL GRDROW(LUHFREQ,MODE,NXF,IROW,ITYPEF,C1)
  IF(MOD(IROW,50) .EQ. 1) THEN
    CALL GSTATUS(IROW,NYF)
  ENDIF
  ! set operation factors for this ROW
  IX = IROW - 1
  IF (IROW > NYQX) IX = IX - NXP
  WX = IX * DELWX
  WXSQ = WX * WX
  WXCD = WX * COSD
  XLANC = 1.0
  XARG = IX * XLFAC
  IF (XARG .NE. 0.0) XLANC = SIN(XARG) / XARG
  XHANN = 0.5 * (1.0 + COS(WX))!
  ! process each COLUMN
  DO ICOL = 1,NYP
  !
    ! branch if first COLUMN OF FIRST ROW - DC component
    IF (IFLAG.EQ.1) THEN
      IFLAG = 2
    ELSE
    !
      ! set operation factors for each COLUMN
      IY = ICOL - 1
      IF (ICOL .GT. NYQY) IY = IY - NYP
      WY = IY * DELWY
      WYSQ = WY * WY
      WNUM = SQRT(WXSQ + WYSQ)
      CFAC = CMPLX(1.0_8,0.0_8,8)
      !
      ! Lanczos
      IF (LOP(1)) THEN
          YLANC = 1.0
          YARG = IY * YLFAC
          IF (YARG .NE. 0.0) YLANC = SIN(YARG) / YARG
          RLANC = XLANC * YLANC
          CFAC = CFAC * RLANC
      END IF
      !
      ! Hanning
      IF (LOP(2)) THEN
        YHANN = 0.5 * (1.0 + COS(WY))
        RHANN = XHANN * YHANN
        CFAC = CFAC * RHANN
      END IF
      !
        ! PSEUDO-GRAVITY TRANSFORM
        IF (LOP(10)) THEN
          WYSD = WY * SIND
! NB COMMENTED OUT LINES DO SAME AS ACTIVE LINES
! COMMENTED LINES ARE IN USGS FORMAT
!           RPOLER = WNUM*SINI**2-((COSI * (WXCD + WYSD))**2)/WNUM
!           RPOLEI = 2*SINI*COSI * (WXCD + WYSD)
!           RDENOM = 1.0/(RPOLER**2+RPOLEI**2)
```

```
!           RPOLEI = COSI * (WXCD + WYSD) / WNUM**2
          RPOLER = SINI*WNUM
          RPOLEI = COSI * (WXCD + WYSD)
          CPOLE=CMPLX(RPOLER,RPOLEI)
!         CPOLE=CMPLX(RPOLER,RPOLEI)/RDENOM
          CPOLE = 1.0 / (CPOLE * CPOLE)
          CFAC = CFAC * CPOLE*CMTOG
        END IF
        !
        ! PSEUDO-MAGNETICS TRANSFORM
        IF (LOP(11)) THEN
           WYSD = WY * SIND
! NB COMMENTED OUT LINES DO SAME AS ACTIVE LINES
! COMMENTED LINES ARE IN USGS FORMAT
!         RPOLER = SINI*WNUM
!         RPOLEI = COSI * (WXCD + WYSD)
            RPOLER = WNUM*SINI**2-((COSI * (WXCD + WYSD))**2)/WNUM
            RPOLEI = 2*SINI*COSI * (WXCD + WYSD)
            CPOLE=CMPLX(RPOLER,RPOLEI)
!            CPOLE = 1.0 / (CPOLE * CPOLE)
          CFAC = CFAC * CPOLE/CMTOG
        END IF!
        ! multiply coefficients by operation factor
      END IF
      C1(ICOL) = C1(ICOL)* CFAC
  END DO!
  ! write updated ROW C1 to output grid
  ! ----> YOUR CODE
END DO
DEALLOCATE(C1)
RETURN
END SUBROUTINE INVF01
```

John Denham's best of *Exploration Geophysics*

John Denham
Editor Exploration Geophysics 1994-99
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My first thought, when asked to nominate a paper for the ASEG's 50th anniversary best of *Exploration Geophysics* series, was to look for a paper that represented a major milestone in geophysics in my own field of petroleum geophysics, perhaps a case history of a major discovery, or the first application of a new technique in Australia.

However, in looking through the tables of contents, one title caught my eye. While the paper does not specifically deal with my chosen field, it does deal with a fundamental issue that has plagued geophysics in all fields throughout my career.

The paper I have chosen is "Geologists and geophysicists: getting them on the same planet" by A.J. Willocks and B.A. Simons.

Unfortunately, I don't think that we can say today that this is an issue of the past, even if the examples detailed in the paper seem to be dated. And as I noted above - the lessons apply, at least in general terms to all fields of geophysics. Even fields that do not really involve geology, such as geophysics in archaeology or forensics, demand that the geophysicist understand the other discipline - and vice versa.

Purely by chance this paper is actually from my period as Editor of *Exploration Geophysics*, and is also from a conference volume.

A. J. Willocks and B. A. Simons (1998), Geologists and geophysicists: getting them on the same planet, *Exploration Geophysics*, **29**:3-4, 658-664, DOI: 10.1071/EG998658

Geologists and geophysicists: getting them on the same planet

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ABSTRACT: The results of new detailed airborne geophysical surveys over Victoria have been lauded by industry as being a great incentive to increase mineral exploration in the State. These data become especially useful when combined with new semi-detailed geological mapping. The Geological Survey of Victoria has now developed a new methodology to integrate geological mapping with the interpretation of the geophysical data to produce a single composite understanding of the rocks and their relationships. It has required a reappraisal of the way geologists and geophysicists map, both together and separately, and additional training to make the process work.

Sufficiently detailed data acquired prior to the geological mapping allows a fully integrated interpretation, using the available geophysical and geological data, to produce maps that reflect both geological and geophysical reality. Previously, geologists and geophysicists worked in partial or complete isolation. Too often geophysicists gave geologists lineament or line maps that bore little resemblance to geological reality, lacked credibility and were almost immediately discarded by geologists as being "unhelpful". The new process requires geologists and geophysicists to work as a team to reconcile all the geophysical and geological observations to produce an accurate, integrated geological map. It demands that the geologist understands the geophysical responses and the geophysicist understands the geology. Both need to acknowledge the limitations inherent in each method.

Presenting the results provides a further series of challenges to the mappers, interpreters, managers and cartographers. We have also yet to integrate the mineralisation history into this mapping process. Meeting these challenges to produce a full and accurate understanding of the geology and geophysics, rather than of one or the other, is essential to ensure increased exploration success.

Keywords: geophysical interpretation, geophysical maps, geological mapping, interpretative maps gravity, airborne magnetics, airborne radiometries

Introduction

The Victorian Initiative for Minerals and Petroleum (VIMP), a major state government exploration initiative, was designed to promote and aid mineral exploration in Victoria. In conjunction with new geological mapping, the initiative has provided over 500 000 line km of high resolution magnetic, radiometric, and digital terrain data with 200 m and 400 m line spacing and over 20 000 gravity stations at a spacing of about 1.5 km (Willocks and Sands 1995; Willocks 1997). As well, the results have been a catalyst for increased mineral exploration of the State. The data have proven especially useful when combined with new 1:50 000 scale geological mapping.

* These contact details were correct in 1998 and are almost certainly out-of-date

Raised awareness of the application of these datasets for geological mapping and exploration has led to an increased demand for maps, images and interpretations. Advances in computer technology and image processing have meant that the geophysical data are more readily presentable and hence more accessible. The need in the 1990s for data integration has seen the advent of many different map combinations (such as potassium over digital terrain model). These are important first steps in visualising the data and getting geologists and geophysicists to work together, but they stop short of fully integrating the geological and geophysical data.

This paper compares the old-style of geological mapping and geophysical interpretation with the new approach developed by the Geological Survey of Victoria (GSV). This new approach aims to integrate the geological mapping with interpretation of the geophysical data to produce a single composite understanding of the rocks and their relationships. The result is better geological maps in shorter times.

Old-style interpretations and mapping

Previously geological mappers have rarely regarded geophysics as a fundamental tool, in stark contrast to, for instance, their use of air photos. The reasons for this include poor quality, unavailability or poor presentation of the geophysical data, insufficient time for geologists to fully utilise the data in a busy mapping program, the lack of understanding of the strengths and weaknesses of the geophysical methods, and the common problem of poor correlation between the petrophysical properties mapped in the geophysical data and the essentially visual properties measured by the geologist.

The single biggest hurdle to having geologists consider geophysics an essential mapping tool, however, has been poor data resolution. Regional datasets with 1500 m line spaced airborne magnetic and radiometric data and 11 km spaced gravity data, provide inadequate resolution of geological features mapped at 1:25 000 scale for publication at 1:100 000 or 1:50 000 scales. Indeed, mapping at these scales, 400 m line spacing is often inadequate and requires at least 200 m and sometimes 50 m line spacing, depending on the complexity of the rocks. The high resolution of the VIMP data provides the level of correlation between the geophysical and geological datasets necessary to convince the mappers of the usefulness of the geophysical data. The data need to be available before commencing mapping and presented at appropriate scales to be used in the mapping programs.

Even when the data resolution was adequate, the previous interpretation style usually identified magnetic "units", trends and lineaments, gravity highs and lows and zones of higher or lower radiometric response. This style of interpretation does not readily translate to the mapped geological units or help to make geological maps. It only partially explains the geophysical features and fails to explain the geophysical responses in meaningful geological terms. As a result, the interpretations were often only given cursory consideration by the geologists, and if the interpretation did not agree with the geological mapping model the geophysics was ignored. This style of geophysical interpretation is still often presented in company exploration licence reports and is typical of that previously used for regional mapping.

Figure 1 shows a part of an interpretation by Sands, in VandenBerg *et al*. (1995), of magnetic and radiometric data for the GSV project in the Mt. Wellington area. The interpretation is in the old style with the geophysicist and geologists having worked in partial or complete isolation. The result bore little resemblance to the geology and was almost immediately discarded by the geologists as "unhelpful". The mapping proceeded with very little reconciliation of the geophysical data or use of the interpretation. As a result, many features in the geophysical data were not explained in the geological map. For instance, in one area, because of time constraints and access, the geologists used a single road traverse and previous mapping compilations to map a major greenstone unit. A far more reasonable outcrop pattern for this unit would have resulted by using the geophysical interpretation of this well defined magnetic unit. Neither geologists nor geophysicist appreciated the significance of many of the responses because of poor communication and the pre-conceived idea that the geophysics was irrelevant to geological mapping. These published maps contain avoidable errors.

The Bendoc and Murrindall 1:100 000 map areas in eastern Victoria were mapped before any detailed geophysical data were available. Parts of the area are in rugged country with poor access and can only be mapped by long foot traverses along creeks or ridges. Figure 2 shows a simplified geology of part of the Bendoc 1: 100 000 sheet and how the map was modified using the new magnetic data. The Goonmirk Rocks Granodiorite has a pronounced tail, which the field mapping missed. The trends and continuity of faults can be clearly seen in the magnetic data but could not be determined accurately by ground mapping. Using geophysical data, if it had been available, would have significantly reduced the time spent on this mapping project and would have resulted in a more accurate map.

Isles, Valenta, and Cooke (1995) and Nash (1995) promoted the use of high resolution regional data sets to recognise geometries to enable the merging of structural geology and geophysical interpretation. This style of interpretation is now being commonly, although not universally, accepted as the preferred style. We have refined their techniques and applied them to the production of regional geological maps.

Realising that the geophysical data was necessary for mapping came to the geologists gradually. It started in 1994, when geologists mapping the Beaufort and Ballarat 1:100 000 map areas in central Victoria found that a Cainozoic capping unit could be mapped using its distinctive radiometric signature (Cayley and McDonald 1995; Taylor *et al.* 1996). This reduced the time required to complete the mapping by six months. The 400 m line spaced data from AGSO was crucial to this success. VandenBerg (1997) reported that while mapping in east Gippsland, the magnetic and radiometric responses of the Snowy River Volcanics were used to provide links between different outcrops of individual flows along strike. Again Cainozoic sediments were mapped using radiometric data with control obtained at easily accessible sites. By using the geophysical data to solve specific geological problems, the GSV took the first tentative steps towards fully integrating the geophysical and geological data in a mapping program.

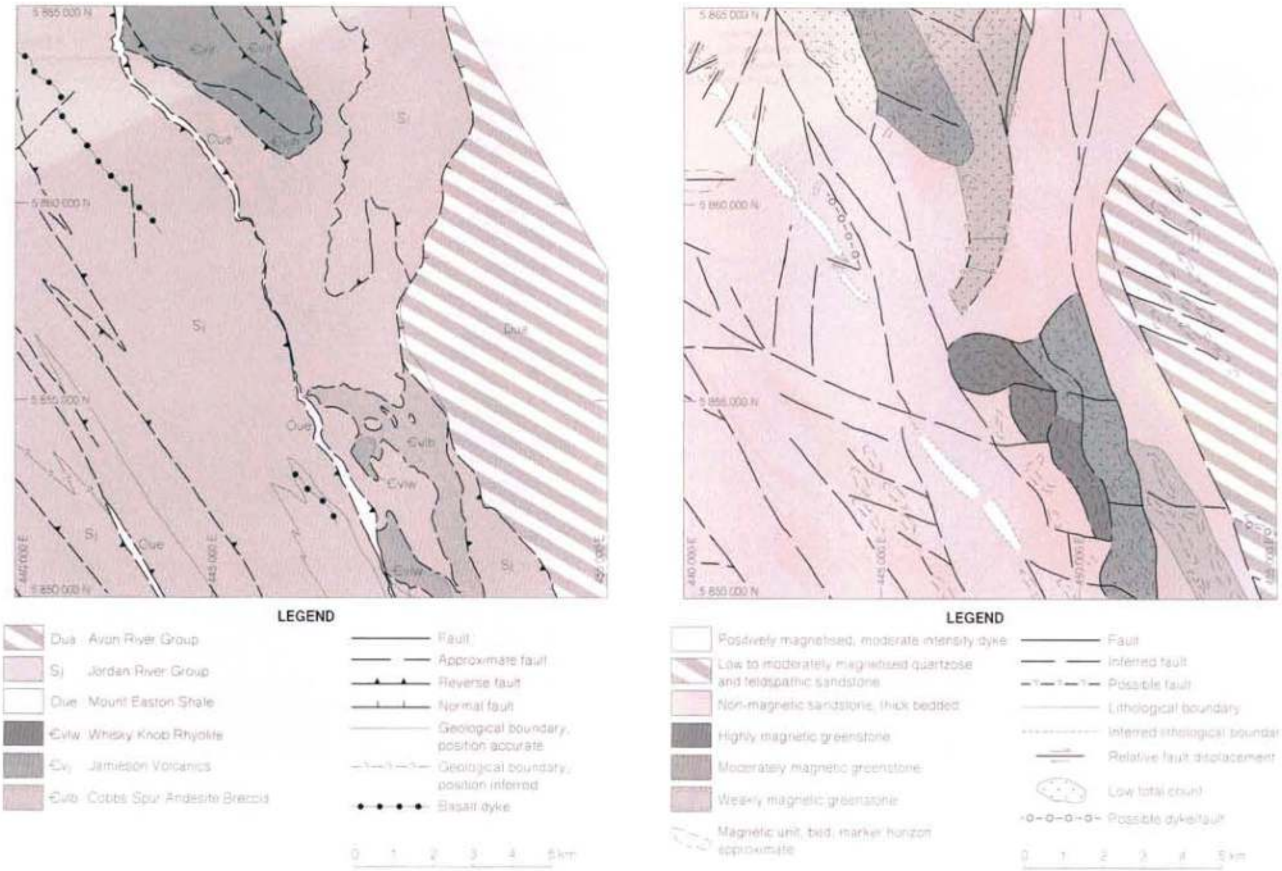

Figure 1. *Old style geological mapping and geophysical interpretation of magnetic and radiometric data in the Mt Wellington area, Victoria (from VandenBerg et al. 1995).*

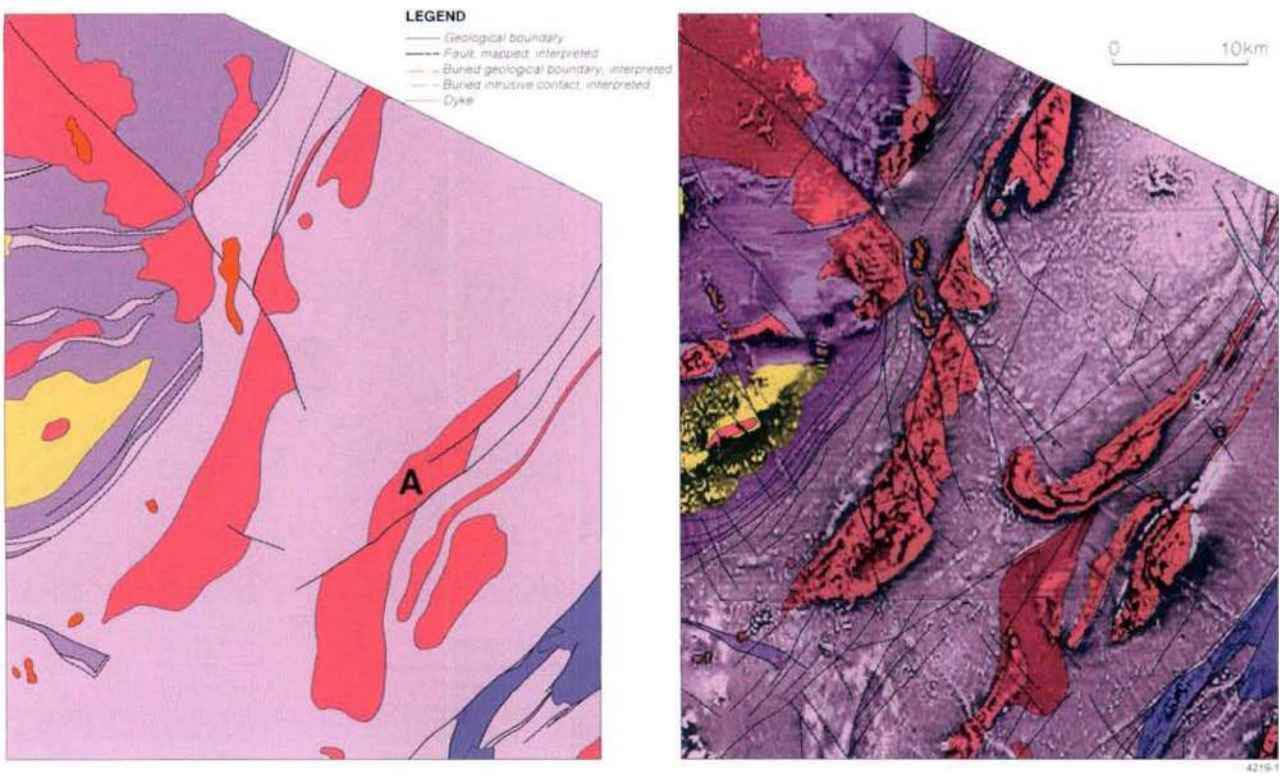

Figure 2. *Simplified geological map pre-geophysics (left) and simplified interpretation of magnetic data over grey scale first vertical derivative of total magnetic intensity. (Granites shaded red, Ordovician sediments are light pink, Silurian sediments are dark pink, Devonian sediments are purple and Devonian volcanics are yellow). The Goonmirk Rocks Granodiorite is labelled 'A'.*

New-style mapping

The new high-resolution geophysical data from the VIMP program has fundamentally changed the way geological mapping is carried out in the GSV. Sufficiently detailed data (200 m line spacing in eastern Victoria) acquired prior to the geological mapping allows a fully integrated interpretation that uses all the geophysical and geological data to produce maps that better reflect geological reality.

The mapping process varies according to the geology and access conditions, but mapping teams include a geophysicist as an active contributor during mapping and data synthesis. When interpreting the data, every geophysical response is assumed to have either a geological or man-made source. Each geophysical unit and structure is assigned geological meaning consistent with the geophysical and geological facts. The interpreted stratigraphy, structure, geological history and tectonic framework must be geologically and geophysically plausible.

Mapping

Depending on access and geology, the mapping processes used in Victoria fall into one of three categories with two styles of products. In the Northwest, where surface mapping is a low priority, the interpretation and report identify basement and surficial features at 1:250 000 scale. In the priority surface mapping areas of central and eastern Victoria, the products are a report, geological maps at I :50 000 scale and a 1: 100 000 scale geological interpretation of geophysical features map.

Northwest Victoria

Where access is good, but the Palaeozoic geology is fully covered by Cainozoic sediments, mapping both basement and cover depend on geophysical interpretation and previous drilling. No new surface geological mapping is carried out. For example, Moore (1996, 1997) has interpreted the geophysical data in a geological context, mapping units from outcrop in the South into areas of cover in the Horsham and Ouyen 1:250 000 maps. Figure 3 shows Moore's 1997 interpretation of the basement features from the geophysical data. The units have been traced over a significant distance under the cover rocks and their structural relationships determined. This geological looking map is very different from the old style of interpretation. These new interpretations rely heavily upon the geological, as well as geophysical, skills of the interpreter and discussions with geologists who are comfortable with geophysical data to construct a plausible geological and structural framework. The GSV tested Moore's (1996) interpretation of the Horsham 1:250 000 map area with a seventeen hole drilling program (Maher *et al.* 1997; Moore & Maher, 1998) which confirmed its geological accuracy.

High resolution data with appropriate interpretations have attracted explorers to the Murray Basin in Victoria. This increased exploration activity has led to the discovery of significant near- surface mineral sand deposits and a developing interest in the basement greenstone rocks for base metals and gold.

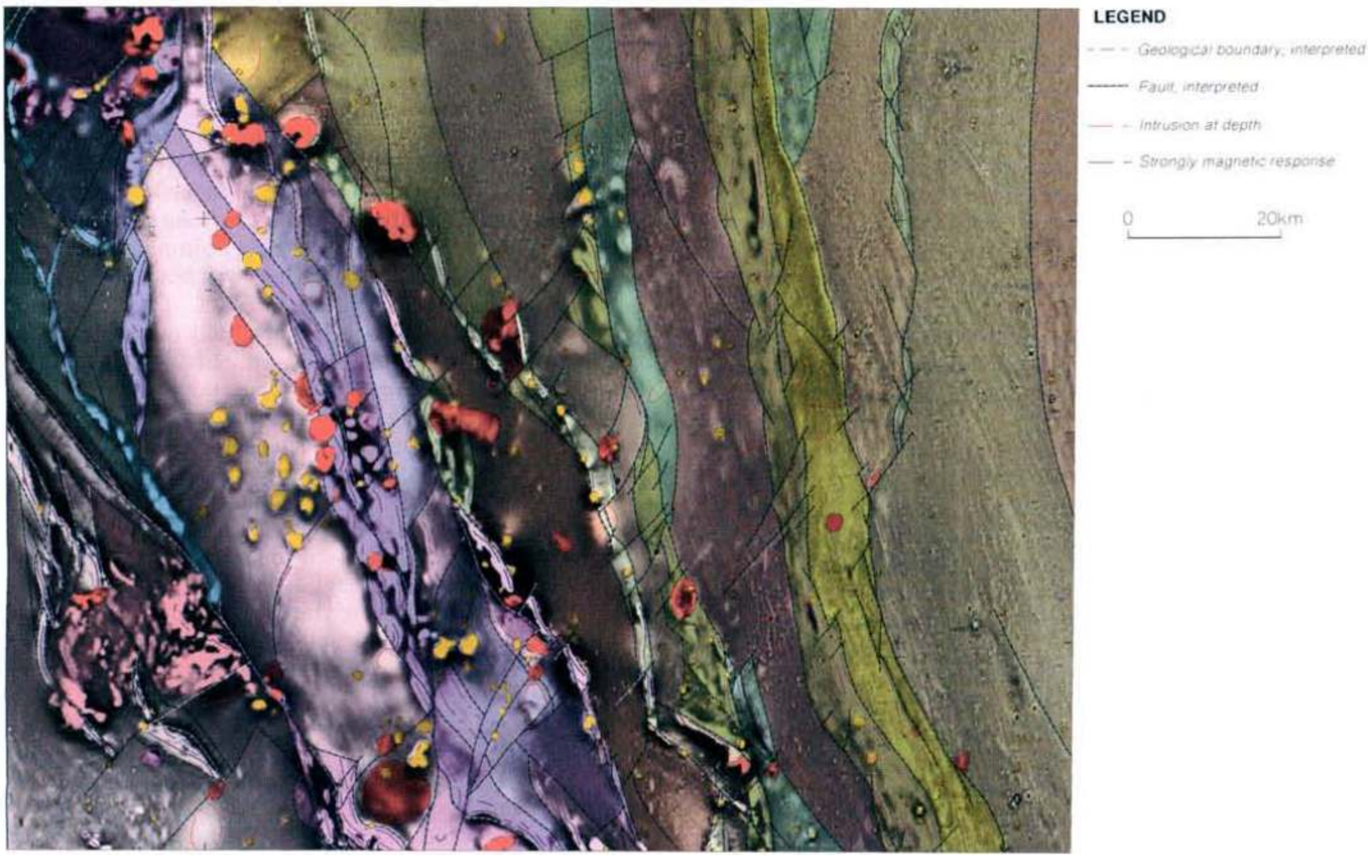

Figure 3. *Simplified geological interpretation of basement geophysical features for the Ouyen 1:250 000 map area, Victoria. The background is a grey scale first vertical derivative of total magnetic intensity.*

Central Victoria

There is a different challenge mapping where access is usually good but Palaeozoic outcrop poor. The radiometric and magnetic data are first used to identify areas of potential outcrop for further follow-up in the field. The geological interpretation of geophysical data involves mapping units beneath cover, depth estimation and modelling of geological units, identification of major faults and interpretation of the overall structural framework. An example from the Heathcote Greenstone Belt (Fig. 4) uses the magnetic data to extend the greenstones to the North as an antiformal thrust stack beneath Quaternary cover (Edwards *et al*. 1998).

Eastern Victoria

In rugged areas, exposure is usually good, but access is often extremely difficult. The geophysical images are used to determine where the mapping effort can best be directed by identifying areas of different lithologies or structural features. Once identified on the ground, the geological boundaries are extended using the units' geophysical characteristics. While this means that most boundaries and structures are common between the geophysical interpretation and the geological map, the geophysical map also shows subsurface geological features on one map at 1:100 000 scale.

By using the geophysical data to assist the mapping process by focusing the mapping effort, a time saving of about 40% was achieved on the Benambra 1:100 000 map area compared to the adjacent Murrindal sheet. It also provided a more accurate and reliable product.

Methodology

Irrespective of the terrain and geology the GSV approach to mapping requires that all of the geophysical features be explained in terms of geology. The key steps in this process are:

Survey timing and specifications

Before mapping starts, magnetic/radiometric and DTM data are acquired with the best specifications affordable, preferably at least 200 m line spacing. We have found that 200 m line spacing is usually required for mapping at 1:25 000 scale. The data need to be collected with as much lead time as possible.

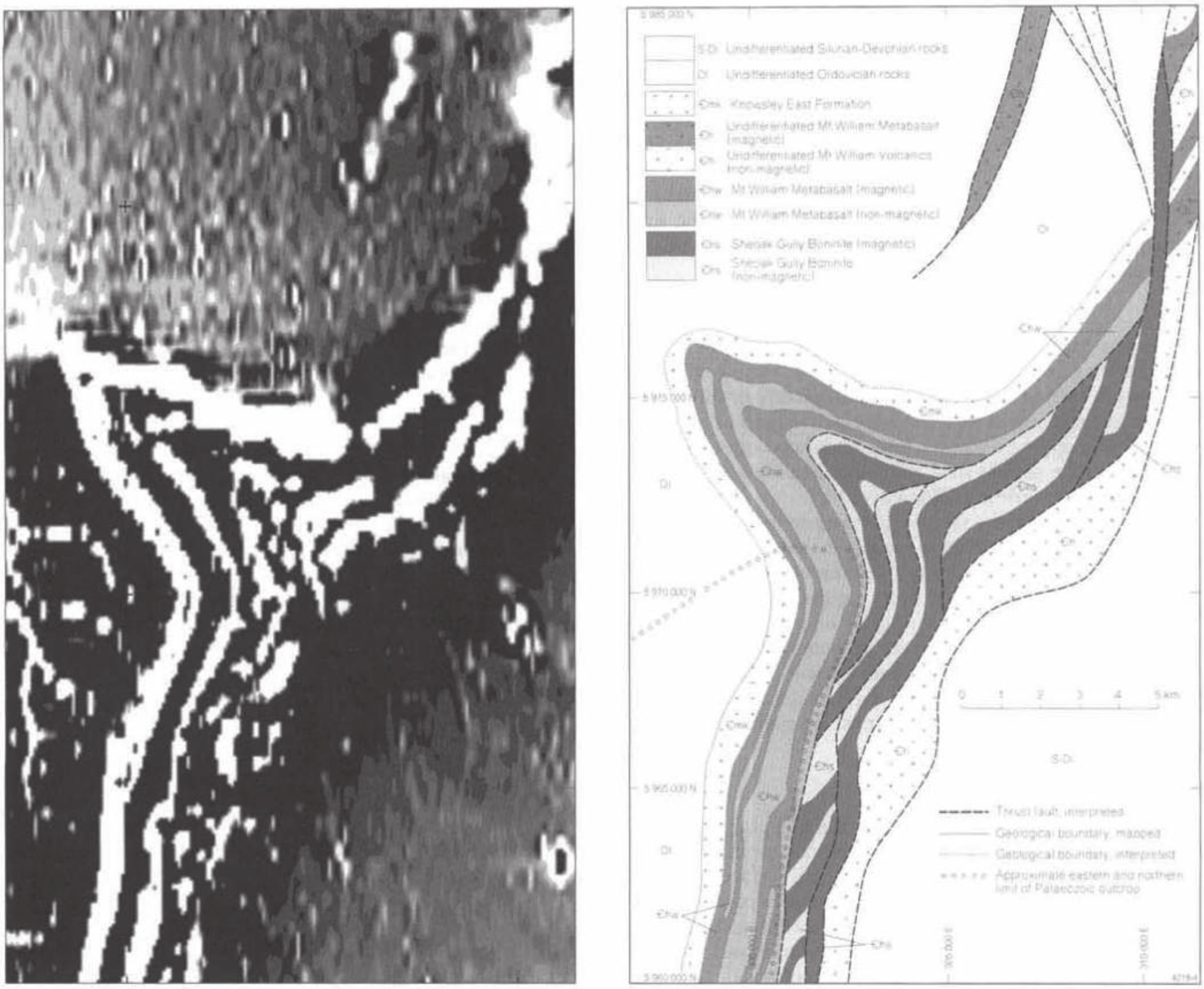

Figure 4. *Grey scale first vertical derivative of total magnetic intensity and geological interpretation of basement geophysical features of portion of the Heathcote Greenstone Belt in Central Victoria showing an antiformal thrust stack beneath Cainozoic cover.*

In western and central Victoria where access and terrain allow, semi-regional (1.5 km station spacing) gravity surveys are carried out to provide a further dataset to help map the structures and granites, particularly subsurface bodies.

Preliminary interpretation

The project team discuss the geophysical data in the context of the known geology and to identify geological problems to be resolved. A preliminary interpretation is made using the existing geology and any rock property measurements and drilling as a guide. This process identifies potential rock boundaries and structures. Maps showing the areas requiring field checking, presented over a topographic overlay, are taken into the field by each of the team members.

Before mapping starts, mapping scale images (1 :25 000) of TMI, 1 VD, ternary radiometric and DTM are prepared. The maps show the same road and stream base as used during the geological mapping.

Field mapping

During this phase the geophysicist is in the field with the geologists. Their role is to define the geophysical response of the rock units and follow up unexplained or unmapped responses. They work with the geologists on areas of geophysical interest, making sure that the team identifies the responses of each rock unit in the area. The mapping scale images are used in the field to match responses with rock type. Field mappers are aware of the geophysical properties and interpreted geology while doing their ground traverses. Magnetic susceptibility measurements are routinely recorded against GPS location and rock type, and compiled into a project database. This awareness encourages thorough ground checking of areas with properties different from background. The geophysicist is on site to discuss the geophysical responses and influence geological decisions as they happen. Traverses are planned into areas where the geophysics indicates contacts, structures and unusual rock types. Significant time savings can be made by using the geophysics to focus the mapping effort.

Agreed interpretation

Where the preliminary interpretation and outcrop match, the interpreted boundary is used to map boundaries between accessible control points. Discussion and geophysical modelling may be required to generate new ideas where questions have been raised. Through discussion, both the geological map and geophysical interpretation converge to agreed solutions that incorporate the best of each approach. The level of interpretation attempted may raise more questions than answers but also provides more accuracy, understanding and confidence in the resultant maps.

Presentation

Presenting the results of this synthesis provides more challenges to the mappers, interpreters, managers and cartographers. The products are presented as geological maps and geological interpretation of geophysical features maps, with the process aiming to ensure consistency between the two.

The geological maps show boundaries and structures interpreted from both the geological mapping, geophysical data and aerial photographs. Subsurface features interpreted from the geophysical data, such as granite boundaries, are used to show unit extents beyond the outcrop contacts.

The geological interpretation of geophysical features map uses boundaries from the mapping and the geophysical data to interpret surface and subsurface geophysical features. These interpretation maps have the geological interpretation draped over a magnetic image surrounded by other enhancements of the data, modelled and schematic cross sections, a stratigraphic legend with description of responses and other reference data.

The maps are complex and present many challenges in their preparation, especially in the conversions between digital and hard copy versions. Currently, interpretation line work and mapping line work are presented on separate stable topographic bases for digitising. This process has problems, including unavailability of digital line work during the interpretation phase, labour intensive transfer of line work from images to stable bases, ensuring geophysical and geological boundaries are coincident, and avoiding duplication of digitising. Digitising the preliminary interpretations for use during the mapping process and use of on-screen image interpretation and digitising process have been tried with limited success. The mapped geological boundaries are not available to the geophysicist in digital form during any part of the interpretation process. Clearly the synthesising and hard copy generating part of the process needs to be improved. We need to be able to interpret onto images at mapping scale in a digital environment, with all relevant data available digitally, and have the resulting line work compatible with the drafting software. This is one of the borders still to be crossed.

The drafting process has become more complicated as more complex maps are produced. Each interpretation map has a geological interpretation as a transparent overlay generally on a TMI derivative image. The map surrounds have images of gravity, radiometrics, and digital terrain model often with either surface geology or interpretation overlays.

To ensure consistently high quality interpretations and presentation, these maps are subject to the same technical and editorial peer reviews as the geological maps. To assist this process we have documented the key elements of the interpretation maps including line type hierarchy, symbols and stratigraphic legend components (Slater 1997). This is an evolving process, with each new map presenting a new range of presentation issues.

The map reports, or explanatory notes, now include integrated descriptions of the various rock units. The geophysical properties and features are described along with the more traditional properties such as lithology, distribution, thickness, thin section descriptions and age. The reports are written by up to five authors and integrate the various contributions into relevant sections. Not having separate chapters for the geophysics makes editing more complex.

Discussion

The need for geologists and geophysicists to work together has been recognised for a long time, often without success. Within the Geological Survey of Victoria significant progress has been made towards making it happen. Intelligent use of the detailed magnetic and radiometric data and their interpretation has improved the mapping process by reducing the time involved and significantly increasing the quality and reliability of the geological maps produced by the GSV. Geologists and geophysicists now work together as a team to reconcile all the geophysical and geological observations and produce an accurate, integrated geological maps and associated interpretation.

The positive team spirit, mutual respect and teamwork developed during these projects is an important factor in their success. The geologists now make best use of the geophysical responses to better understand the geology. The skills required to fully integrate different datasets have developed over several years and are reinforced by each new project. The geologists need to understand the geophysical responses and the geophysicists need to understand the geology. This required both formal and informal on-the-job training in magnetic and radiometric interpretation, understanding geological structures and field mapping procedures.

Our survey specifications are significantly better than the standards used in the past decade. Major advances have been required in the data display and presentation, creating products of the geophysical data that show greater detail than previously seen or expected. These improved presentation methods of the data have been a major step in developing our methods of interpretation.

The new process has raised the overall awareness of the limitations inherent in each of the methods. The small-scale variations observed in outcrop are often not resolved in the geophysical data. The ambiguities in interpretation are, in part, dependent on the data resolution. Subtle features clearly seen in 50 m data may well be unresolved in 400 m data. The geologists will only visit a few thousand sites in any one project and the geophysicist needs to be aware that these are valuable control points. Both geologists and geophysicists need to recognise where alternative geological interpretations could be valid.

The team needs to recognise where the geophysical data will be useful. In a qualitative sense it may be used to recognise patterns associated with rock units and variations within them, for example for mapping granites and variations within them, and discontinuities indicative of structure. In a quantitative sense, it provides 3D information about deep seated features and enables depth computations to rock units.

Even where semi-regional geophysical data are available, in some areas it is unable to assist the mapping. The geologists lament that the Ordovician bedrock units have little or no magnetic contrast and rarely have any magnetic markers. Large layer parallel faults within these units are often missed unless they happen to have dykes along them, have oxidised a magnetic host rock or have a significant gravity response. In these areas, other broad, rapid coverage techniques, such as airborne EM or side-scan radar, may provide answers.

Further developments will take place in the use of geophysical data to streamline the mapping and drafting. We will trial the use of laptop computers in the field with an image processing or GIS system linked to GPS to interrogate the data in real time. Having digital geological boundaries available during mapping will improve the iterative interpretation process. Economic geologists now work on the project teams. Their role, in addition to the more traditional role of cataloguing mining and exploration history, is to document and understand the mineralisation styles, to integrate them into the geological framework, and so to present models for possible mineral exploration.

The process is now refined to the stage where it is used in all of GSV's mapping projects. In crossing the borders between geology and geophysics we have accelerated field mapping and produced a better understanding of the rocks and their relationships. The next generation of geological maps in Victoria will rely heavily upon the geophysical data to provide a comprehensive geological interpretation. With renewed exploration interest in Victoria, these new maps provide a basis for the State to be systematically explored using modern exploration techniques within extensive exploration programs.

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Preview crossword #8

Across	Down
3. The period between infection and the appearance of signs of a disease. **8.** A popular, catchy phrase yet slippery term that has regularly and misguidedly been interchangeably applied to the first case of an infectious disease outbreak. **9.** To refrain from any contact with other individuals for a period of time during the outbreak of a contagious disease usually by remaining in one's home and limiting contact with family members. **12.** The immunity or resistance to a particular infection that occurs in a group of people or animals when a very high percentage of individuals have been vaccinated or previously exposed to the infection. **13.** The first documented case of an infectious disease or genetically transmitted condition or mutation in a population, region, or family. **14.** The law administered by military forces that is invoked by a government in an emergency when the civilian law enforcement agencies are unable to maintain public order and safety.	**1.** Derived from the Latin word insula, meaning island. **2.** The avoidance of close contact with other people during the outbreak of a contagious disease in order to minimize exposure and reduce the transmission of infection. **4.** Showing no evidence of disease. **5.** The spread of a contagious disease to individuals in a particular geographic location who have no known contact with other infected individuals or who have not recently travelled to an area where the disease has any documented cases. **6.** The worldwide spread of a new disease. **7.** An object, such as a doorknob, that may be contaminated with infectious organisms and serve in their transmission. **10.** A usually temporary layoff from work. **11.** An individual who is highly contagious and capable of transmitting a communicable disease to an unusually large number of uninfected individuals.

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Good luck!

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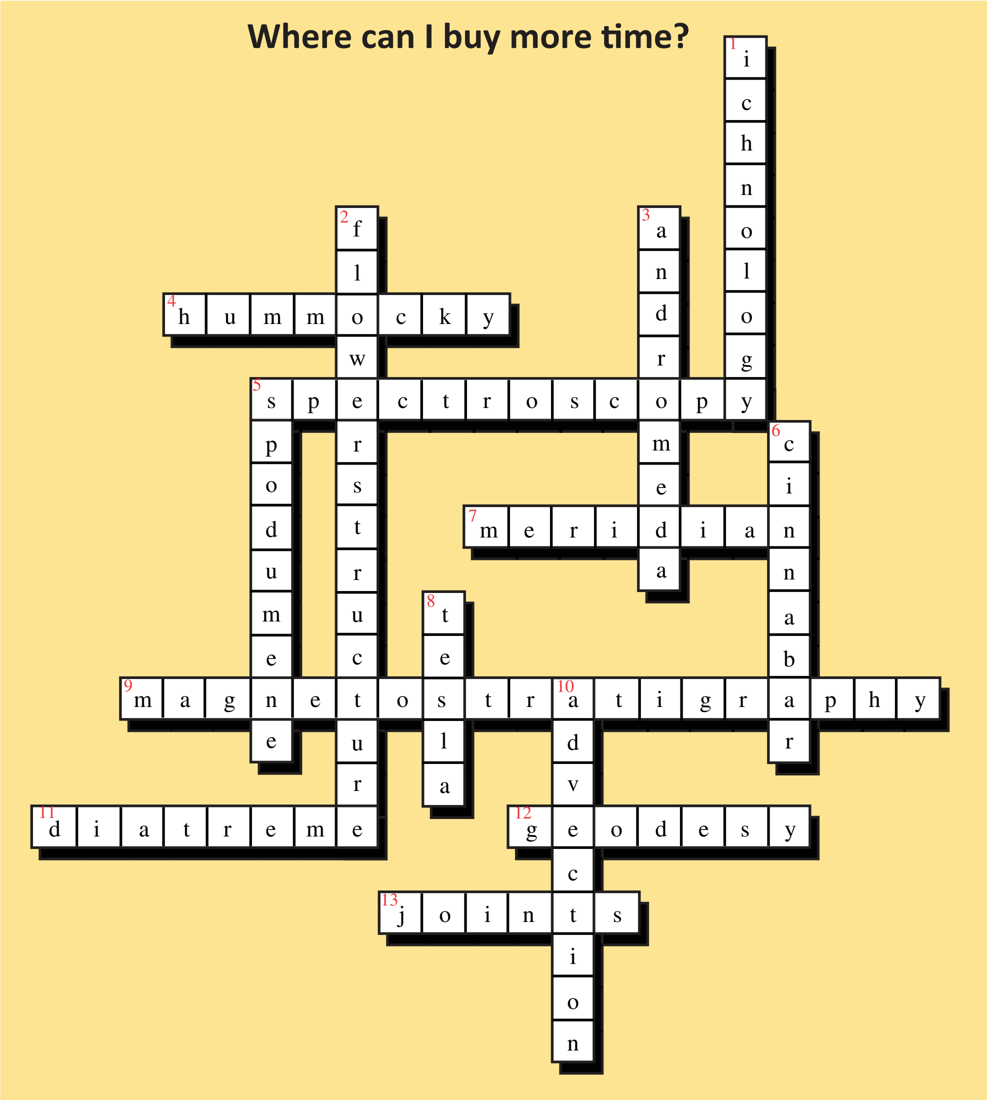

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Phone: +61 2 9431 8691 Fax: +61 2 9431 8677
Email: secretary@aseg.org.au Website: www.aseg.org.au

Application for Active & Associate Membership 2020

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. Student members must include a Supervisors Name and Signature. Under exceptional circumstances the Federal Executive Committee may waive these requirements.
3. Attach the appropriate dues and submit the two pages of your application to the Secretariat at the address shown on the top of this page, retaining a copy of this page for your own records. If payment is to be made by credit card, the application may be sent by fax.

Section 1. Personal Identification

Surname | Date of Birth

Given Names | Mr / Mrs / Miss / Ms / Other

Address

State | Post Code

Organisation

E-mail

Phone (W) | Phone (H) | Fax

Mobile

Section 2. Choice of Membership Grade (Tick one)

- ❑ Active — Please complete all sections (With the exception of **Section 5)**
- ❑ Associate — Please complete all sections (With the exception of **Section 5)**
- ❑ Active Graduate — Please complete all sections
- ❑ 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.

Active Graduate – an applicant is available for no more than two years. The membership is subsidized by 50%. Members accepting Graduate Membership Grants would be required to write on article for the newsletter and *Preview* with the goal of raising both their profile and ASEG's support.

Student – an applicant must be a full-time graduate or undergraduate student in good standing, registered at a recognised university or institute. Eligibility for Student Membership shall terminate at the close of the calendar year in which the Student Member ceases to be a graduate or undergraduate student. 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			
Seconder			

Section 5. **Expected Graduation Date:** ______________________________

Section 6. **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 7. **ASEG Membership Directory Record**

Please complete this section for the ASEG membership database. The same information is included in the ASEG Website (www.aseg.org.au)

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 8. **Payment Details** (This document will be an Australian Tax Invoice when you have made payment)

MEMBERSHIP GRADES AND RATES

❑ Active/Associate (Australia) - $172.00	❑ Active/Associate 5 Year Membership (Australia) - $860.00
❑ Active/Associate (Group IV Countries) - $156.00	❑ Active/Associate 5 Year Membership (Group IV Countries) - $780.00
❑ Active/Associate (Group III Countries) - $68.00	❑ Active/Associate 5 Year Membership (Group III Countries) - $340.00
❑ Active/Associate (Group I & II Countries) - $13.00	❑ Active/Associate 5 Year Membership (Group I & II Countries) - $65.00
❑ Active Graduate (Australia) - $86.00	

Section 8. ***Preview* & *Exploration Geophysics***

The association produces a magazine called *Preview* and *Exploration Geophysics*. The ASEG has a new publisher for 2019 onwards 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 continue to receive copies of the ASEG publications. Taylor & Francis have given an undertaking not to use the member list for any purpose other than advertising and 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 (please circle)

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:*____________

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

A.B.N. 71 000 876 040

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Phone: +61 2 9431 8691 Fax: +61 2 9431 8677
Email: secretary@aseg.org.au Website: www.aseg.org.au

Application for Student Membership 2020

INSTRUCTIONS FOR APPLICANTS

1. Student Membership is available to anyone who is a full-time undergraduate 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 to be a graduate or undergraduate student. However, 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 the two pages of your application to the Secretariat at the address shown on the top of this page, retaining a copy of this page for your own records.

Section 1. Personal Details

Surname		Date of Birth
Given Names		
Mr / Mrs / Miss / Ms / Other (list)		
Address		
	State	Post Code
E-mail *(Personal email address not university is preferred)*		
Phone (W)	Phone (H)	Fax (W)
Mobile		

Section 2. Student Declaration

Institution	
Department	
Major Subject	Expected Graduation Date
Supervisor/Lecturer*	Supervisor Signature

* Must be an active member of the ASEG

Section 3 Membership Grade
(This document will be an Australian Tax Invoice when you have made payment)

MEMBERSHIP GRADES AND RATES

❑ Student (Australia & Group IV Countries)	FREE
❑ Student (Group III Countries)	FREE
❑ Student (Group I & II Countries)	FREE

Section 4 *Preview & Exploration Geophysics*

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Yes / No (please circle)

Section 5 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 or 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 membership 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 my 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.

International calendar of events 2020–21

June	**2020**		
25	Update structural Models in Real Time using Machine Learning https://seg.zoom.us/webinar/register/WN_IkCzXT6aT8mE5qY_3YR0yg		*Webinar*
August	**2020**		
17–19	Offshore Technology Conference asia (OTC asia) http://2020.otcasia.org/welcome	Kuala Lumpur	Malaysia
September	**2020**		
6–10	1st Asia-Pacific Geophysics Student Conference (aPGSC) http://apgsc.ustc.edu.cn/index/lists/001		China
7–11	ISC (International Conference on Geotechnical and Geophysical Site Characterization) conference www.isc6.org	Budapest	Hungary
21	Biogeophysics: Exploring Earth's subsurface biosphere using geophysical approaches https://www.knowledgette.com/p/biogeophysics-exploring-earth-s-subsurface-biosphere-using-geophysical-approach		*Webinar*
October	**2020**		
11–16	SEG International Exposition and 90th annual Meeting https://seg.org/aM/2020	Houston	USA
November	**2020**		
10–11	2nd Joint SbGf-SEG Workshop on Machine Learning https://seg.org/Events/Second-Workshop-on-Machine-Learning	Rio de Janeiro	Brazil
December	**2020**		
2	Advances in Marine Seismic Data Acquisition Workshop https://seg.org/Events/Advances-in-Marine-Seismic-Data-Acquisition-Workshop	Singapore	Singapore
7–11	AGU Fall Meeting https://www.agu.org/Fall-Meeting	San Francisco	USA
8–11	82nd EAGE annual Conference and Exhibition https://eage.eventsair.com/eageannual2020/	Amsterdam	The Netherlands
April	**2021**		
25–30	European Geosciences Union https://www.egu2021.eu/	Vienna	Austria
May	**2021**		
31–3 Jun	83rd EAGE Conference & Exhibition 2021	Madrid	Spain
August	**2021**		
23–27	Advanced Earth Observation Forum 2020 https://earthobsforum.org/	Brisbane	Australia
September	**2021**		
15–20	Australasian Exploration Geoscience Conference (AEGC 2021) 2021.aegc.com.au	Brisbane	Australia
27–1 Oct	Australian and New Zealand Geomorphology Group Conference https://www.anzgg.org/conferences	Alice Springs	Australia

Preview is published for the Australian Societyof 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

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 August issue is 10 July 2020. For the advertising copy deadline please contact the Publisher on advertising@taylorandfrancis.com.au