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PREVIEW

NEWS AND COMMENTARY

FEATURES

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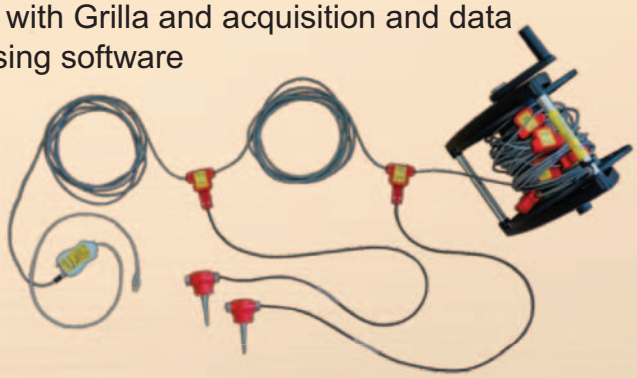

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FRONT COVER

Stephen Griffin of Gap Geophysics explains features of their precision UXO and metal-detection cart to students during a field day organised by the Queensland Branch of the ASEG.

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CONTENTS

Editor's desk

This issue of *Preview* features two articles that examine deep time – deep from the perspective of the practice of exploration geophysics in Australia anyway! The first article, by Doug Morrison, takes a close look at the geophysical observations made by the navigators James Cook and Matthew Flinders. The data recorded by these extraordinary individuals in 1770 and 1802 set the foundation for the practice of geophysics on our continent. Roger Henderson then takes a great leap forward to the Federation Era and to exploration geophysics as it was practised in the early part of the Twentieth Century – before the ground-breaking work of the Imperial Geophysical Experimental Survey (IGES), which was carried out between 1928 and 1930. Roger's analysis of this early work will be published in two parts.

The article by Dave Isles on 'The discovery of Olympic Dam' that was featured in the last issue of *Preview* provoked considerable comment. Reg Nelson, a key player, shares some of his memories in a Letter to the Editor – and shares the glory just that little bit further. To paraphrase the saying 'it takes a village to raise a child' it would seem that it takes a community of geoscientists to create the right environment for a discovery!

As always, our regular commentators engage us with entertaining reports and analysis. David Denham (*Canberra observed*) reviews the impact of Trump's proposed budget cuts on Australian science, and draws our attention to the release of a new World Stress Map. Michael Asten (*Education matters*) reports on the World Bank's finding that clean energy technologies will increase demand for minerals and metals. Mike Hatch (*Environmental geophysics*) considers the impact that the use of drones is having on the miniaturisation of geophysical technology. Terry Harvey (*Mineral geophysics*) warns us about the dangers of following fashion, Mick Micenko (*Seismic window*) ponders the future of interpretation and Guy Holmes (*Data trends*) enjoins us to take another look at the C suite.

Sadly this issue of *Preview* will be the last issue to feature the words of Guy Holmes. Guy is retiring as *Preview's* regular commentator on data management and analysis – and on life, the universe and everything! He is starting a new business, which requires his full attention. The business is called Tape Ark and is providing high volume migration data from tape media directly to the cloud. Google Tape Ark if you want to know more. I am sure I speak for all *Preview* readers when I say that he will be sorely missed, but that we wish him, his family and his new enterprise well.

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

Letter to the Editor

Dear Lisa

I was delighted to be able to help Dave Isles with his article on Olympic Dam and the contributions made by Hugh Rutter and Bernie Milton.

Bernie was a great friend and mentor for me. He is one of the unsung heroes of Australian geophysics. Apart from his contributions so well set out by Dave in his article, Bernie was one of the stalwarts who really got the ASEG going in the early 1970s.

I should also mention the contributions made by Peter Woyzbun, who sadly passed away in 2014 at the age of 86. Peter stood out in any crowd with a black 'pirate' patch over one of his eyes. I believe that he lost an eye during World War II.

Peter was a teenager in Poland during World War II and had been active in the Polish Resistance. Captured by the Germans in the latter half of the war, he was freed by the Americans and eventually found his way to England where he completed a science degree, majoring in physics. He joined Hunting Geophysics, which later merged with Adastra Aerial Surveys to become Adastra Hunting. He came to Australia with Adastra Hunting in the 1950s to carry out contract surveys on behalf of the then BMR, and some of the State Geological Surveys. One of his earliest surveys was to fly the Middleback Ranges in SA.

Peter became Senior Geophysicist for the Northern Territory during the 1980s, which is when I first met him. I worked with him over the years, and I well remember his mentioning that re-flying a couple of 1:250 000 sheets in the NT in the late 1980s had led to an upsurge in exploration. At the time I was Chief Geophysicist for the South Australian Department of Mines and Energy, and about to become Director of Mineral Development. The conversation that I had with Peter was a direct stimulus for my urging the South Australian Government to undertake large-scale airborne surveys and other initiatives, as recounted in Dave's article (David Tucker's and John Pitt's contributions also deserve a big mention in this respect).

Peter moved to Canberra in the early 1990s and I was able to secure his services as a consultant to interpret reprocessed map sheets in the Gawler Craton.

We owe so much to our early geophysical pioneers and it's great to see a light shone on some of their history through articles such as Dave's – and also the estimable Roger Henderson's historical notes.

I'm indebted to Doug Morrison for his more detailed notes on Peter's career and personality, which have greatly refreshed my memories of him.

Kind regards
Reg Nelson
reg.nelson@vintageenergy.com.au

President's piece

Andrea Rutley

Any search that you conduct on the vast amount of information (or dis-information) that can be accessed from internet search engines on mining and its relationship with communities and or the environment consistently brings to the front the negative impacts. Topics that frequently top the list are climate change, poor rehabilitation practises, groundwater or surface water contamination and the impacts on biodiversity. Whilst many of these effects have unfortunately occurred in some instances, we must also remain cognisant of the positive effects that mining can have on communities.

During the last school holidays we loaded our car with family and assorted paraphernalia that is of absolute necessity on a road trip; cameras, tripods, fishing rods, picnic hampers, gold pan, sieves, bagpipes, to name but a few. It is truly remarkable what can actually fit into one car!

Our planned itinerary was to drive from Brisbane to Snowy Mountains, Gippsland, Melbourne, Great Ocean Road, Western Victoria, Central NSW and New England. Remarkably we did this and retained our sanity, albeit that sometimes such sanity was hard to find.

It was during this trip that we drove through many towns, both small and large, where mining had either historical or current influence. For example, Orange in NSW is a spectacular city with a vibrant food and wine industry, strong agricultural ties and both historic and current mining in the region. The photo below was taken on sunset at Lucknow, a small town outside Orange. The Poppet Head was constructed in 1935 to assist in draining the persistent inflow of water into the gold mine, a problem that plagued many mines in the district.

Photo of Poppet Head at Lucknow, NSW.

Whilst many of the small towns that witnessed an influx of thousands of workers to seek their early fortunes fell into abandonment as soon as that easy-to-win gold was exhausted, there were those towns that continued to flourish. Bendigo and Ballarat in the Victorian goldfields come to mind. Servicing large areas of rich mining land, these towns were important regional centres with their own mining exchanges and government offices. Such was the money available to the state at this time that these magnificent buildings are a visual reminder to the wealth and contribution that mining made to these areas. This continues today and a new industry of tourism has grown on the back of mining success. Sovereign Hill in Ballarat is by far the greatest example of public education in an interactive mining environment. By day or night, the history and character of the early Victorian goldfields is clearly apparent.

As the gold was being discovered in NSW, the newly formed government of Victoria was luring explorers to Victoria in 1851, promising significant rewards to the first explorer to find gold within 200 miles of Melbourne. For the time this was a revolutionary change in thinking.

Now we commonly expect governments, both State and Federal to continue the trend of supporting explorers in all commodities. It is certainly pleasing to see that there is significant activity within Australia in this regard. Our geophysicists have only to read each edition of *Preview* to see just how much data the relevant State and Federal Departments are acquiring and releasing to aid explorers. In the last issue of *Preview* alone, there were seven pages dedicated to available or upcoming geophysical data

Main Street Sovereign Hill by day.

Night-time spectacular in Sovereign Hill.

programmes. Such considerable support and recognition of the importance of collaborative exploration data is of mutual benefit to explorers and governments in terms of activity and potential revenue. From successful exploration, regional areas of Australia continue to benefit from the influx of people and money to build strong and lasting communities. I encourage all explorers to use these available datasets to their fullest advantage and who knows, just as Olympic Dam was discovered from the innovative use of government data, the next 'big thing' could be just around the anomaly corner.

Happy exploring!

Andrea Rutley
ASEG President
president@aseg.org.au

Welcome to new Members

The ASEG extends a warm welcome to 15 new Members approved by the Federal Executive at its July meeting (see table).

First name	Last name	Organisation	State	Country	Membership type
Benjamin	Awortwe	University of Mines and Technology	Tarkwa	Ghana	Student
Nicholas	Botross	Macquarie University	NSW	Australia	Student
Mohammad	Farooqui	Quaid-i-Azam University	Islamabad	Pakistan	Student
Jayson	Gregg	M&EC	QLD	Australia	Active
Olaoluwa	Ibilola	University of WA	WA	Australia	Student
Muhammad	Junaid	University of Technology Malaysia	Johor	Malaysia	Student
Partha	Mandal	PGS	WA	Australia	Active
Inianga	Omiela	Niger Delta University	Bayelsa	Nigeria	Student
Louis	Paterniti	University of WA	WA	Australia	Student
Zixing	Qin	Curtin University	WA	Australia	Student
Michael	Reveleigh	Velseis Pty Ltd	QLD	Australia	Active
Aundre	Rodrigues	University of WA	WA	Australia	Student
Hayley	Rohead-O'Brien	Curtin University	WA	Australia	Student
Azadeh	Salehi	University of SA	SA	Australia	Student
Ben	Spyridis	Macquarie University	NSW	Australia	Student

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Executive brief

The Federal Executive of the ASEG (FedEx) is the governing body of the ASEG. It meets once a month, via teleconference, to see to the administration of the Society. This is a brief report on the last monthly meeting, which was held in June.

Several of the long-standing and highly regarded FedEx team have retired from their positions in 2017 after many years of dedication and hard work contributing to our Society. Subsequent to this, the FedEx have decided there is a crucial need for the creation of a succession plan for the Fedex and each of the sub-committees. This will be a priority to ensure the continuing success of the ASEG.

Last month the ASEG released our Membership Survey and we have been delighted by the number of responses. We seek to improve our Society for the benefit of our Members, and can only do this through your increased contribution. If you would like to volunteer to be involved in a committee within the FedEx, please contact: fedsec@aseg.org.au

Society finances

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

Year to date income $177 303

Year to date expenditure $233 005

Net Assets $1 021 137

Membership survey results

The ASEG membership survey closed as this edition of *Preview* is going to press. The winners of the free membership for 2018 are Giraud Jeremie from WA and Richard Newport from NSW.

We would like to give a big thank you to the 400 people who replied for all of their considered responses. We are currently reading through all of your valuable feedback, and a summary of the results will be published in the next edition of *Preview*.

Megan Nightingale
Secretary
fedsec@aseg.org.au

News from the ASEG Young Professionals Network

Thank you to everyone who has responded to my requests seeking members and mentors for the Young Professional Network. It's not too late to register your interest, please contact ypadmin@aseg.org.au with your name and preferred email address.

Since June's edition of *Preview*, the YPN has welcomed a co-president Jarrod Dunne. Jarrod has over 20 years of experience in seismic amplitude interpretation, reservoir characterisation and seismic processing. He has experience in a large number of basins throughout the world, having worked for Shell, Woodside and a number of smaller oil companies. Jarrod has remained actively engaged in R&D through involvement in software development and post-graduate student supervision. Jarrod is an active member of ASEG and PESA and holds committee roles in both societies. Jarrod champions the interests of Young Professionals at the state level for PESA in VIC/TAS, and now at a National Level for the ASEG through the Young Professional Network and the Education Committee. Jarrod's extensive experience and involvement in the industry is a wonderful asset to our YPN, and we are grateful for his support.

The YPN is focused on coordinating the efforts of connecting societies, including PESA and SPE, at a National and State level for the development of Young Professionals through education, mentoring and networking events. Our first priority is organising events for the upcoming AEGC Conference in Sydney 2018. The YPN will hold a networking function and have a booth on the Exhibition floor. Additionally, we will be running a Presentation Skills Workshop – *'Find your Voice – Present with Confidence'*. We will have a synopsis and registration information up on the AEGC website in the coming weeks.

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

The ASEG Research Foundation thanks all donors in 2016/17

During the 2016/17 financial year 38 ASEG Members used the ASEG website to donate a total of $4506 to ASEG Research Foundation (see Table 1). We thank each and every one of you for your generosity.

The total amount donated is sufficient for one project for a year, which is significant in the context of the five to six projects we normally support and is important when added to the $5500 raised at the conference in Adelaide last year.

We also thank Rio Tinto for their donation of $1000 after the Adelaide conference and, once again, the support of the ASEG, which donated $50 000 to the Foundation for the 2017 year is gratefully acknowledged.

The ASEG's excellent website makes it easy to donate to the ASEG Foundation using a credit card, and bear in mind that all donations are tax deductable.

Once again thanks to all of our supporters and keep up the good work!

Phil Harman
ASEG Research Foundation Chair
research-foundation@aseg.org.au

Table 1. Member donors to the ASEG Research Foundation

Peter Grant	Bob Musgrave	Roger Clifton	Barry Bourne
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Phillip Cooney	Noll Moriarty	Robert Peacock	Robert Eliott-Lockhart
Paul Hayston	Anthony Yeates	Stephen Abernethy	Emma Brand
Aaron Davis	Maxim Lebedev	Lindsay Horn	David Robinson
Rory Murray	Ross Costelloe	Peter Betts	Phillip Harman
Mark Duffett	Chaw Hong Woo	Kate Hine	Barry Smith
Ted Lilley	Stephen McIntosh	Ross Brodie	James Macnae
Anonymous	Donald Pridmore		

ASEG Branch news

Tasmania

Over the past month we have had the good fortune of receiving several presentations in conjunction with the GSA Tasmania branch and CODES. At the July meeting of the GSA, **Michelle Salmon** presented on 'Using geophysics to empower communities to study and understand the Earth beneath their feet: a practical example utilising seismometers'. The talk was enjoyed by GSA and ASEG Members.

At CODES and co-advertised to ASEG Members, **Steve Kuhn** presented 'Geological Classification of 3D Inverse Model Volumes via Supervised Multiband Image Classification: A prospect scale example from Cave Rocks, WA'. The seminar was attended by CODES staff and students, ASEG Members and staff from Mineral Resources Tasmania (MRT).

We started July with a farewell seminar by **Esmaeil (Esi) Eshaghi** entitled 'A Geophysical investigation of Tasmania at multiple scales' and presented to CODES, MRT and ASEG Members. Esi has been a Member of the ASEG since moving to Tasmania from Iran to commence his PhD with CODES. His final talk provided a summary of his work over the last 4 years on 3D modelling at scales ranging from crustal to project. His work included an investigation of the seismic and gravity derived Moho and Curie point depth beneath onshore and offshore Tasmania as well as parts of eastern mainland Australia. Using these constraints Esi has constructed detailed models of regions of Western Tasmania using gravity and magnetic inversion. Esi has completed his PhD this month and will be moving to Canada to join the Metal Earth Group at Laurentian University in Sudbury under the supervision of Professor Richard Smith. The ASEG Tasmania Branch would like to thank Esi for his contribution to a geophysical understanding of Tasmania and wish him all the best in his research at Laurentian.

As always, we encourage Members to keep an eye on the seminar program 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.

Please contact ASEG Tasmania Branch Secretary **Steve Kuhn** with any queries.

Steve Kuhn
tassecreatry@aseg.org.au

Victoria

Contrary to widespread belief, the Victorian branch has NOT gone into hibernation during these colder winter months! On the back of our most well-attend technical meeting so far in May this year, there was anticipation of hosting a second successful technical night in as many months. Unfortunately, our efforts to bring a much-anticipated speaker to present to our Members was thwarted due to a clash of schedules. We do, however, hope to have this speaker at one of our future technical meetings so stayed tuned!

Nevertheless, the Branch was invited to co-host a joint PESA technical luncheon on 21 June at Henry and The Fox. It was a very good turnout despite the late invitation to our Members. The guest speaker was **Michael Wilson**, an independent technical consultant, whose talk was peculiarly titled 'Seismic Reflections: Reminiscence before Alzheimer'. Michael enthusiastically delivered a string of entertaining anecdotes, which at times were interjected by various audience members who recalled those same events, often adding their own spin to the entertaining story. We thank Michael for his animated participation in June.

Our committee is in final discussions with speakers for our August and September technical meetings. Again, due to misfortune we had to cancel our scheduled July technical meeting but hope to resume in early August. Finally, we are pleased to announce the upcoming Winter Social 2017, to be jointly hosted once again with our sister branch of PESA. This event is slated for the end of August so keep an eye out for updates!

Seda Rouxel
vicpresident@aseg.org.au

Western Australia

The WA Branch continues to be very active with Tech Night presentations. In June the Branch hosted **Andrew Fitzpatrick**, presenting on behalf of Cameco Australia, who gave a talk on 'Maximising the Benefit of Historical Airborne EM in the Search for Unconformity Style Uranium Deposits'. In July **Aaron Davis**, Senior Research Scientist at CSIRO, presented on 'Focussing AEM Acquisition for Groundwater Resource Assessment in the Murchison, Western Australia'. Both talks were well attended and received by Members.

The WA Branch also hosted the SEG DISC course by **Doug Oldenburg** on EM fundamentals in July. The course consisted on a full day lecture program followed by an optional lab session on day 2. The course was well received by attendees, though numbers were lower than anticipated.

The WA Branch is in the process of renewing its sponsorship and currently has committed sponsorship from the following companies for the 2017–2018 financial year: Resource Potentials (Gold), Western Geco, NRG Australia, First Quantum Minerals Inc, Southern

Esmaeil Eshaghi presenting to the Tasmanian Branch of the ASEG.

Andrew Fitzpatrick presenting to the WA Branch of the ASEG.

Geoscience, GPX Surveys, CGG (Silver), Atlas Geophysics, and ExploreGeo. The Branch could not put together a wide range of technical activities without the support of our sponsors, and we look forward to a long standing partnership with these companies. If you are interested in sponsoring the Branch please contact the Branch President on wapresident@aseg.org.au.

Our technical program has presenters lined up through the end of the year with the following presenters:

- August – **Ben Jupp** (SRK Consulting) presenting a case study of geophysics at the Mt Magnet gold camp;
- September – Schlumberger Oil and Gas themed presentation (details to follow);
- October – **Bill Peters** (Southern Geoscience) presenting on geophysics for nickel-copper exploration; and
- November – Student presentations from UWA and Curtin University.

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

Kathlene Oliver
wapresident@aseg.org.au

Australian Capital Territory

In May the ACT Branch enjoyed a guest speaker presentation from **Yusen Ley-Cooper** on the use of airborne electromagnetics (AEM) for mineral and ground water exploration. In particular, the use of inversion and the generation of non-unique solutions was discussed. The presentation was well received and generated a lot of discussion on the use of AEM inversion to better understand and assess data, and how it can lead to gaining data driven geological knowledge.

It was with great pleasure that the ACT Branch was able to award **Ron Hackney** and **Leonie Jones** with Silver Certificates signifying 25 years of membership with the ASEG. The time and effort that Ron and Leonie have contributed to the ACT Branch has ensured that it runs smoothly and is a place that fosters fellowship and learning. Thank you and congratulations Ron and Leonie!

In the coming months the ACT Branch is looking forward to a special site visit and tour of the Geophysical Observatory located just outside of Canberra and maintained by Geoscience Australia. Further details on this event will be distributed to ACT Branch Members shortly.

James Goodwin
actpresident@aseg.org.au

Leonie Jones and Ron Hackney being awarded Silver Certificates by ACT Branch President James Goodwin.

New South Wales

In May **John Warburton** from Oil Search spoke about 'Potential Petroleum Resource Growth in PNG'. John gave a holistic 'Plates to Prospects' assessment of how Oil Search has approached evaluation of the petroleum potential of PNG at a country scale. John discussed Oil Search's programs in PNG and the approach that they took to exploration and some of the issues that they faced. There was quite a large crowd who interacted and asked many questions of John.

Before John's talk we also thanked our three Branch scholarship recipients and wished them well with their studies this year. The recipients were **Anthony Finn** from Macquarie University and **Lauren Harrington** and **Lena O'Toole** from the University of Sydney.

In June, **Chris Firth** from Macquarie University spoke about 'Using satellites to investigate eruptive behaviour at remote volcanoes'. Chris discussed how satellite-borne volcano monitoring instruments (for instance MODIS and OMI) have now been in operation for long enough that year-to-year variation in eruptive behaviour can be investigated at a number of persistently active volcanoes. Through satellite images Chris took us to Heard Island, Bagana and Ambrym volcanoes and showed how such monitoring data can be used to understand eruption regimes at those remote and rarely visited volcanoes. Many questions and much discussion followed Chris's presentation.

An invitation to attend NSW Branch meetings is extended to interstate and international visitors who happen to be in town at the time. Meetings are generally held on the third Wednesday of each month from 5:30 pm at the 99 on York Club in the Sydney CBD. Meeting notices, addresses and relevant contact details can be found at the NSW Branch website

Mark Lackie
nswpresident@aseg.org.au

Queensland

Since the last issue of *Preview* the Queensland Branch has hosted the SEG president, **William Abriel** for a technical night. We learnt a bit more about the SEG and enjoyed a presentation detailing 'Digital integration of subsurface models – where are we and where are we going'.

Mark Lackie (NSW President) with scholarship recipients Lauren Harrington, Lena O'Toole and Anthony Finn.

Nick Josephs from the Qld Branch also worked with local students to organise a field trip. The ASEG Qld Branch provided transport for 19 students of geophysics, geology and geosciences from QUT and UQ to visit Gap Geophysics. **Mal Cattach**, Chairman and Chief Geophysicist of Gap Geophysics gave an overview and history of Gap, then **Stephen Griffin** and **Will Rowlands** demonstrated UltraTEM system for unexploded ordnance detection. This was followed by a BBQ put on by Gap and then an optional brew at the pub afterwards. The Students were accompanied by Nick Josephs and **Ron Palmer** from the Qld branch. We would like to thank all that contributed to an awesome day!

In July we held our annual Zoeppritz night as well as a Technical Night with presentations by students from UQ. In August we are hosting the **Doug Oldenberg** DISC course and joining with PESA for an annual Trivia Night.

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

Fiona Duncan
qldpresident@aseg.org.au

Stephen Griffin and Will Rowlands demonstrating the UltraTEM system to students.

South Australia & Northern Territory

After a run of fantastic talks in the first half of the year, the SA/NT Branch remained relatively quiet going into winter, with only one talk since my last update. In late May we were joined by SA/NT Branch stalwart **Philip Heath** who gave us an update on recent microgravity surveys he and his fellow workers at the Geological Survey of South Australia have undertaken this year. In his talk titled 'Microgravity Surveys on the Nullarbor Plain', Phil ran through some of reasoning behind the surveys, the techniques, and the potential pitfalls (in some sense quite literally) of running microgravity surveys with the aim of detecting underground cavities, sinkholes and large cave networks across the Nullarbor Plain. It was a really fascinating talk and leads well into more future work by Phil and his team as well as future mineral exploration drilling in the region. We thank Phil for presenting and giving up his time to join us.

Our technical meetings are made possible by our very generous group of sponsors, including the Department of the Premier and Cabinet, Beach Energy, Minotaur Exploration, and Zonge. Of course, if you or your company are not in that list and would like to offer your support, please get in touch at the email below.

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

Josh Sage
sa-ntpresident@aseg.org.au

ASEG national calendar: technical meetings, courses and events

Date		Branch	Event	Presenter	Time	Venue
02	Aug	SA	SEG DISC	Doug Oldenburg	0900–1700	Hotel Richmond, Rundle Mall
07	Aug	QLD	SEG DISC	Doug Oldenburg	0900–1700	Christie Conference Centre, 320 Adelaide Street, Brisbane
08	Aug	QLD	Trivia night		1800–2000	Stock Exchange Hotel – 131 Edward Street, Brisbane
09	Aug	WA	Tech night	Ben Jupp	1730–1900	TBA
09	Aug	VIC	Tech night	Steve Micklethwaite	1800–2000	The Kelvin Club, 14–30 Melbourne Place, Melbourne
16	Aug	NSW	Tech night	TBA	1730–1900	99 on York, 99 York Street, Sydney
	Aug	VIC	Winter Social	TBA	TBA	TBA
13	Sep	WA	Tech night	Schlumberger Oil&Gas	TBA	TBA
20	Sep	NSW	Tech night	TBA	1730–1900	99 on York, 99 York Street, Sydney
11	Oct	WA	Tech night	Bill Peters	1730–1900	TBA
18	Oct	NSW	Tech night	TBA	1730–1900	99 on York, 99 York Street, Sydney
08	Nov	WA	Student presentations	Various	TBA	TBA
15	Nov	NSW	Tech night	TBA	1730–1900	99 on York, 99 York Street, Sydney

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

Nominate a colleague for an ASEG Honour or Award for 2018

An important role of the ASEG is to acknowledge the outstanding contributions of its individual Members both to the profession of geophysics and to the ASEG. The Society has a number of different Honours and Awards across a range of categories. Nominations are now open for the next round of Awards scheduled to be presented in conjunction with AEGC 2018, to be held from 18–21 February 2018 in Sydney.

All ASEG Members as well as State and Federal executives are invited to nominate those they consider deserving of these awards. A list of the various available awards is set out below.

These awards carry considerable prestige within the Society and the geoscience community and therefore require some documentation to support the nomination. Please contact the Committee Chair, Andrew Mutton, if you require further guidelines on what is required.

ASEG Gold Medal

For exceptional and highly significant distinguished contributions to the science and practice of geophysics, resulting in wide recognition within the geoscientific community. The nominee must be a Member of the ASEG.

Honorary Membership

For distinguished contributions by a Member to the profession of exploration geophysics and to the ASEG over many years. Requires at least 20 years as a Member of the ASEG.

Grahame Sands Award

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

Nominations now open for awards to be presented at the AEGC in Sydney in February 2018

Lindsay Ingall Memorial Award

For the promotion of geophysics to the wider community. This award is intended for an Australian resident or former resident for the promotion of geophysics (including but not necessarily limited to applications, technologies or education), within the non-geophysical community, including geologists, geochemists, engineers, managers, politicians, the media or the general public. The nominee does not need to be a geophysicist nor a Member of the ASEG.

Early Achievement Award

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

ASEG Service Awards

For distinguished service by a Member to the ASEG, through involvement in and contribution to State Branch committees, Federal Committees, Publications, or Conferences over many years. The nominee will have been a Member of the ASEG for a sustained period of time. All nominations will be considered for the award of an ASEG Service Certificate. Where the nomination details outstanding contributions to the shaping and the sustaining of the Society and the conduct of its affairs over many years, consideration will be given to the award of the ASEG Service Medal to the nominee. Honorary Members are not eligible for nomination.

Nomination procedure

Any Member of the Society may nominate applicants. These nominations are to be supported by a seconder, and in the case of the Lindsay Ingall Memorial Award by at least four geoscientists who are members of an Australian geoscience body (e.g. GSA, AusIMM, AIG, IAH, ASEG or similar).

Nominations must be specific to a particular award and all aspects of the defined criteria should be addressed. To gain some idea of the standard of nomination expected, nominees are advised to read past citations for awards published in the *Preview* edition immediately following each conference.

Lists of previous awardees, award criteria and nomination guidelines can be found on the ASEG website at: https://www.aseg.org.au/about-aseg/honours-awards *Proforma* nomination forms are available from the website or by contacting the Committee Chair. Nominations including digital copies of all relevant supporting documentation are to be sent electronically to:

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

Awards for geoscientists in the 2017 Queen's Birthday Honours list

The ASEG would like to congratulate the following worthy recipients of prestigious awards in the 2017 Queen's Birthday Honours list.

Dr Phil McFadden: For distinguished service to earth sciences as a geophysicist, through leadership of Australia's peak geoscience body, through collaboration and innovation in research, and to professional societies. Officer (AO) in the General Division of the Order of Australia.

Professor Andrew Gleadow: For distinguished service to the earth sciences, and to education, as an academic and researcher in the field of thermochronology and landscape evolution, and to professional geological and scientific societies. Officer (AO) in the General Division of the Order of Australia.

Dr Brian Richards: For distinguished service to geotechnical engineering and soil science, particularly through research and development of measuring and understanding soil suction and its effect on soil strength. Officer (AO) in the General Division of the Order of Australia.

Fulbright Senior Scholarship for Professor Anya Reading

Anya Reading at the Australian-American Fulbright Commission Gala evening for 2016, Melbourne, prior to her sabbatical semester in Colorado.

Anya Reading, Professor of Geophysics at the University of Tasmania, has spent February-June 2017 carrying out research into the 3D structure of the Antarctic lithosphere at the Centre for Imaging the Earth's Interior, Department of Physics, University of Colorado, Boulder, USA. Anya's research focus while in Boulder was the comparison of Bayesian algorithms for Earth imaging using seismic tomography. The extended visit was made possible through a Fulbright Senior Scholarship awarded in the 2016 round by the Australian–American Fulbright Commission.

During her time in the US, Anya gave seminars at 12 academic institutes in Colorado, and also in locations as far east as Penn State University and as far west as University of California, Berkeley. In the spirit of the Fulbright program, she laid foundations for future collaborations between US and Australian researchers in seismology, Earth imaging and machine learning. While the visit had a research focus, Anya also took the opportunity to discuss Earth Sciences teaching and STEM education in general at both public and private universities.

Alongside the formal research and education visits, Anya took time for mentoring discussions with early career researchers and graduate students, gave radio interviews and outreach talks, and found time to develop new skills in downhill skiing.

Vale: Dr Phillip Playford AM (1932–2017)

Dr Playford after the unveiling of the HWB Talbot memorial in Nannup Cemetery, November 2007.

The ASEG is saddened by the death of Dr Phillip Playford AM at the age of 85 after a long battle with cancer.

Dr Playford was born and grew up in Western Australia. He holds a BSc (Hons) in geology, an Honorary DSc from the University of Western Australia, and a PhD from Stanford University. He attended Stanford as a Fulbright Scholar.

Phil had a career with both government and the oil exploration industry. He was a former Director of the Geological Survey of WA and is well known through his many publications and lectures on the geology and history of the State. He is particularly renowned for his work on the Devonian reef complexes of the Canning Basin and geology of the Shark Bay area, and as a primary discoverer of the Zuytdorp wreck, the first Dutch wreck to be found and identified in Western Australia. His book 'Carpet of Silver; The wreck of the Zuytdorp' received a Premier's prize for literature, and another, 'Voyage of discovery to Terra Australis by Willem de Vlamingh in 1696–97', was short listed for a Premier's award.

Phil was an Honorary Associate of the Geological Survey and the WA Museum, a Fellow of the Geological Society of Australia, and a Fellow of the Australian Academy of Technological Sciences and Engineering. Among the honours he has received are the Lewis G Weeks Gold Medal of The Australian Petroleum Production and Exploration Association, a Special Commendation Award of the American Association of Petroleum Geologists, the Gibb Maitland Medal of the Geological Society of Australia, and the Medal of the Royal Society of WA. In 1998 he was made a Member of the Order of Australia for his contributions to knowledge of the geology and history of Australia.

Update from the AEGC 2018 Conference Organising Committee

At the time of writing there are only seven months until the conference and still a lot to do. Extended abstracts are being lodged, booths are being sold, workshops have been finalised and sponsors are being sorted.

Early bird registration is now open. It will close on 31 October 2017, so get in quickly! The exhibition hall is filling up fast so if your company would like a booth, please get in contact with us ASAP. The prospectus is available for download on the conference website: http://www.aegc2018.com.au/. The Conference Organising Committee has endeavoured to contact as many companies as possible – if your company hasn't been contacted please let us know ASAP!

There are still sponsorship opportunities available if your company is looking for exciting promotion opportunities. Again, please do not hesitate to contact us if you are interested and would like further information.

We have reviewed all the initial abstracts and have decided on the draft programme. We were very impressed with the quality of the abstracts and are very happy with the programme. Our thanks to all who submitted an abstract, this is an exciting programme. For those of you who will be giving an oral or poster presentation, please do not forget that the extended abstracts will need to be submitted by the end of August.

We have now confirmed all the keynote speakers. All keynote speakers are listed in the table below and the conference website contains photos and a short biography of most of them.

Please stay tuned to the website for any updates to this programme. We are also constructing an exciting schools programme. Local high schools will be invited to participate in an information day to learn about the geophysical industries, and be given the opportunity to visit the trade exhibition. We are also finalising a couple of excursions to visit some key geological sites in the region.

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

Max Williamson
Co-Chair Petroleum

Table 1. Confirmed Keynote speakers

Speaker	Affiliation
Peter Baillie	CGG
Katarina David	University of New South Wales
Natasha Hendrick	Santos
Kevin Hill	Oilsearch
Jim Macnae	RMIT
Graham Heinson	University of Adelaide
Richard Flook	Private Consultant in Industrial Minerals
Ryan Noble	CSIRO
John McGaughey	MIRA Geoscience
Richard Hillis	Deep Exploration Technologies CRC
Kevin Ruming	Geological Survey of NSW
Ross Large	University of Tasmania
Steve McIntosh	RioTinto
Mike McWilliams	CSIRO
Richard Blewitt	Geoscience Australia

SAVE THE DATE!

AEGC2018

FIRST AUSTRALASIAN EXPLORATION GEOSCIENCE CONFERENCE

18-21 FEBRUARY 2018 | SYDNEY AUSTRALIA

EXPLORATION • INNOVATION • INTEGRATION

On behalf of the Conference Organising Committee, we would like to invite you to attend the First Australasian Exploration Geoscience Conference in Sydney, to be held from February 18-21 2018. The event will be jointly hosted by ASEG, PESA and AIG. The theme of the meeting is Exploration, Innovation and Integration.

The Conference will also incorporate the Eastern Australia Basins Symposium normally managed by PESA and the rolling 18 months Conference of ASEG and will be home to the highest quality technical program and Exhibition that members will have grown accustomed to from our three organisations.

Discover Sydney, Australia's famous harbour city and capital of New South Wales. Plan your Sydney visit with beautiful sundrenched beaches and much more.

See you in Sydney in 2018!

Max Williamson and Mark Lackie (Co-Chairs)

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Mineral Exploration Trends and Developments 2017

Ken Witherly
ken@condorconsult.com

Dr Peter Hood founding Editor of ETD.

Dr Pat Killeen, current Editor of ETD.

The 2017 edition of ETD (Mineral **E**xploration **T**rends and **D**evelopments) again tracks new developments in exploration technology from around the world. ETD has been published since 1965, and has been under the stewardship of only two editors; Dr Peter Hood and Dr Pat Killeen. Dr Hood started ETD (initially just called Trends and Developments) and continued as Editor until 1992 when Dr Killeen took over. In addition to their duties as ETD Editors, both Hood and Killeen have had long and distinguished careers with the Geological Survey of Canada.

The Northern Miner Press, which took on publishing ETD in 2004, provides it as a special supplement to the early March edition of the *Northern Miner*. In the past decade KEGS (Canadian Exploration Geophysical Society) became the primary patron for ETD, but gradually more commercial support was found for the publication. Most recently DMEC (Decennial Minerals Exploration Conferences) has taken over the role of major patron for ETD, and with it the responsibility for the funds raised to cover the costs associated with publication. The current supporters of ETD are listed on the inside cover of the publication and their support is gratefully acknowledged. Any group working in exploration technology can submit material for potential inclusion in the next edition of ETD. Those interested in submitting material can contact Pat via email (his contact is provided at the end of this article).

In summary, the latest edition of ETD reports that the business climate in 2016 was an improvement over 2015 and companies appeared to be putting more funds into improving their technology.

Killeen noted the following as important advances:

- TDEM: more companies modified helicopter-borne TDEM systems to fly surveys faster.
- Airborne Gravity Gradiometer (AGG): a new generation AGG system was successfully test flown and another company has a new AGG system in development.
- Airborne IP: more companies are processing AEM data for IP information and even including it in joint inversions.
- Drones: more companies are providing magnetic survey capabilities using drones and some are offering radiometrics. EM still appears to be in development.
- 3D IP-array style systems are becoming more common place.
- Modeling of all types of data is advancing.
- Borehole: there are significant advances in acquisition and processing of EM, IP, magnetic gravimetric sensors.

The introduction to ETD cites continuing slow level of activity in the industry, but notes that innovation continued regardless. In the Airborne Section there is a clear move to the heli-time domain EM systems that have become the industry standard for airborne EM surveys. Table 1 shows EM systems included in last year's ETD and indicates which systems have reported major changes/improvements to the technology over the past year. Two new systems are also shown. The reported efforts on improvements relate to technical and operational efficiencies – getting more data cheaper.

The drone story continues to advance and, encouragingly, more case studies are being provided so as to allow the industry to assess this technology. One that EGGS has provided is 'Drone Topographic Mapping of Great Sand Dunes National Park.' The issue of FastTIMES containing this case study can be accessed at the url provided eegs.org/FastTIMES/Latest Issue. The next Society of Exploration

Table 1. EM systems included in the 2016 and 2017 ETD

System	Company	Head office
VTEM[A]	Geotech Ltd	Canada
HeliTEM[A]	CGG MultiPhysics	Canada
SkyTEM[A]	SkyTEM	Denmark
Xcite	New Resolution Geophysics	South Africa
GPRTEM2	Geophysics GPR	Canada
Poco	Terraquest	Canada
P-THEM	Pico Envirotec	Canada
AirTEM	Triumph Surveys	Canada
New for 2017	**New for 2017**	**New for 2017**
ITEM	Precision GeoSurveys	Canada
EQUATOR (combined TD/FD)	GeoTechnologies	Russia

[A]ETD 2017 indicates major changes in past year.

Table 2. Gravity systems included ETD 2017

System	Company	Head office
HD-AGG[A]	GEDEX	Canada
Falcon family[A]	CGG MultiPhysics	Canada
Lockheed Martin FTG[A]	Austinbridgeporth	UK
Lockheed Martin FTG[A]	Bell Geospace, Inc.	USA
AIRGrav	Sander Geophysics	Canada
TAGS-6	GyroLAG	South Africa
CMG GT-2A	MagSpec Airborne Surveys	Australia
CMG GT-2A	New Resolution Geophysics	South Africa
CMG GT-2A	Prospectors A.S. Ltda.	Brazil
CMG GT-2A	Terraquest	Canada
CMG GT-1A/GT-2A	Thompson Aviation	Australia
CMG GT-2A	Geotech/UTS Geophysics	Canada/Australia
CMG GT-1A/GT-2A	CGG MultiPhysics	Canada

[A]*Gravity gradient systems.*

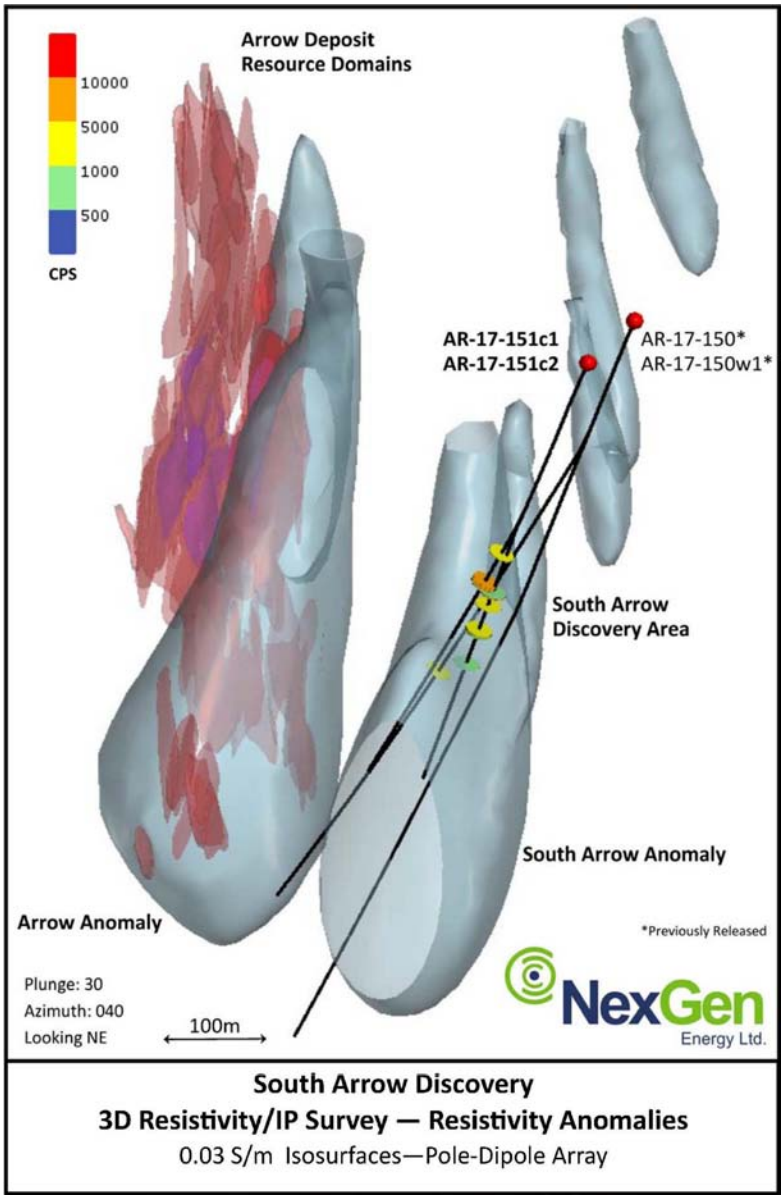

Figure 1. *Results of a 3D IP/resistivity survey carried out by Dias Geophysical for the NexGen Energy Ltd on their Arrow property.*

Geophysicists conference (Houston, October 2017) is slated to have a workshop on drones.

There are now a significant number of contractors offering airborne gravity (Table 2), with the Lockheed Martin systems the most popular AGG technology and the Canadian Microgravity (CMG) GT-2A the most popular scalar technology offered. For a recent update on airborne gravity technology, the video recording of the Airborne Gravity workshop held at the 2016 ASEG conference is now available on the GA website: http://www.ga.gov.au/scientific-topics/disciplines/geophysics/gravity.

On the ground technology front (includes petrophysics and borehole), most groups seem to be taking a similar tack to the airborne contractors, where the emphasis has been on improving existing products rather than taking large leaps into major new technology. One system that caught my attention was a new magnetic instrument called the Qmeter Magnetization Meter being offered by Terraplus. The purpose of the system is 'to measure and differentiate remnant magnetization from induced magnetization'. What is interesting is that the idea behind the technology appears in article published in *Exploration Geophysics* in 2014 (Schmidt and Lackie, 2014). It is not that often we can see an idea advanced from a journal to a commercial product in such a short time. Wouldn't it be great to see this happen more often!

We hope all the 3D IP-resistivity systems noted in the last report are out in the field getting well used. A nice example of one system in action came out last week from the Athabasca Basin (Canada), one of the major areas of exploration focus for high grade uranium. Figure 1 shows the results of a 3D IP/resistivity survey carried out by Dias Geophysical for the NexGen Energy Ltd on their Arrow property. NexGen states in their press release (http://www.nexgenenergy.ca/news/index.php?content_id=303) that the drilling of the new Arrow South zone with significant uranium mineralization encountered was in part due to the results of the 3D survey.

In closing I quote some lines from the first ETD (1965): 'A vibrating-string gravimeter suitable for use in a drill-hole has been developed by Shell Oil Company (Goodell and Fay, 1964). It is claimed that it is capable of measuring

differences between stations of one milligal and that it has proved to be a useful instrument for determining average densities over a one thousand foot section'. When reading these lines it struck me that our quests for better technology and useful data are seldom solved quickly but require enormous time and effort to achieve useful results.

The full ETD report and tables can be accessed on the KEGS website: http://www.kegsonline.org/?dir=6&sub=23&typo=news&doc=1062&action=show&title=Trends%20in%20Geophysics%202016.

The full record of ETDs since 1965 can be found on Condor Consulting, Inc. website (www.condorconsult.com) under Downloads\ETD Archive.

If you have a story you would like included in the next ETD, please contact Pat Killeen at pkilleen@xplornet.ca to get on the mailing list.

Reference

Schmidt, P. W., and Lackie, M. A., 2014, Practical considerations: making measurements of susceptibility, remanence and Q in the field: *Exploration Geophysics*, **45**(4), 305–313. doi:10.1071/EG14019

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 12 July 2017)

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

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km^2)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Murloocoppie	GSSA	GA	MAGSPEC Airborne Surveys	11 Feb 2017	109 560	200 m 60 m EW	19 540	25 May 2017	Contract executed by GA 12 Jan 2017. Field data were delivered to GA in Jun 2017.	183: Aug 2016 p. 34	TBA
Warrina	GSSA	GA	MAGSPEC Airborne Surveys	11 Feb 2017	135 628	200 m 60 m EW	24 140	25 May 2017	Contract executed by GA 12 Jan 2017. Field data were delivered to GA in Jun 2017.	183: Aug 2016 p. 34	TBA
Andamooka	GSSA	GA	Sander Geophysics	23 Feb 2017	81 396	200 m 60 m EW	14 560	The survey flying was completed on 6 Jun 2017	Contract executed by GA 17 Jan 2017. Field data were delivered to GA in Jun 2017.	183: Aug 2016 p. 34	TBA
Barton	GSSA	GA	Thomson Aviation	22 Jan 2017	111 758	200 m 60 m EW	20 560	11 May 2017	Contract executed by GA 12 Jan 2017. Field data were delivered to GA in Jun 2017.	183: Aug 2016 p. 34	TBA
Fowler	GSSA	GA	Thomson Aviation	18 Feb 2017	95 009	200 m 60 m EW	17 360	2 Jun 2017	Contract executed by GA 12 Jan 2017. Field data were delivered to GA in Jun 2017.	183: Aug 2016 p. 34	TBA
Torrens	GSSA	GA	Sander Geophysics	4 Mar 2017	79 990	200 m 60 m EW	14 800	15 Jun 2017	Contract executed by GA 17 Jan 2017. Field data were delivered to GA in Jun 2017.	183: Aug 2016 p. 34	TBA
Coonabarabran	GSNSW	GA	UTS Geophysics	17 May 2017	50 827	250 m 60 m EW	11 000	TBA	Contract executed by GA 12 Jan 2017. The survey is 44% complete to 10 Jul 2017.	184: Oct 2016 p. 23	The survey mobilised on 10 May 2017
Tasmanian Tiers	MRT	GA	TBA	TBA	Up to an estimated 66 000	200 m 60 m NS or EW	11 000	TBA	TBA	TBA	National Collaborative Framework Agreement between GA and MRT was expected to be executed in Apr 2017. The survey has been deferred to occur between Oct 2017 and Mar 2018
Isa Region	GSQ	GA	GPX	3 Jul 2017	Estimated 120 000	100 m 50 m EW	11 000	TBA	TBA	188: Jun 2017 p. 21	TBA

TBA, to be advised.

Table 2. Gravity surveys

Survey name	Client	Project management	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Stavely	GSV	GA	Atlas Geophysics	3 Dec 2016	Approx. 3465	200 m station interval along 14 traverses	200 m station spacing on 14 individual traverses	5 Jan 2017	23 Feb 2017	The proposed survey covers parts of the Horsham, Hamilton, Ballarat and Colac Standard 1:250 000 map sheets. The survey is to collect gravity stations spaced 200 m apart on 14 separate road traverses.	17 Jun 2017
Coompana – PACE area	GSSA	GA	Atlas Geophysics	30 Jan 2017	13 801	Regular grid of 2, 1 and 0.5 km	20 000	4 Mar 2017	21 Mar 2017	183: Aug 2016 p. 34	26 Jun 2017
Tanami-Kimberley	GSWA	GA	Thomson Aviation	16 Jun 2017	Up to 50 000	2500 m line spacing	110 000	TBA	TBA	187: Apr 2017 p. 22	TBA
Kidson Sub-basin	GSWA	GA	CGG Aviation (Australia)	14 Jul 2017	Up to 70 000	2500 m line spacing	155 000	TBA	TBA	The proposed survey area covers the Anketell, Joanna Spring, Dummer, Paterson Range, Sahara, Percival, Helena, Rudall, Tabletop, Ural, Wilson, Runton, Morris and Ryan 1:250 k standard map sheet areas	TBA
South Nicholson	GA	GA	Atlas Geophysics	30 Jul 2017	2724	4 km spacing	43 330	TBA	TBA	The proposed survey area covers parts of the Mount Drummond, Ranken and Avon Downs standard 1:250 k map sheet areas	TBA

TBA, to be advised.

Table 3. AEM surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Musgraves – PACE Area	GSSA	GA	CGG Aviation	18 Aug 2016	8489	2 km; E–W lines	16 371	The survey completed flying on 17 Sep 2016	Expected on 24 Nov 2016	179: Dec 2015 p. 23	Released on the GA website on 19 Apr 2017
Musgraves – CSIRO Area	GSSA	GA	SkyTEM Australia	15 Sep 2016	7182	2 km; E–W lines	14 320	The survey completed flying on 13 Oct 2016	Expected early Dec 2016	179: Dec 2015 p. 23	Preliminary final data were supplied to GA in Jan 2017. Data to be released on the GA website in Sep 2017.
Isa Region	GSQ	GA	Geotech Airborne	8 Aug 2016	15 692	2 km; E–W	33 200	The survey completed flying on 4 Nov 2016	TBA	182: Jun 2016 p. 23	TBA
AusAEM (Year 1)	GA	GA	CGG	TBA	<50 000	20 km with areas of infill	TBA	TBA	TBA	186: Feb 2017 p. 18	TBA
Ord-Keep River	GA	GA	SkyTEM Australia	May 2017	6146	Variable	TBA	TBA	TBA	TBA	TBA
Surat-Galilee Basins QLD	GA	GA	SkyTEM Australia	14 Jul 2017	4477	Variable	Traverses	TBA	TBA	188: Jun 2017 p. 21	TBA
Stuart Corridor, NT	GA	GA	SkyTEM Australia	Jun 2017	8626	Variable	Traverses	TBA	TBA	188: Jun 2017 p. 22	TBA

TBA, to be advised.

In other news, the 2016 ASEG conference Airborne Gravity Workshop videos are now available from GA's website http://www.ga.gov.au/scientific-topics/disciplines/geophysics/gravity. GA would like to acknowledge and thank the ASEG, as well as the organisers of the conference workshop and, particularly, the speakers.

Geological Survey of South Australia: Gawler Craton Airborne Survey

Data acquisition of the first six regions of the Gawler Craton Airborne Survey was completed in mid-June. The completed regions represent approximately 600 000 line kilometres out of a total of 1 800 000 line kilometres of new magnetic, radiometric and digital elevation data and a survey area totalling 324 000 km^2. This new data will surpass the current patchwork of historical surveys and provide a single, uniform dataset that will be fundamental in reinterpreting the geological structure of the Gawler Craton (see Figure 1).

The second phase of the survey is scheduled to begin in August 2017. The survey, being undertaken by the Government of South Australian in partnership with Geoscience Australia is a key programme within the Plan for Accelerating Exploration (*PACE*) Copper initiative, part of South Australia's Copper Strategy.

The geophysical data is being captured by fixed-wing aircraft flying approximately 60 m above the ground along flight lines spaced 200 m apart. Approximately 25 000 land parcels are covered by the survey and a key element in coordinating landholder and community information for this very large programme has been a dedicated web page with near-real-time survey flight plans and other general information about the survey. Subscribers to email updates are informed of project milestones and are provided with the necessary tools to find further information or contact the contractors flying in their area. These additions to the programme acknowledge the public value of the work being carried out. Further information can be found at minerals.statedevelopment.sa.gov.au/gcas.

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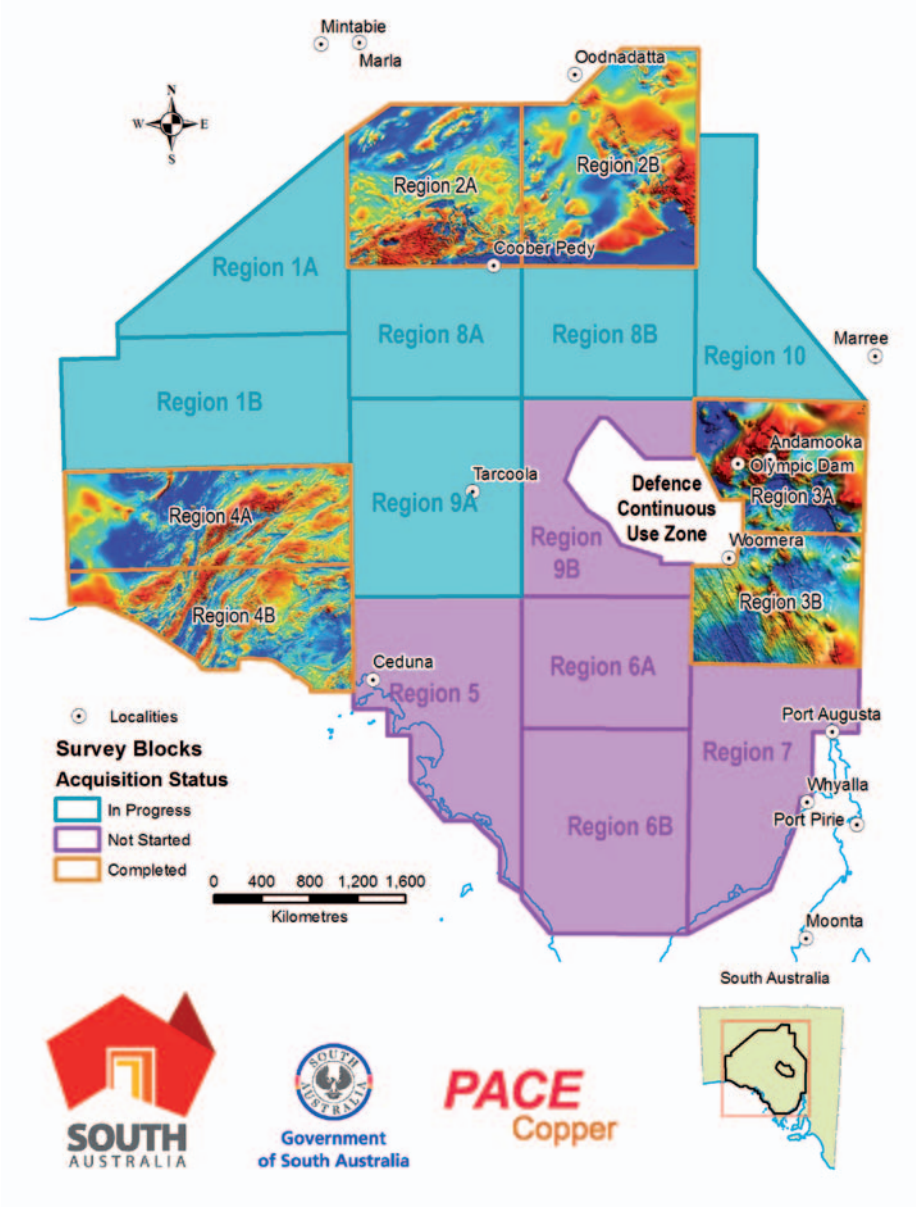

Figure 1. *Map showing preliminary total magnetic intensity over the completed portions of the PACE Copper Gawler Craton Airborne Survey. Areas shown in blue are scheduled to commence in August, 2017. Areas shown in mauve are scheduled to commence acquisition early in 2018.*

Geological Survey of Victoria: Science in the Surveys 2017 presentations now available

Rapt audience for Science in the Surveys 2017.

The Geological Survey of Victoria (GSV) recently hosted Science in the Surveys 2017 on behalf of Australia Minerals – a collaboration of Australia's federal, state and territory government geoscience agencies. The theme was 'Impediments to exploration success: solutions and implementation strategies'. The bi-annual, one-day conference was attended by over 150 delegates from across government, industry, and research both from Australia and abroad.

Presentations and posters were delivered by senior representatives from each of the geoscience agencies, as well as CSIRO, AMIRA International (the UNCOVER initiative), and Deep Exploration Technologies CRC (DET CRC). Topics covered included updates on pre-competitive geoscience programmes, minerals exploration incentive schemes and initiatives across the country. The state, territory and national geoscience agencies presented new research, data and mineral exploration opportunities. Copies of the government presentations are available online at http://australiaminerals.gov.au/conferences.

Highlights included:

A keynote presentation from Dan Wood AO on 'Future Exploration – How we will need to explore' (Society of Economic Geologists' 2017 Thayer Lindsley Visiting Lecturer);

Astronomer, professional astrophysicist and passionate science communicator Dr Alan Duffy on 'Dark Matter Detection – Parallels with resource exploration' (Research Fellow and Associate Professor at Swinburne University of Technology); and

Professor Peter Betts on 'The value of regional geophysical data in terrane scale assessments' (Associate Dean Graduate Research at Monash University).

Attendees were able to directly engage with senior government geoscientists whilst perusing a large poster display in the foyer of the Melbourne venue. The greatly coveted door prize – a high-grade mineralised sample from the Fosterville Gold Mine, kindly gifted to the event by Kirkland Lake Gold Ltd – was won by a lucky Monash University student.

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Mineralised hand specimen from the Fosterville underground gold operation.

Canberra observed

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Trump proposes big cuts to science in 2018 US budget: how will they affect Australia?

I often complain about low levels of investment in science by Australian governments, whether they be Labor or the Coalition. At least most of them recognise the importance of Research and Development, even if the rhetoric isn't always backed up by the numbers in the budgets.

Not so Donald Trump. His 2018 budget request as presented to Congress appears to be a bad deal for science, health, and all research unless it involves nuclear technology and defence.

The outlays proposed by Trump for 2018 will be approximately the same as in 2016 but $47 billion more will be allocated to the military, $20 billion more to infrastructure and there will be miscellaneous increases of $5 billion. Consequently, to achieve the same outlay, savings of $72 billion will have to be found in other areas.

It should be noted that in 2016 US military investment was estimated as more than the total military spending from the next eight biggest-spending countries. To put this in perspective, the increase requested in one year is larger than Japan's total annual military spending in 2016.

Before some of the detailed programmes are considered, it is worthwhile comparing the size of the US budget with Australia's.

Table 1 compares the overall outlays in US$ for the US and Australia. The annual per-capita investment is US$12 500 in the US and US$14 000 in Australia. The debt/GDP value is much worse in the US, but the R & D investment in the US (according to the latest OECD report https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm) at 2.8% GDP is much better than Australia's 2.1% GDP, which is below the OECD average of 2.4%.

Cuts to US science agencies

Figure 1 from http://www.sciencemag.org/news/2017/03/trumps-first-budget-analysis-and-reaction shows how the main science agencies fared in the President's budget request. Since the President tabled his requests in June 2017, a House of Representatives appropriations subcommittee has already advanced a $37.5 billion energy and water bill that would slash funding for renewable and efficiency programmes and eliminate the Advanced Research Projects Agency-Energy agency, which had a budget of over $300 million in 2017.

Fortunately all the President's proposals will have to be approved by Congress, so the lobbying will already have started to amend his proposals. The estimated R & D investment by the US Science Agencies in 2017 was about $140 billion, of which half was spent by the Department of Defence. Therefore, there must be savings from the other agencies of approximately $70 billion to meet the overall budget outlays. In this context the USGS, which had a budget of just over $1 billion in 2017 is small, but significant. Its role and functions are similar to Geoscience Australia's.

How did the USGS fare?

The President Trump has proposed a $922.2 million allocation for the US Geological Survey in 2018. This amounts to a saving of $137.8 million from the FY 2017 allocation or a cut of 13 percent.

The Minerals and Energy programmes remain intact, which is good, but there is a 19% cut in the Natural Hazards Programme from the $145 million provided in 2017 to the $118 million, requested. A good summary of what the impact would be is at: https://www.usgs.gov/news/president-proposes-922-million-fy18-budget-usgs

This two-page document has been prepared by the USGS and is accessible in the public domain, presumably for consideration by lobbyists, stakeholders, and clients. It contains summaries of the goals of the different programmes and what the impact would be if the President's budget is accepted.

There is no equivalent process in Australia. It's like the Director of the National Library of Australia producing a public document to outline the impact of the efficiency divided cuts on the NLA's programme. I don't think the Government would allow such openness.

Table 2 summarises the situation for each of the Hazard Programmes in the USGS.

The most significant of these proposals is probably the elimination of the Geomagnetic Programme, a component of the multi-agency US National Space Weather Programme. This would not only affect the United States, but has global implications. It would mean there would be almost no reliable, real-time,

Table 1. Comparisons between Federal USA and Australian budgets

Comparisons between Federal USA and Australian budgets (assume A$ = US$0.78)[A]					
2017/18 estimates	Population millions	Outlays (billions, US$)	Current debt % GDP	Target year for balanced budget	Military spending billions 2016 + (US and Aus. for 2018)
US	327	4100	77	2027	611+ (47)
Australia	25	350	25	2020	25 + (2)

[A]*From the following websites:*
https://www.google.com.au/search?q=A+Quick+Summary+of+President+Trump%27s+FY+2018+Budget&oq=A+Quick+Summary+of+President+Trump%27s+FY+2018+Budget&aqs=chrome..69i57j69i64j69i60.2687j0j8&sourceid=chrome&ie=UTF-8
http://budget.gov.au/2017-18/content/glossies/overview/download/Budget2017-18-Overview.pdf
https://www.sipri.org/sites/default/files/Trends-world-military-expenditure-2016.pdf
https://www.nytimes.com/2017/05/22/us/politics/trump-budget-winners-losers.html

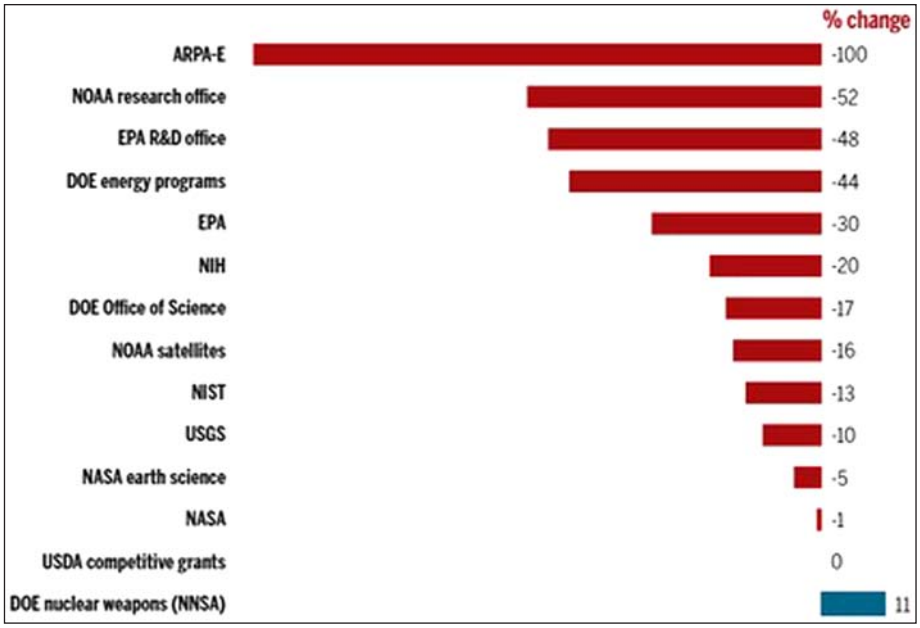

Figure 1. *Cuts to USA Science Agencies in in Donald Trump's 2018 budget request. Source: http://www.sciencemag.org/news/2017/03/trumps-first-budget-analysis-and-reaction). ARPA-E, Advanced Research Projects Agency (Department of Energy); NOAA, National Oceanic and Atmospheric Administration (US Department of Commerce); EPA, Environmental Protection Agency; DOE, Department of Energy; USGS, US Geological Survey; NIH, National Institutes of Health; NIST, National Institute of Standards and Technology; NASA, National Aeronautics and Space Administration; USDA, US Department of Agriculture.*

open access of geomagnetic data from the US and its Territories (including Antarctica).

The long time-series of geomagnetic activity, some covering periods of more than 100 years, would be interrupted and the standard geomagnetic indices would not be measured over a significant part of the globe. These data are used to provide geomagnetic storm alerts for aeromagnetic surveys, operators of electricity grids and satellite systems.

The accuracy of the International Geomagnetic Reference Field (IGRF) would be degraded without US input of both data and modelling capability. This will affect the results from aeromagnetic surveys where the data are blended with earlier and overlapping surveys and where the IGRF is used to determine the anomalies.

The US commitments to the World Data Centres in Japan and Germany will no longer be met. The Paris Climate Accord revisited?

How will these changes affect Australia?

At least four issues could/would affect Australia:

1. The geomagnetic global data-set will be degraded and the quality of the applications of these datasets for global studies will be reduced because of the gaps.
2. The global expertise in recording, analysing, and using the geomagnetic data will be significantly reduced. Although only 15 people are employed in this programme, they have very special skills that will be lost to the global geophysical community.
3. The anti-science factor in the Australian Parliament may use the Trump budget as an opportunity to reduce the Australian capability, not just in geomagnetism but throughout the science sector. Notice that the global seismological programme has also been cut by Trump.
4. If the US withdraws from this discipline, it could withdraw from other global studies carried out by NOAA and NASA and this would result in a bad outcome for everyone on planet Earth.

The Agencies like NOAA, NASA, the USGS and the NSF are the ones that have made America great. There is no point in spending big on defence if there is not enough to sustain these wonderful institutions.

I hope that the value of these agencies will be recognised and the resources needed to carry on their good work will be provided, but lobbying from Australia is unlikely to work – we would just be asked to contribute to the short fall!

Table 2. Impact of Donald Trump's 2018 budget request on the USGS Hazard Programmes

Programme	Budget request	FTE	Reduction from 2017	FTE losses
Earthquake Hazards	$51 388 000	220	$9 000 000	12
Volcano Hazards	$22 432 000	135	$3 639 000	7
Landslide Hazards	$3 531 000	22	0	0
Geomagnetism	$0	0	$1 884 000	15
Global Seismographic Network	$4 986 000	10	$1 455 000	2
Coastal-Marine Hazards and Resources	$35 774 000	188	$4 659 000	16

FTE, full-time equivalent staff.

New World Stress Map released

For the 30th anniversary of the World Stress Map project a new data base, WSM 2016, has been released. It now contains 42 870 data records from a number of regions including Australia, Canada, Great Britain, Iceland, Texas, Oklahoma, Switzerland, China, Italy, and New Zealand. The number of data records has almost doubled since the last major release in 2008. They have all been added in a standardised format and quality-ranked for reliability and comparability on a global scale. The new data include the observations from approximately 4000 boreholes.

The WSM project started in 1986 as a project of the International Lithosphere Programme (ILP), under the leadership of Mary-Lou Zoback. From 1995 to 2008 it was a project of the Heidelberg Academy of Sciences and Humanities headed by Karl Fuchs and Friedemann Wenzel. Since 2012 the WSM is a member of the ICSU World Data System. The data are maintained at the Helmholtz Centre Potsdam GFZ German Research Centre.

All stress information is analysed and compiled The WSM is an open-access public database and is used by various academic and industrial institutions working in a wide range of Earth science disciplines such as geodynamics, hazard assessment, hydrocarbon exploitations and engineering. The main operational areas are:

- Reservoir characterisation and management
- Stability of mines, tunnel, boreholes and waste disposal sites
- Calibration of geomechanical-numerical models
- 4D Thermo-Hydro-Mechanical (THM) simulations
- Hazard assessment, e.g. by means of fault-slip tendency and fracture potential analysis.

The website is: http://www.world-stress-map.org/ and Figure 1 shows the detail of data in the World Stress Map in the Australian region.

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Heidbach, O., Rajabi, M., Reiter, K., Ziegler, M., and WSM Team, 2016, World Stress Map database release 2016. GFZ Data Services. doi:10.5880/WSM.2016.001

Heidbach, O., Tingay, M., Barth, A., Reinecker, J., Kurfeß, D., and Müller, B., 2010, Global crustal stress pattern based on the World Stress Map database release 2008: *Tectonophysics*, **482**, 3–15. doi:10.1016/j.tecto.2009.07.023

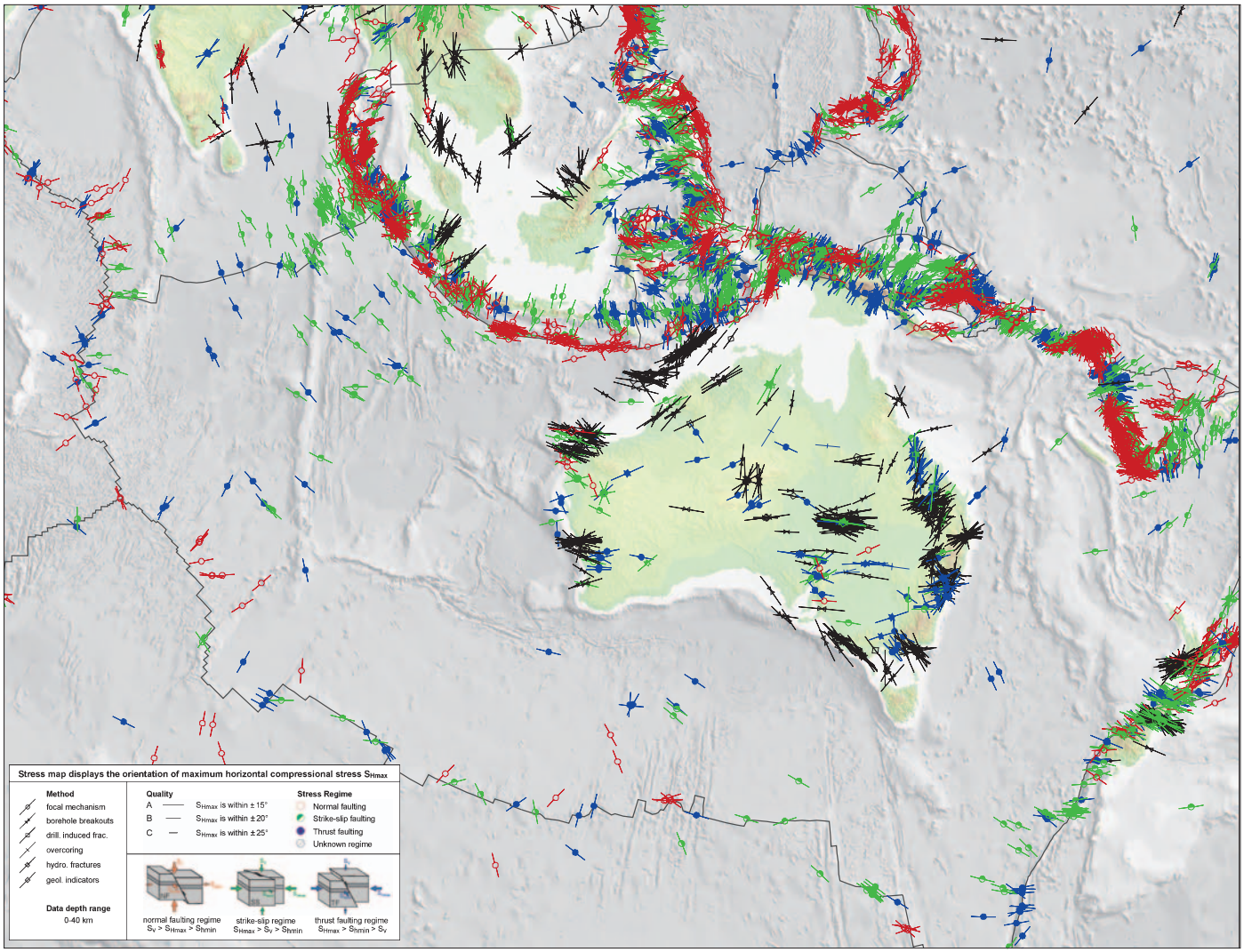

Figure 1. *Detail of data in the World Stress Map in the Australian region. Source: http://www.world-stress-map.org/*

Education matters

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Clean energy transition will increase demand for minerals: World Bank

Students today are understandably cautious about employment prospects in the future, with the move away from fossil fuels in the western world, and the increasing levels of environmental restrictions which limit exploration and development in both the hydrocarbon and mineral industries. I was glad to read a note of optimism this month in a report from the World Bank ('The Growing Role of Minerals and Metals for a Low-Carbon Future' http://documents.worldbank.org/curated/en/207371500386458722/The-Growing-Role-of-Minerals-and-Metals-for-a-Low-Carbon-Future).

The report highlights the potential impacts that the expected continuing boom in low-carbon energy technologies will have on demand for many minerals and metals; far from anticipating a reduction in demand for mineral commodities under the scenario of a low-carbon future, it predicts growing demand for selected minerals and metals as the world works towards commitments to keep the global average temperature rise at or below 2°C.

Minerals and metals expected to see heightened demand include: aluminium, copper, lead, lithium, manganese, nickel, silver, steel, and zinc, and rare earth minerals such as indium, molybdenum, and neodymium. The most significant example is electric storage batteries, where the rise in relevant metals – aluminium, cobalt, iron, lead, lithium, manganese, and nickel – grow in demand from a relatively modest level under 4°C to more than 1000 percent under 2°C.

The report shows that a shift to a low-carbon future could result in opportunities for mineral-rich countries, but also points to the need for these countries to ensure they have long-term strategies in place that enable them to make smart investment decisions. In readiness for growth in demand, countries will need to have appropriate policy mechanisms in place to safeguard local communities and the environment.

'With better planning, resource-rich countries can take advantage of the increased demand to foster growth and development,' said Riccardo Puliti, Senior Director and Head of the Energy and Extractive Industries Global Practice at the World Bank. 'Countries with capacity and infrastructure to supply the minerals and metals required for cleaner technologies have a unique opportunity to grow their economies if they develop their mining sectors in a sustainable way.'

Demand for individual metals and minerals will reflect the component mix of low-carbon technologies, corresponding with economic changes and technical developments. To position themselves well, countries will need reliable sources of economic data and market intelligence, as well as the capacity to turn that information into plans, investments, and sustainable operations.

Based on current trends, it is expected that Chile, Peru, and (potentially) Bolivia, will play a key role in supplying copper and lithium; Brazil is a key bauxite and iron ore supplier; while southern Africa and Guinea will be vital in the effort to meet growing demand for platinum, manganese, bauxite, and chromium. China will continue to play a leading role in production and reserve levels in practically every key metal required under low-carbon scenarios. India is dominant in iron, steel, and titanium, while Indonesia, Malaysia, and Philippines have opportunities with bauxite and nickel.

A 'green' technology future has the potential to be materially intensive, the report states. Increased extraction and production activities could also have significant impacts on local water systems, ecosystems, and communities. As countries develop their natural resource endowments, it will be critical that sustainability, environmental protection, and options to recycle materials be integrated into new operations, policies and investments.

While the report strikes a welcome note of optimism for the mineral industry, I find it curious (even alarming) that Australia is not rated more highly as a major player by the World Bank; tables of production and reserves by commodity show Australia leading other countries in its reserves of lithium and nickel and it follows that exploration and mining technology for these commodities should be a major focus for us.

The World Bank report looks 30–50 years ahead into the global future. It is undoubtedly useful in that it reflects the assumptions and projections of economists and policy makers based on an uncritical acceptance of climate science and intergovernmental policies of this decade. Students who like to think outside the box will notice two missing features. First, nuclear energy (uranium/thorium) is excluded, and second, the risk to the conclusions in the event that the consensus science of anthropogenic CO_2 and global warming is found in error, does not gain a mention.

A brief reference to history will inspire the curious student on both of these caveats. While nuclear energy today is meeting progressively increasing opposition in the western world, it wasn't always so; in 1973 a local war in the Middle East prompted an oil embargo against the western world, and France, after being brought to its knees by lack of energy supplies, made a dramatic move to nuclear energy, which now accounts for 77% of its electricity supplies. Could a local conflict elsewhere in the world during the next 50 years produce a similar result in other countries?

On the second caveat, we as geoscientists are used to testing models against observational data sets, and we are used to looking back in geological time in order to understand the present. I have in recent years had cause to re-examine evidence for past natural climate cycles with periods in the range 60 to 6000 years – a recent commentary article in

The Australian gives a brief overview ('A cold climate for science', http://www.theaustralian.com.au/opinion/a-cold-climate-for-science/news-story/f82f4126477b029feb76dbff2fdf467d). I find the evidence in peer-reviewed journal articles for the existence of these centennial-millennial natural cycles to be compelling, and their magnitude is such as to modify the underlying assumptions of studies such as that of the World Bank reviewed here. It is unlikely that I will see a definitive yea or nay in my professional lifetime, but many students with a 40+ year career in geosciences ahead of them will discover the truth on one side, the other side, or in a direction nobody has thought of yet.

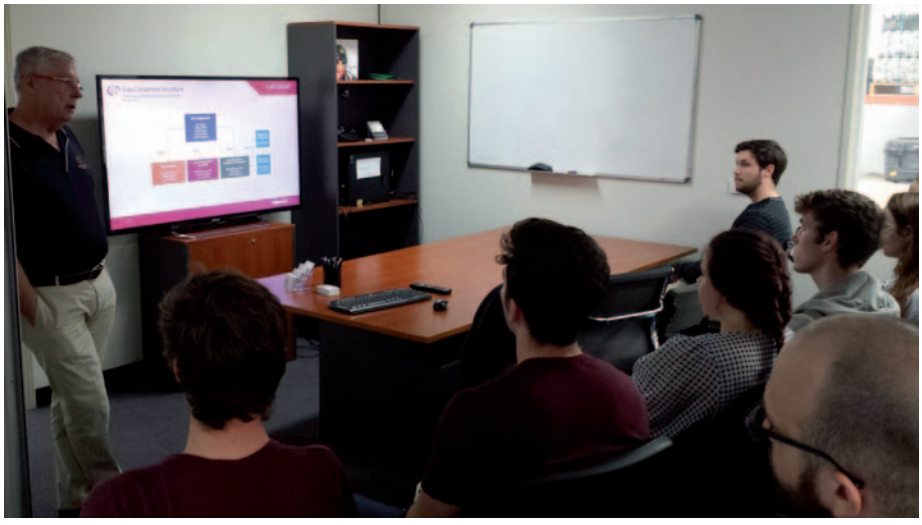
Brisbane students meet industry in field demonstration at Gap Geophysics

The ASEG student group at Gap Geophysics. From right, Nick Josephs (ASEG Qld Branch organiser of the tour), Stephen Griffin (Gap), Mal Cattach (Gap), and geosciences students from QUT and UQ. Will Rowlands (Gap) is 2nd from the left.

In mid-May, students from Queensland University of Technology (QUT) and the University of Queensland (UQ) went on a field trip to the head office of the Gap Geophysics Group (Gap) in West End, Brisbane with the support of the ASEG Queensland Branch and its Members Ron Palmer and Nick Josephs.

A group of 19 students of geophysics, geology and other geosciences who were keen to learn about geophysics arrived at Gap and were greeted by Mal Cattach, Chairman and Chief Geophysicist of Gap Geophysics. Mal gathered the students in the boardroom and presented a history of the company, highlighting the importance of research in its longevity and success. Gap Geophysics has been a pioneer for decades in the development of total-field and three-component EM electromagnetic methods for both mineral exploration and environmental applications such as unexploded ordnance detection.

Mal continued by explaining the wide range of applications for geophysics across the broad spectrum of exploration, environmental and engineering industries, as well as the global reach of the company and the demand for their specific expertise. The case studies in a variety of countries and the variability of the applications of the EM geophysical techniques certainly piqued the students' curiosity.



Mal Cattach of Gap Geophysics addresses QUT & UQ students.

Trent Retallick, the General Manager, then directed the students to a nearby park where an EM survey was set up by the GapEOD team for demonstration. The students gathered around and were shown a demonstration survey with a fixed loop pulsed electromagnetic source together with real-time feedback on a SAMSON digital logging magnetometer receiver. Students were able to see, and hear, the influence of replica unexploded ordnance (UXO) that was brought near and into the loop.

Stephen Griffin, Head of Technical Services for Gap, and Will Rowlands, UXO Technician, then provided a detailed explanation of the techniques being used in detection of UXO and hazardous metal fragments on mine-sites, incorporated in Gap's UltraTEM2 cart – a moving-loop time-domain EM system combined with an array of three-component sensors that gives maximum directional sensitivity in detection of such objects.

It was great to see curious students focused on a screen depicting the potential field and TEM responses, and asking pertinent questions about the techniques being used.

Stephen Griffin of Gap Geophysics explains the features of the UltraTEM2 precision UXO and metal-detection cart.

Following the return to headquarters, the staff at Gap provided some food and drinks for the hungry university students. This social setting allowed the students to engage one-on-one with the staff and afforded them great networking opportunities that will inevitably lead to employment prospects and further studies into geophysics.

From the student feedback, it became apparent that most were especially captivated by the global opportunities that a career in geophysics involves and were happy to see geophysics in action. From this response and success, the Branch will probably organise another outing later in the year.

This is the third year that student field trips have been organised and conducted by the Queensland Branch of the ASEG. They originally started from the Perth ASEG-PESA 2015 conference where students, who were awarded bursaries to attend the conference, struck up conversations with companies at booths and floated the idea of students getting some industry exposure. Special thanks to Ron Palmer, the student representatives and Gap for giving their time to open the eyes of budding geophysicists and geologists as to the capabilities of geophysics.

Australian School of Petroleum Oman Study Tour

The gang at the Nizwa Fort, one of the oldest fortresses of Oman (photo taken by Hugo Burgin).

On 8 April 2017 petroleum geoscience honours and masters students at the Australian School of Petroleum (University of Adelaide) embarked on a two week study tour to Oman, a country located on the Arabian Peninsula, one of the most significant petroleum passages of the world. Due to its prime location, Oman, like various other nations in the Middle East, depends on its oil and gas industry, making it the ideal setting for a petroleum geoscience field trip.

Mandatory lectures were held four days per week from 9 am until 2 pm at the Sultan Qaboos University in Muscat, with Professor Khalid Amrouch (the Study Tour organiser and leader) covering aspects of structural geology and geomechanics. As the city of Muscat is surrounded by great outcrops, all less than a few hours' drive away, the remainder of the days were spent tying in-class learnings to practical exercises in the field.

Students were also required to give an oral presentation on the stress field of a particular area of the world by applying the knowledge learned both in class and in the field to the world stress map. This was a great way for students to not only develop presentation and speaking skills, but also to sharpen their critical thinking about the multiscale effects of stress and stress regimes through time and space.

Another fascinating and geologically significant part of the trip was the chance to see a completely intact section of the oceanic crust obducted and perfectly preserved on the continental crust, only a short drive away from the University. Professor Andreas Scharf (from SQU) presented a short lecture followed by a tour of the Semail Ophiolite, an amazing cross-section of a textbook ophiolite, from pillow basalts to layered gabbros and harzbugite all the way down to the Moho, a depth that has not been achieved in even the deepest ocean drilling projects.

Aside from the technical education, another highlight of this Study Tour for many students was the exposure to a very different culture and the geotourism associated with the trip. Afternoons and evenings were spent wandering through the busy Souk Matrah (local markets), touring mosques and learning about the Omani culture and history at the Bait Zubair Museum. It was great for students to immerse themselves in a foreign culture, an experience that is relevant for almost all professionals working in the minerals and energy resources industries.

The Hajar Mountain Range overlooking the Indian Ocean was a spectacular sight from the Jabal Akhdar peak, which reaches 3000 m. And of course, after so much trekking and field work in 40°C+ weather, the refreshing swims at Wadishap and the Bimmah Sinkhole followed by fine dining at traditional restaurants in Seeb were the cherry on top.

As a hopeful future exploration geophysicist, it was a highlight to see the structural geology firsthand, such as faults, folds and other kinds of structural elements that are commonly sought out in seismic data in petroleum exploration. Stress regimes, sources of stress, geomechanical concepts and fault seal analysis are all also integral parts of a career in petroleum geoscience and it was

Anna Manka (the author) sitting on the Moho.

Examining fractures to determine stress regimes in the field (photo taken by Hugo Burgin).

very enjoyable to learn about these topics without being constrained by the walls of a classroom.

The two-week study tour was not only a great opportunity to visit the largest non-OPEC oil producer in the Middle East, but also an educational milestone for future geoscientists, with the chance to stand on the Moho and examine the Semail Ophiolite. It was a fantastic occasion to get to know fellow classmates and network with professional geoscientists, while learning important skills in structural geology and geomechanics and admiring the beautiful scenery of Oman.

Anna Manka
University of Adelaide

Happy geoscientists relaxing in the crystal clear waters of the Bimmah Sinkhole after a packed day.

Environmental geophysics

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Developments in miniaturisation technology

Welcome readers to this issue's column on geophysics applied to the environment. This month I thought that I would highlight a few interesting developments in miniaturisation technology that are contributing to our ability to collect geophysical data using unconventional vehicles (drones and bikes) – of interest to most geophysicists, whether we are biased towards environmental geophysics or not.

My interest was piqued when I had a look through the March 2017 issue of *FastTimes* and found it dedicated to environmental geophysics – with quite a few interesting articles on a range of geophysical applications aimed at the environmental space. For those of you who don't know it, *FastTimes* is the scientific 'magazine', similar to *Preview*, published by the (American) Environmental and Engineering Geophysical Society (EEGS, see www.eegs.com for issues of *FastTimes*).

My attention was drawn especially to the Drone News column, a regular feature in *FastTimes*, that introduced a range of really interesting initiatives in the geophysics-applied-to-drones space. The now relatively 'common' use of drones to make base maps was mentioned (see this column in *Preview* 185) but much more was made of the ongoing miniaturisation of geophysical instruments that could be mounted on or hung under a drone. It looks as if Gem is leading the way on this for magnetometers (e.g. Figure 1), but Scintrex and others are not far behind. The magnetometer bird from Gem shown in Figure 1 weighs about 3.3 kg (although the article mentions a Gem system that weighs <1.8 kg – I couldn't find that one on their website). In those 3.3 kg they have mounted the magnetometer unit, a one hour battery, a GPS, a laser altimeter, an inertial movement unit (IMU), data storage, and a radio link for data transmission. Not bad at all. The *FastTimes* feature also mentions some applications that are a little more on the wild side. For example, they show some preliminary results from a drone-based GPR system that look potentially interesting.

I also ran into an interesting article in the 25 April online issue of *Eos*

Figure 1. *Sling-mounted magnetometer weighing ~3.3 kg hanging under various UAVs. The system's heart is the Gem GSMP 35U Potassium UAV magnetometer shown in the upper left (www.gemsys.ca/uavs-pathway-to-the-future/).*

(https://eos.org/project-updates/a-bike-built-for-magnetic-mapping) where a group of researchers in Israel have mounted a small magnetometer onto a mountain bike (Figure 2) and have achieved pretty good production rates (Figure 3) – in the 10s of kms per day (personally I would rather ride those kind of kms than walk them every day – terrain and vegetation permitting). The mag was a Gem Systems model GSM-19 (Overhauser style) mounted on a variation of the All-Terrain Bicycle Geomagnetic Mapping System developed by researchers at the SouthWest Research Institute in the US (http://bit.ly/ATBGMS). The system looks a little unwieldy, but I wonder what would happen if you used a smaller (developed for drones?) magnetometer mounted on a lighter frame. Would it be prohibitively expensive to use a mountain bike with minimal metal (e.g. I have seen bikes out there with carbon fibre spokes)? Probably, but that would allow the mag to be mounted closer to the bike…

I'm sure that this review is nowhere near complete; there must be a huge number of people out there who love their drones and are trying to figure out how to use their favourite 'toys' for more than just taking pictures and occasionally making basemaps. Obviously the key is to continue miniaturising the measuring devices that hang off of the drone. Anyone out there got some cool drone-based toys to show off?

Figure 2. *Uri Schattner from the University of Haifa testing the bike mounted magnetometer system. Picture courtesy of Eos/AGU.*

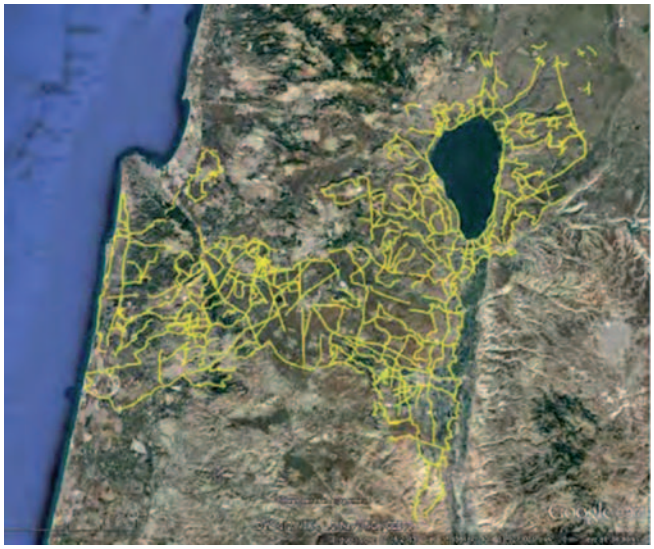

Figure 3. *Bike mag data collected for the Israeli study since April 2016 – about 2100 km. Photo courtesy of Eos/AGU.*

Minerals geophysics

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I don't get fashion

I don't get fashion (I don't get some aspects of art, either, but that's a different story). Why spend $2000 on a big name hand-bag, or $20 000 on an exclusive wrist watch, when similar equally functional alternatives can be had for a fraction of the price? Are we defined by how much we spend on ourselves? Fashion features in weekend newspaper magazines and some advertisements in airline in-flight magazines suggest that we are!

In contrast to this desire for exclusivity, the latest fad can have many in the population scrambling to purchase a particular must-have item, or subscribing to a particular in-vogue belief. What has happened to independent thought?

Our industry is also influenced by fashion. Publicity for the development of new geophysical instrumentation or refinements to a geophysical technique can excite company interest and increase management pressure to use them. Exploration success with a particular geophysical technique can spark a flurry of copy-cat activity. Needless to say, not all of this usage will be appropriate to the target or to the conditions prevailing in the search area. Here are a couple of Australian examples.

In electromagnetics the arrival of the time domain MPPO-1 in Australia in the early 1970s (see Brian Spies' article in *Preview* 187) and the subsequent development of SIROTEM in the 1970s and 1980s (see Roger Henderson's article in *Preview* 172) were game changers for electrical geophysical exploration in Australia. Prior to this, IP-resistivity usage had dominated over frequency domain electromagnetics, which had been developed for exploration in the more resistive environments in the Northern Hemisphere. Time domain electromagnetics (TEM) proved to be much better suited to the typical Australian conditions of thick conductive weathering and high telluric noise. Such was SIROTEM's impact that well into the 1990s TEM was often the method of choice, even where targets and environments were not necessarily suited to electromagnetic exploration. The use of IP-resistivity declined substantially, in some cases to the detriment of exploration efficacy.

In 2006 sub-audio magnetics (SAM) was used with much-publicised success by CuDECO Ltd. at their Rocklands Project in the Cloncurry area. Understandably there was an upsurge of interest in SAM by other explorers in the area. SAM clearly highlighted known ore zones in this environment of shallow cover and enhanced weathering of structurally controlled sulphide mineralisation (see EQMMR image Figure 1). But, would it be appropriate to consider using SAM where there were substantial thicknesses of conductive cover, or where the target bodies themselves were not conductive?

Our conferences play a part too. During a conference there can be heightened interest in new instrumentation developments, or a particular geophysical technique will receive prominence in presentations, posters, booths and workshops. In 2016 there was a buzz about passive seismics, and in 2015 there was the ADROK session – that certainly sparked a lot of interest. Recent conferences have raised the profiles of helicopter EM, 3D IP-resistivity, magneto-tellurics and seismic reflection techniques in mineral exploration.

Of course exploration companies, geophysical instrument manufacturers, geophysical contractors, government organisations and academics must be able to publicise their successes and developments. How else are we to be kept informed, improve our technical prowess, and advance as an industry? It's up to us as geophysicists to assess each technique on its suitability for the target and its environment and to recommend accordingly, whether it is fashionable or not. Inappropriate use of geophysical exploration techniques can waste resources, damage the reputation of the technique for future more appropriate exploration and, in a worse-case scenario, result in a missed target.

That's enough preaching. I'm off to do some shopping – our local electronics store is advertising a lap-top with rose gold highlights to die for and I don't want to miss out!

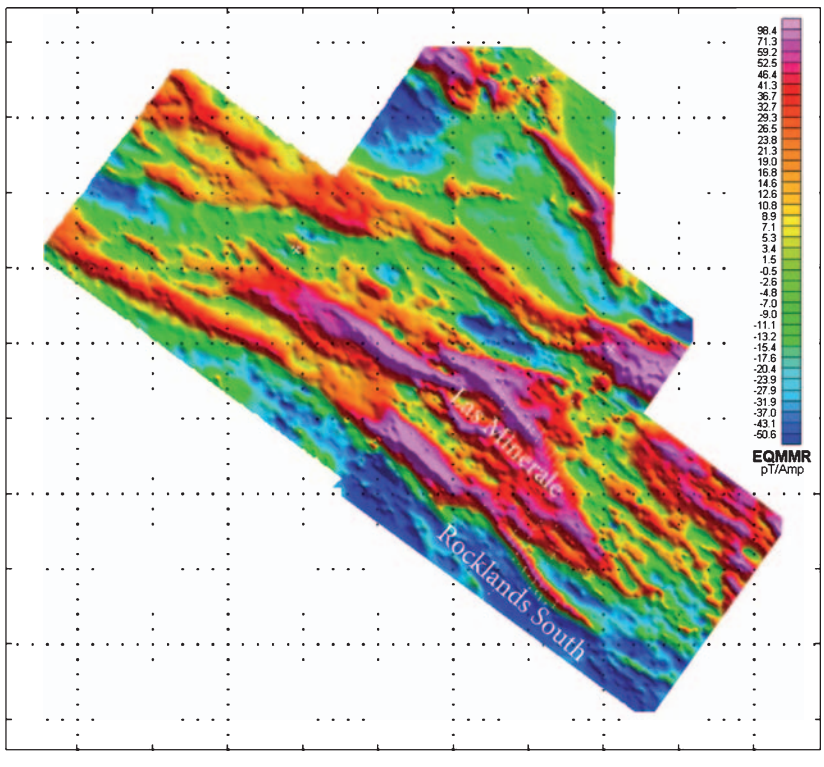

Figure 1. *Rocklands Project SAM EQMMR (Equivalent Magnetometric Resistivity) image.*

Seismic window

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Interpretation formulae

An old retired mate, I'll call him Dave, and I were chatting over dinner recently and both being seasoned interpretation geophysicists a question arose about how many complicated formulae we needed to know in our work. It turns out there is only one, which Dave and I both blurted out simultaneously.

$$D = VT/2$$

D = depth in metres

V = velocity in m/s

T = two way time in seconds

Of course there are other formulae like continuous wavelet transforms, migration algorithms, Shuey approximation, or even the Zoepritz equations, but we don't have to actually know them. Depth conversion, however, is our bread and butter and we use D = VT/2 daily. Naturally there are variations but they mostly take the form D = aVT/2 where for instance:

a = 0.001 for most interpretation software that specify travel time in milliseconds, or

a = –0.001 for a popular package that insists on using negative time, or

a ~ 0.9 to 0.95 for adjusting seismic derived depths to tie well tops.

It seems that Dave and I are trend-setters. At the recent EAGE meeting in Paris, Kurt Marfurt of Oklahoma University gave a presentation describing his idea of the future interpreter. The new age interpreter will not need to know much about wave propagation theory (or any formulae) but will need to know a lot about geology. The interpreter will be a mix of geologist, geophysicist and engineer with a broad knowledge of everything. Specialist tasks like rock physics and heavy mathematics will be handled by in-house experts or service companies. Table 1 is a compilation of things that an interpreter will need to know and those that not required according to Professor Marfurt. It would be interesting to know how many of today's interpreters have the required skills shown.

The new age interpreter will not need to know much about wave propagation theory (or any formulae) but will need to know a lot about geology

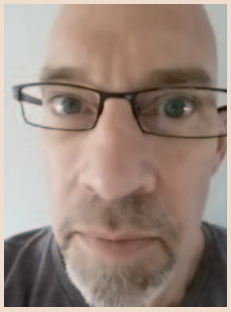
Also at the EAGE meeting, several booths and presentations showcased software that is being developed to assist the interpreter. Future software will use machine learning algorithms and techniques developed in spyware and music recognition to ease the burden. This is not only a response to the approaching retirement of many skilled oil hunters but also to the growing amount of seismic data available. These days there are dozens if not hundreds of data volumes to review for a single survey, and it all needs analysing. Since humans have difficulty understanding the relationships between several types (more than four, say) of data and how it can be applied to well prediction this is inevitable. Hence, machine learning algorithms that iteratively learn from the data, self-organised mapping that classifies data, and spyware based software that will recognise keystrokes and repeat the steps to update a map with new data when, say, an extra well is drilled. Or music based software that could translate SEGY into a MIDI format and analyse attributes such as pitch or note length, searching for patterns to aid in stratigraphic interpretation. Self-organised mapping techniques could then be used to create a more robust interpretation.

These are exciting times and not a formula in sight!!

Table 1. The future seismic interpreter will have a broad knowledge of geology, geophysics and engineering without specialising in any one area according to Professor Marfurt

NEXT GENERATION INTERPRETER	Skills required	Skills not required
Geology	Structural geology Stratigraphy Weathering/diagenesis Well logs – tie to seismic, QC logs	Petrography Petrophysics • Other advanced skills
Geophysics	Post stack data conditioning Seismic facies analysis Recognise noise from signal Impedance inversion DHIs Attributes to geocellular model Integration with specialty data	Acquisition Processing Migration Prestack data conditioning Microseismic event analysis Simultaneous inversion
Engineering	Pressure, mud weights etc. Enhanced recovery Microseismics related to completion Dynamic modelling	Drilling Completions Bits Mud selection Corrosion

Webwaves



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Phishing for beginners

TED's website (ted.com) is an archive of over 2400 talks given on topics loosely related to Technology, Entertainment and Design. TED talks started in 1984 and until 2004 there was only one conference per year. There are now many TED-sanctioned conferences in many countries (223 planned in 2018), some are general and others more focussed. Few talks run longer than 20 minutes, most are thought provoking and also entertaining. One particularly entertaining talk was given by James Veitch (https://www.ted.com/talks/james_veitch_this_is_what_happens_when_you_reply_to_spam_email) about his reply to an attempt at phishing. General advice when receiving spam email is to delete rather than reply to it.

Wikipedia (wikipedia.com) defines 'phishing' as 'the attempt to obtain sensitive information such as usernames, passwords, and credit card details (and, indirectly, money), often for malicious reasons, by disguising as a trustworthy entity in an electronic communication'. As befits any neologism in 2017, there are variations around how the attempt is made and the intended target. For example, 'spear' phishing targets individuals. 'Whaling' targets high-value individuals who know who they are. 'Pharming' employs DNS redirection, and two-factor authentication can be effective against this method.

Phishing relies on targets failing to notice the disguise. Email addresses and URLs can be long, and therefore they are often aliased. Thus, Veitch's talk referenced in the introduction might be presented using the code James Veitch. 'James Veitch' is displayed in the browser's HTML style and the alias can be followed to the URL. A phishing exploit might be written Bank account.

Invariably programs capable of interpreting HTML contain a feature where the URL that is aliased can be revealed by moving the pointer over the HTML link without following the link ('hovering'). A pause of less than a second will expose the attempt. Nevertheless, the time-poor or rushed might easily follow the legitimate text to the bogus URL. Gutmann (2006) describes many more examples of successful phishing expeditions.

So while phishing exploits are quite old and often crude, they are often effective, and James Veitch's talk is a timely reminder to be vigilant when following HTML links.

The current ASEG website is approaching its first anniversary and has mostly grown since it was launched by Katherine McKenna during the 26th ASEG Conference and Exhibition in Adelaide. As might be expected from any reasonably complicated system there were some issues. These were mostly related to the way the website interacts with the publisher. A solution to occasional problematic access to *Exploration Geophysics* has been identified, though yet to be implemented.

The website access data has demonstrated that the most successful additions to the site have been equipment manuals, the virtual museum and presentations from ASEG workshops. Material from two more workshops remains to be added to the site, and a standing invitation is extended to organisers who would like to see their efforts reach a larger audience.

Reference

Gutmann, P, 2006, 'Phishing tips and techniques: tackle, rigging, and how & when to phish', DefCon14, Las Vegas, NV. Available at: https://www.youtube.com/watch?v=MZ19WWGl5wI

*This **vertical component magnetic variometer** is from the ASEG virtual museum collection and was generously donated by John Stanley, formerly lecturer at the University of New England and inventor. In was built in 1947 by E. R. Watts & Son of London, England with a resolution of 2.9 nT. Its serial no. is 50 275, suggesting at least 275 were built, and it weighs 9 kg.*

The calibration record for this instrument indicates that 1 scale division equalled 29.4 nT and that consecutive readings were repeatable to 0.1 of a division, or 2.94 nT. Temperature compensation for this instrument was adjusted to zero over a temperature range of 15 to 55 degrees C. Measurement firstly required precise levelling of the instrument on a tripod, unclamping the mechanism, recording the temperature, and then reading the scale through a microscope. The centre value was set at 52 000 nT. Setup and measurement time was typically 1 minute for an experienced operator.

Data trends

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The C Suite

If you are looking for examples of data driven change in the world, look no further than who is sitting in all the Level 38 corner offices around the globe. The CEO and his personal assistant are there, of course, and so is the CIO. But now a whole new band of brothers is forming – so many bands that buildings will need a lot more than four corners to accommodate them.

The changes we are seeing are new roles at the most senior levels. These roles have been created because data about key features of a business are now available to be analysed that previously was not, or the relative importance of a set of data are only now being seen as truly important.

Some banks, for instance, recognise that the complete end to end user experience of a customer is critical to retaining their client base. Some banks have taken the step of appointing Chief User Experience Officers (CUXO) – a role created after banks realised the true power of tracking data about user behaviour in minute detail.

The C suite used to have a CFO and maybe a CIO reporting to the CEO at the top, and the CEO was usually on the Board. The ultimate decision-maker and go-between involving Board members and the business, the CEO was 'the man'. This is not the case anymore.

One of the powerful things that data does is allow the people that have access to it to become experts within very narrow but important knowledge bands that can make a company's competitive edge just that much sharper.

In a recent Forbes article entitled 'Big Data: 20 Mind-Boggling Facts Everyone Must Read', it was stated that 'more data has been created in the past two years than in the entire previous history of the human race,' and we have been slowly building the tools to deal with this data. When I say 'deal', I mean use, dissect, draw conclusions, make predictions and, in a business context, essentially make new and exciting types of experts that allow the sharpening of that competitive edge I mentioned.

masters of data can change a company's view of the competitive landscape

Generating more data in the last two years than has ever been created in the history of the world is one thing. Trying to make use of this data in a meaningful and impactful way is another. All of this new data needs experts, and experts need bosses. This has seen the C suite blow up and out in all sorts of new directions; Chief Artificial Intelligence Officer (CAIO), Chief Analytics Officer (CAO), Chief Data Officer (CDO), Chief Content Officer (CCO) and even one called Chief Ninja (CN).

The other important change that this spawning of Chiefs has created is that the lines of reporting no longer go up and through the CEO to the Board. Many of these new 'Chief' positions that are being generated are so important to strategy that they report directly to the Board. This is changing the dynamics of how companies operate, report and achieve their objectives in very significant ways.

It is data that has opened up all of these new possibilities, and the pursuit of new possibilities that has created all of this data. Within this circular dynamic lies the future of most organisational change – hard core pillars of strategic focus and new empires to be won.

If you are in the game of generating data, and don't have a Chief in your domain, ask for one or become one yourself – go on – give yourself a ridiculous title and just run with it.

Businesses (oil and gas, miners or otherwise) need to take serious note of the way data and masters of data can change a company's view of the competitive landscape. The Board is used to seeing the landscape at the level of forests, oceans, cities and suburbia. The use of data can now let them see the individual leaves, fishing holes, taxi ranks and the very doorsteps of consumers.

If you fear having too many Chiefs and not enough Indians, then just count the Indians. Then the Indians become data, and creating data is what makes Chiefs. Don't wait until your company needs Chiefs, just go with the confidence that data can be turned into knowledge and knowledge wins every time.

Editor's note: Guy Holmes is retiring as *Preview's* regular commentator on data management and analysis – and on life, the universe and everything. He is starting a new business, which requires his full attention. I am sure I speak for all *Preview* readers when I say that he will be sorely missed, but that we wish him, his family and his new enterprise well.

Geophysical surveying in Australia by the navigators James Cook and Matthew Flinders

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James Cook at Pier Head in 1770

On Wednesday, 30 May 1770 when heading north along Queensland's tropical coast, and after going ashore from HM Bark *Endeavour,* Lieutenant James Cook climbed an isolated hill on the eastern tip of the coastal Quail Island to make observations with his azimuth compass. He named the hill Pier Head (Figures 1 and 2). Cook found that the local magnetism of the place had serious effects on the compass bearings he was attempting. He wrote:

> *...the first thing I did was to get upon a pretty high Hill, which is at the North-West entrance of the inlet, before Sunrise, in order to take a view of the Sea Coast and Islands, &c., that lay off it, and to take their bearings, having the Azimuth Compass with me for that purpose, the Needle of which differ'd from its True position something very considerable, even above 30 degrees, in some places more, and in other less, for I try'd it in several places. I found it differ from in itself above 2 points* [a point = 11¼ degrees] *in the space of about 14 feet. The loose stones that lay upon the Ground had no effect upon the Needle; I therefore concluded that it must be owing to the Iron Ore upon the Hill, visible signs of which appeared not only here, but in several other places.*[1]

Cook's brief mention and opinion of the effects of the hill's magnetism, and the character of the rocks themselves (from his published journal), are almost certainly the earliest of what could be construed as a geophysical observation in Australia. His last sentence being his interpretation – although this may be stretching things slightly. The information is of interest to us nowadays, and it was also of interest to others much closer to Cook's era, in particular to Matthew Flinders. In September 1802, on his circumnavigation of Australia in HM Sloop *Investigator* (accompanied up the east coast by HM Colonial Brig *Lady Nelson*), Flinders made a point of investigating the unusual observation that Cook made in 1770.

Matthew Flinders at Pier Head in 1802

On Sunday 5 September 1802, after having sailed through the opening to Thirsty Sound, which separates Quail Island from the mainland, *Investigator* and *Lady Nelson* anchored safely in six fathoms. Almost immediately Flinders' botanists headed for the mainland to investigate, and the expedition's launch was sent by Flinders 'to haul the seine [*net*] on that side, at a beach a little way up the Sound'. Independently of these scientific activities,

Figure 1. *Looking north to Pier Head from the mainland coast between Mackay and Rockhampton.*

Figure 2. *Pier Head, Queensland. Imagery©2017 Cnes/SpotImage. Digital Globe. Mapdata©2017 GBRMPA. Google.*

[1]Wharton, Captain W. J. L. (ed.), 1893, *Captain Cook's Journal during his first voyage round the World made in H.M. Bark 'Endeavour' 1768–71. A literal transcription of the Original MSS*, London.

Flinders went ashore at Quail Island and there climbed the 110 metres to the top of Pier Head where later, in his published journal (1814), he recorded that he took bearings 'to the Northumberland Islands, as also of the points and hills of the coast to the east and west' (Figure 3).

Flinders' 1814 description of his magnetic observations on and around Pier Head on that, and the following day, 6 September 1802, is an enlightening historical record. It is not known by many that his journal entries of those observations were in themselves a summary of information he had sent to Sir Joseph Banks in a letter written on 5 March 1804, when he was a prisoner of the French on Isle of France (Mauritius). The 1804 letter is an important document. It was Flinders' first communication on observations he had made onboard *Investigator* of the changes in the terrestrial magnetism observed with his ship's compass when travelling from the northern hemisphere to the southern hemisphere and, importantly, the large observed variations (four degrees or more) in his compass headings with changes in the direction of the ship's head. He included specific examples for Banks, in a set of tables, and then explained his thoughts on the matter with suggestions for correcting the discrepancies.

Flinders' 1804 writings on ship's magnetism to Banks were pioneering, and his thoughts were to become the basis for experiments he later carried out in 1812 onboard Royal Navy vessels after he had returned to England. His 1812 experiments led to another paper, which in turn led to official instructions and orders to all Royal Navy commanders to both experiment and to understand their onboard compass environment, and to standardise and maintain their compass binnacles free from magnetic interferences. Flinders' 1804 letter to Banks finished off with a description of external magnetic interferences, including his Pier Head observations along with a summary of Cook's observations at the same place. Flinders also noted other observations he later made on the west coast of the Gulf of Carpentaria, where on one occasion he observed the needle in his theodolite had turned over fifty degrees from its proper direction, and in another case where he confirmed the existence of a local disturbance by placing a sample rock close to the instrument which 'drew the needle of the theodolite entirely around'. Banks read Flinders' letter to The Royal Society of London meeting on 28 March 1805, and it was later published in full in the Society's transactions.

Figure 3. *Part of Flinders 1814 published chart, showing his and Cook's routes, Pier Head and West Hill Island (top left). From facsimile of original held by D. Morrison.*

Combining the information from both Flinders' 1804 letter and his published 1814 journal we have a good record of what occurred at Pier Head. In his 1804 letter he wrote that he took back bearings to 'Extensive Mount' (later renamed by Flinders to Mount Westall) some 34 miles away and observed a difference of 4°35′ to the right and to an island some thirty miles away, a difference of 4°45′ also to the right. Conscious of Cook's reported disturbances, Flinders moved his theodolite three yards to the westward and the same two objects bore 2°10′ to the right of the back bearings. He then moved the instrument to a place three yards to the southeast from the original place and they differed 2° to the left. On moving the theodolite again, to a place four yards to the north, the same objects bore 1°10′ to the right. These unusual discrepancies were enough to prompt Flinders to return the following day (Monday 6 September 1802). His letter finished with a detailed description of his Pier Head magnetic observations:

> *... On the following morning I determined to try the magnetism more particularly. Taking the theodolite and dipping-needle, I landed upon the shore of the Head, whence the top of the hill bore N50°W, about one-third of a mile. The variation of the theodolite in this place I observed to be 8°2′E, and the inclination of the south end of the dipping needle 50°50′, the needle stood vertical when the face of the instrument was S2°E. I then took the following bearings: Extensive Mount* [Mount Westall] *108°30′, the same exactly as by back bearing. Double Peak 143°30′; from hence I rowed round the Head, and landed on a rock, whence the top of the hill bore SSW one-sixth of a mile; Extensive Mount bore 110°14′, the inclination of the dipping-needle 50°29′, and the needle stood vertical when the instrument faced S3°E. Thus the difference was 1¾° in the horizontal, and ½° in the vertical direction of the needle. Ascending the hill, I made the following observations on the top: Extensive Mount 113°50′, a island 133°52′, Double Peak 148°32′; the inclination of the needle was 53°20′, and it stood vertical at S3°E. The differences here are 5°10′ in the horizontal, and 2°30′ in the vertical direction, from what the needle stood at in the first morning's place. On moving ten yards SSE, the bearings were, Extensive Mount 108°44′, Double Peak 143°25′; the inclination was 52°18′, and the needle was vertical when the instrument faced S5°W. In this 4th set of observations, the horizontal direction of the needle is only a few minutes different from the first place, but the vertical direction is 1°28′. From the top of the hill I now moved twenty yards to the north-eastward, when Extensive Mount bore 110°, Double Peak 144°42′; the inclination of the dipping needle was now 50°35′, and it stood vertical at S3°W. Thus it appears that the polarity of the magnetic needle is most interrupted at the top of the hill, both according to the theodolite and dipping-needle. Whether this may arise from some particular magnetic substance lodged in the heart of the hill, or from the attractive powers of all the substances which compose Pier Head being centered in a similar point to what I have supposed to take place with all the ferruginous bodies lodged within a ship, I shall not attempt to decide. The greater differences in the horizontal direction of the needle observed by Captain Cook, might have arisen from his using a common azimuth compass,*

which was probably not further elevated from the ground than to be placed on a stone.
MATTHEW FLINDERS
Isle of France
March 5th, 1804.[2]

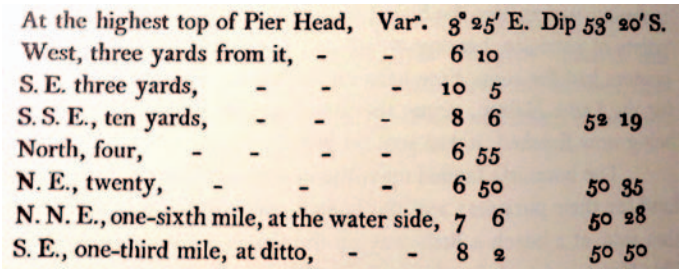
In Flinders' published 1814 journal he summarised, with vector adjustments and corrections, his Pier Head variation and dip observations. He again commented on Cook's original discrepancies and contemplated the causes of the geological interference, he wrote:

Azimuths were taken, and the bearing of Mount Westall, distant thirty-four miles, was set at S. 63°28′ E. (true), whilst the theodolite remained in the same place; and from a comparison between this bearing and those of the same object at different parts of the head [i.e. Pier Head]*, the variations were deduced. The dip was observed with both ends of the needle, and the face of the instrument changed each time.* [followed by observations at eight locations] (Figure 4)

There are here no differences equal to those found by captain Cook; but it is to be observed, that he used a ship's azimuth compass, probably not raised further from the ground than to be placed on a stone, whereas my theodolite stood upon legs, more than four feet high. The dipping needle was raised about two feet; and by its greater inclination at the top of the hill, shows the principal attraction to have been not far from thence. The least dip 50°28′, taken at the shore on the north side of the head, was doubtless the least affected: but it appears to have been half a degree too much, for at Port Bowen, twenty-two miles further south, it was no more than 50°20′. An amplitude taken on board the ship in the Sound by Lieutenant Flinders, when the head was S.S.W., gave variation 8°39′, or corrected to the meridian, 7°40′ east. ...

Notwithstanding this very sensible effect upon the needle, both horizontally and vertically, I did not find, any more than captain Cook, that a piece of stone applied to the theodolite drew the needle at all out of its direction; nevertheless I am induced to think, that the attraction was rather dispersed throughout the mass of stone composing Pier Head, than that any mine of iron exists in it. The stone is a porphyry of a dark, bluish colour.[3]

The published Australian 1:250 000 geological map (Port Clinton, SF 56-9) broadly identifies Pier Head as being within an area mapped and described as a 'trachyte plug, andesite intrusion' (*sic*). The steepest magnetic dip observed by Flinders turned out to be at the top of Pier Head. It should also be considered that the place had, and has been, for aeons, subject to lightning strikes (Figure 5).



At the highest top of Pier Head,	Var^n.	8°	25′	E.	Dip 53°	20′ S.
West, three yards from it, - -		6	10			
S. E. three yards, - - -		10	5			
S. S. E., ten yards, - - -		8	6		52	19
North, four, - - - -		6	55			
N. E., twenty, - - -		6	50		50	35
N. N. E., one-sixth mile, at the water side,		7	6		50	28
S. E., one-third mile, at ditto, - -		8	2		50	50

Figure 4. *An image of Flinders' original journal table from his 1814 Journal Vol II.*

A few days after departing Pier Head, on the morning of Thursday 9 September 1802 and on climbing 'West Hill', i.e. West Hill Island, a prominent conical peak of some 300 metres, Flinders took further bearings (including one back to Pier Head) and following his experience with the geological effects on his observations at Pier Head he noted:

The stone of the hill [i.e. West Hill Island] *had in its specks of quartz or feldtspath, and was not much unlike that of Pier Head; but it had a more basaltic appearance. A piece of it applied to the theodolite, drew the needle two degrees out of its direction, and yet the bearings did not show any great differences from the true variation ...* [4]

Flinders was obviously becoming very aware of the local magnetic environments of his observations. Undoubtedly he was, by this time, forming his opinions on the serious errors being observed with compasses both onboard and onshore from the local geological environment – all in addition to his dedicated studies on his ship's deficiencies in compass observation and in tracking a true course. His later, 1812, compass and heading experiments with Royal Navy ships at Sheerness, Portsmouth and Plymouth were, in part anyway, a last opportunity to fine tune his expedition bearings before publication[5].

Flinders 1812 experiments, made just two years before his premature death (aged 40), included procedures for magnetic compensation of compass heading errors by the strategic placing of soft iron rods near the binnacle compass, procedures that soon became standard – highly significant and essential procedures for iron and steel constructed vessels. Many years later such ship soft iron compensation bars and rods became identified as 'Flinders bars', they still are.

Flinders, in Appendix II of his 1814 Journal, when discussing and philosophising the heading errors of compasses and his 'precautions for obviating their effects in marine surveying', made the following comment:

... there are few masses of stone totally devoid of iron, and that all iron which has long remained in the same position will acquire magnetism, or a power of attracting one end of the magnetic needle towards one part of it, and the opposite end towards another, is, I believe, generally admitted. The kinds of stone which I have observed to exert the greatest influence on the needle, are iron ore, porphyry, granite, and

[2]Flinders, M., 1805, Concerning the differences in the magnetic needle, on board the Investigator, arising from an alteration in the direction of the ship's head: *Philosophical Transactions of the Royal Society, London* **95**, 186–197. In a letter to Sir Joseph Banks, read to the Royal Society 28 March 1805.

[3]Flinders, M., 1814, A voyage to Terra Australis; undertaken for the purpose of completing the discovery of that vast country, and prosecuted in the years 1801, 1802, and 1803, ...etc. London, vol. II, chapter III, pp. 53–57.

[4]*Ibid* p. 60.

[5]Ingleton, G. C., 1986, *Matthew Flinders Navigator and Chartmaker*: pp. 405–413.

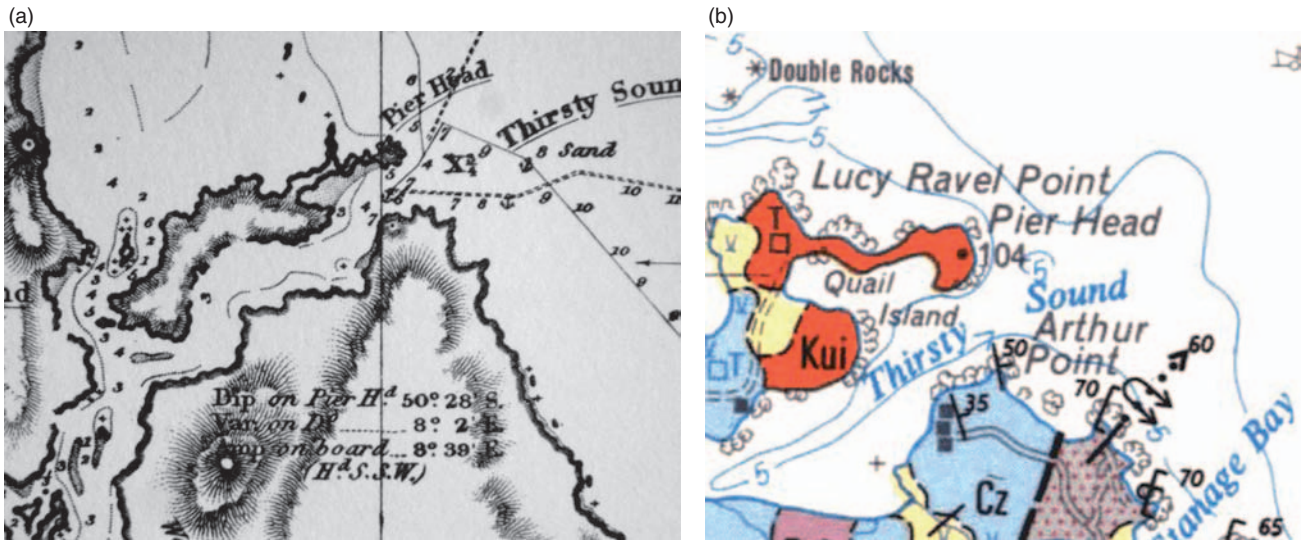


Figure 5. *(a) From Flinders 1814 chart. (b) Geology from the Port Clinton 1: 250 000 geological map.*

> *basaltes, and the least, are sand or free stone, and calcareous rock, and the argillaceous earths very little*[6].

Flinders was assisted in his geological investigations by Robert Brown, the expedition's botanist. Brown had been tutored, before the voyage, in geology and mineralogy. Together with his assistant, John Allen (a miner), and the ships's horticulturist, Peter Good, Brown collected and documented rock specimens throughout the voyage. Some of the expedition's rock specimens, and Brown's geological collection catalogues, have survived and are held in the British Museum, but many specimens, stored in barrels, were lost in the wreck of HMS *Porpoise* in August 1803. No rock specimen survives from Pier Head but two specimens survive from West Hill Island[7].

A plaque commemorating the visits of both Cook and Flinders to the top of Pier Head was set in concrete on Pier Head in December 1959 by a group of central Queensland residents. It is not known whether the plaque is still there.

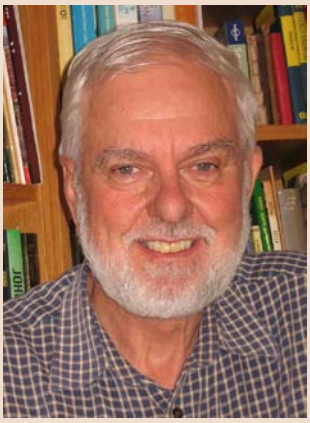
Biography

Doug Morrison has been an ASEG member for 35 years. He joined Aero Service Corporation in February 1962 as a 'geophysical data compiler' on the Bass Strait aeromagnetic survey. He studied land and engineering surveying at night. Doug has supervised geophysical data processing for governments, exploration companies and contractors on numerous projects over the years. In the 1970s he was Project Manager on major surveys from Alaska to Zambia and later Operations Manager for Geometrics International Corporation in Australia. Doug has contributed a number of geophysical history papers and articles to journals including Preview and in 2012 was awarded an ASEG Service Certificate for his contributions and promotion of the exploration geophysics industry.

[6]Flinders, 1814, *op. cit*., Volume II, Appendix II, pp. 512–532.

[7]Vallance, T. G., and Moore, D. T., 1982, Geological aspects of the voyage of HMS Investigator in Australian Waters, 1801–05, *Bulletin of the British Museum (Natural History)*, historical series, vol. 10, no. 1, 28 January, pp. 1–43.

The level of knowledge about exploration geophysical methods in Australia prior to the Imperial Geophysical Experimental Survey (IGES), 1928–30. Part 1



Roger Henderson
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Introduction

Thyer (1963) begins his 33-page review of geophysical exploration in Australia with the words: "The application of geophysical methods to the search for mineral deposits in Australia *began during 1929 and 1930 with the Imperial Geophysical Experimental Survey [IGES]* …"[1]. Thyer then focuses on the history of geophysical exploration in Australia from 1930, with one exception, as described later in this article.

Rayner (2007) similarly begins his excellent article on the practical reality of the IGES, with the words: "*The Imperial Geophysical Experimental Survey (IGES) of 1929 to 1931 arguably marks the beginning of exploration geophysics in Australia*"[2].

There can be no doubt that the IGES was important in the history of exploration geophysics in Australia; however, there were isolated geophysical surveys in Australia before the IGES. They were single method surveys conducted by observers who may have only known about the method deployed. Some examples follow, but Thyer (*op cit*) and Rayner (*op cit*) were referring to the beginning of systematic exploration geophysics, especially where more than one method is available, and it would seem that essentially they were correct. Certainly, the content of the IGES report (Broughton Edge and Laby, 1931) showed that remarkable advances were made with most methods in the few years of the IGES. The reasons why such concerted activity in Australia came later than in North America, Scandinavia and South Africa will discussed in Part 2 of this article.

Day (1966–1967) in his comprehensive history of geophysics in Australia, states that: "*the application of geophysical methods to prospecting* (as distinct from purely scientific observations)…in this country appears to have commenced shortly after 1910". Here he gives as his references Thyer (1963) and Booth (1938). Day alludes to Australian patents taken out in 1913 by the Electrical Prospecting Company of Sweden (ABEM) and the Schlumberger Company (of France), both involving electrical methods. These patents served to restrict the application of the methods then known, Part 2 of this article discusses how these companies were accused of keeping their knowledge confidential.

Surveys conducted before the IGES

Day (1966–1967) refers to (single-purpose) magnetic surveys conducted by G. F. Dodwell in various places in South Australia from 1915. Some of these surveys noted, incidentally, the association of anomalies with mineralisation. Day (*op cit*) also refers to resistivity depth soundings by Gish and Rooney at Watheroo Observatory WA from 1923 (Gish, 1923; Gish and Rooney, 1925; Rooney and Gish, 1927) and an electrical survey at Broken Hill in 1927 by the South Victoria Prospecting Company[3].

Thyer (1979), who also refers to the Gish and Rooney, the South Victorian Prospecting Company and Dodwell surveys, believed Dodwell's survey in 1915 in the Musgrave Ranges of SA "was perhaps the first recorded use of applied geophysics in Australia", although it was only incidental to a regional geomagnetic survey.

Certainly the first survey of the IGES, an equipotential survey at Anembo, NSW with a known geology and a truly applied purpose, may have a better claim on being the first exploration geophysics carried out in Australia (see Broughton Edge and Laby, 1931, p. 74–5). However, since Broughton Edge and Laby, strangely, do not give any dates for when surveys of IGES were conducted, this claim cannot be substantiated[4].

In regard to the pre IGES surveys Thyer (1979) further suggests that "It seems likely that it was these early successes that stimulated the interest of Australian mining engineers and geologists". Figure 1 shows 'Bob' Thyer giving his 1979 address; Georoots – early geophysical prospecting in Australia to the first ASEG conference in Adelaide.

The pre IGES surveys involved only electrical and magnetic methods. No gravity or seismic surveys were conducted in

[1]Robert F. Thyer was a field assistant in the IGES, then became Chief Geophysicist of the Bureau of Mineral Resources in 1952. He retired as Chief Director (Operations) of the BMR in 1973.

[2]These two references refer to the period of the IGES as 1929–1930 or 1931. However, the official report on the survey, (Broughton Edge and Laby, 1931) "includes a full account of the activities and findings of the Survey, from the date of its inception in London in February 1928, until its close in February 1930. It was the production of the report on the survey that occupied 1931.

[3]Oliver H. Gish and W. J. Rooney, from the Department of Terrestrial Magnetism (DTM) of the Carnegie Institute of Washington (CIW), were primarily conducting global geophysics.

[4]It is intriguing that when describing actual surveys nowhere in Broughton Edge and Laby (1931) are dates indicated. This would appear to be intentional for some reason.

Figure 1. *'Bob' Thyer delivering his address, Georoots – early geophysical prospecting in Australia to the first ASEG conference in Adelaide, August 1979.*

Australia before their use in the IGES other than one by Elbof at Roma in late 1928 (Thyer, 1979, p. 239).

Day (1966–1967) states that "*Systematic geophysical surveying for metalliferous deposits* appears to have commenced about 1925 or 1926", without giving any direct evidence for this assertion. He then refers to the report by E. C. Andrews (1928), Government Geologist of New South Wales, which was reviewed in detail by Henderson (2013). This report was recommending the institution of geophysical facilities by the NSW Geological Survey and will be discussed further in Part 2 of this article, particularly in relation to the methods it described.

Day also claims a paper by H. W. Gepp and others (Gepp et al., 1927) advocating the use of geophysics in Australia, together with the report by Andrews (1928), started the processes that led to the formation of the IGES[5].

Petroleum exploration in Australia commenced later than mineral exploration, and Thyer (1979) claims the "first geophysical prospecting for oil was a gravity survey conducted by IGES in the Lakes Entrance region". However, once again, as dates of IGES surveys are not given this cannot be verified and especially because Thyer (1963) suggested that another survey could be the first. This other survey was a petroleum survey at Roma in Queensland by the German Company, Elbof, involving seismic, gravity and magnetics. Thyer (1979) claims that this survey "commenced late in 1928". Which was first? More on that later.

Sources available before IGES

In the following section, various sources are used to examine what general knowledge existed in Australia before the IGES about various geophysical methods.

The sources, all of which are documents describing geophysical methods and presented and/or published and available in Australia before 1929, are listed in chronological order:

[1] Andrews, March 1925.*
[2] *Western Argus* newspaper, December 1925.
[3] Krahmann, 1926. *(Andrews' copy dated '1928')
[4] Elbof, 1927. *(Andrews' copy, not dated)
[5] Sub-Committee (for Geophysical Surveying) of the Committee of Civil Research, November 1927. *(Andrews' initials on cover)
[6] Gepp et al., June 1927.
[7] Mason, December 1927 *(Andrews' copy dated 21 05 28)
[8] Barton, February 1928 *(Andrews' copy dated 21 05 28)
[9] Andrews, 1928.*
*Denotes copies that were held originally by E C Andrews and are now held by the author[6].

Copies of seven of the nine sources listed were in the possession of E C Andrews, but it is not known if any copies were available elsewhere, except possibly the article written by Krahmann (1926). In this regard it is apparent that Gepp et al. (1927) copied material on magnetics from Krahmann (1926). Gepp et al. (*op cit*) may have used Andrews' copy of Krahmann, or may have had access to another copy.

Also, as Krahmann gave a lecture in Adelaide in October 1927 (see pop out box "Krahmann in Australia"), possibly on the contents of his book, his knowledge was made publicly available just a few months before the IGES.

Andrews' copies of Mason (1927) and Barton (1928) were dated on the cover, presumably by Andrews, as "21/5/28", that is, after his return from North America on 3 March 1928. As a consequence they may not have been seen by anyone else in Australia before the start of the IGES[7].

In addition, as we will see below, some of the sources refer to the Yearbooks of the Geological Survey of Sweden as sources of geophysical information. It is quite possible that these Yearbooks were available in geology libraries in Australia before the IGES.

[5]The story of the formation of the IGES via the Empire Marketing Board and its committees is well described by the Sub-Committee (for Geophysical Surveying) of the Committee of Civil Research (1927), Day (1966–1967, p. 49), Thyer (1979, p. 245), and Butcher (1984) and will not be dealt with any further here.

[6]See Henderson (2013) for more explanation of the author's retrieval of documents once belonging to E C Andrews.

[7]Andrews' return from North America was reported in the *Sydney Morning Herald* of 5 March, 1928 together with some detail on the outcomes of his visit including a description of the geophysical methods he encountered there. See http://nla.gov.au/nla.news-article16446971.

Descriptions of individual sources

In the following descriptions of the individual sources, the theoretical basis for the methods (the measurement of physical property differences, etc.) usually referred to by each is assumed, and also descriptions and operations of instruments have not been included as they are, in any case, now mostly obsolete. The particular methods in these sources are discussed by individual method in Part 2 of this article.

Source [1]: **Andrews, 1925.**

The earliest source of general information on exploration geophysics available in Australia that the author is aware of is a carbon copy of a three-page typed document that was retrieved from the property of E C Andrews, the Government Geologist of the NSW Dept of Mines. It is titled Electrical Prospecting, signed "E. C. Andrews", and dated "5/3/25". The document gives some indication of what Andrews knew in 1925 about the electrical method and its use by others in "the Northern Hemisphere". The document begins, "The literature of prospecting for ore bodies by electrical methods is becoming quite voluminous, dating from 1907 onwards".

It is not clear why the year 1907 was chosen for the start of the literature survey. However, Thyer (1979) noted that in 1907 "the primitive electrical method…achieved some success at Kongsberg, Norway". In the report from the *Western Argus* newspaper, to be discussed in detail below, 1907 was also the year when; "The 'electromagnetic methods' (*sic*) for prospecting were first adopted" (*Western Argus*, 1925).

Andrews then lists: "Prof. C. Schlumberger, Chief Inspector of Mines for France; Mr. G. Bergstrom, Geological Survey, Sweden; H. Lundberg, H. Nathorst, and S. F. Kelly, U. S. A." as "prominent in this connection" (that is, electrical methods).

Also, Andrews states, "Especially significant are the prospecting results obtained by the Geological Survey of Sweden during the period 1913 to 1924…". Andrews then describes the 'electrical method' as he knows it, which was the 'equipotential method'. This, I believe is **the first description of the equipotential method in documentation in Australia.** Figure 2 is a simple illustration of the principle of use the equipotential method to detect anomalously conductive bodies. This method is described in more detail in 'The Electrical Method' in Part 2 of this article.

The author is not aware of this document of Andrews ever entering the public domain.

Source [2]: ***Western Argus*, 1925**.

On 22 December 1925, the *Western Argus* newspaper from Kalgoorlie, WA contained an article titled: Electric Prospecting – Methods in Use. It acknowledged that the source was a paper by Hans Lundberg, read before the American Institute of Mining and Metallurgical Engineers (AIME)[8].

The article describes "two principal [electrical] groups, potential and electromagnetic". As we shall see later, the 'electromagnetic' method referred to here has a grounded source and thus not full

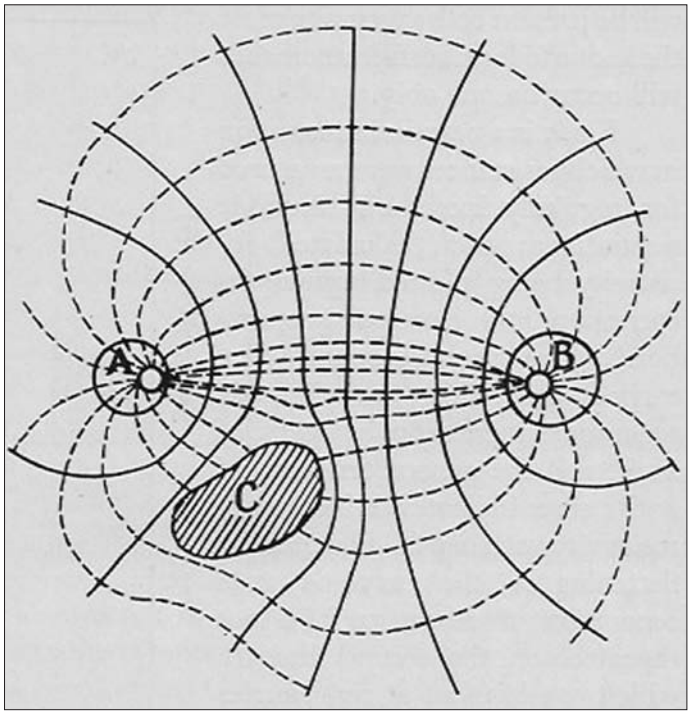

Figure 2. *An illustration of the principle of the equipotential method showing the distortion of the field by a conductive body, C (from Broughton Edge and Laby, 1931, Fig. 6).*

EM. The 'potential' method is "tracing equipotential curves" and the "electromagnetic methods are of more recent origin". "The main development [of the latter] occurred in 1921 [by] Karl Sundberg…" (that of using a non-contact receiver). Note that the first group, the equipotential method, was described by Andrews for the first time in 1925 and here, the author believes that, **for the first time in Australia, the 'electromagnetic method' (such as it was then known to be) is described**. Details of these methods are outlined individually in Part 2, in the 'Electrical Method'.

Source [3]: **Krahmann, 1926**.

This source is a 43-page soft cover book describing all the known geophysical methods in 1926, including radioactivity and "geo-thermic" with 36 figures, including some of equipment and some of operators in the field. Details of these methods will be discussed in Part 2 of this article. See Figure 3 for the Table of Contents ("Index")[9].

Krahmann's term "Electromagnetic" refers to a grounded source and inductive receiver similar to the Sundberg method referred to in the *Western Argus*, 1925. The Preface to Krahmann (1926) advises that this book is an "elaboration" of two lectures given in September 1925 to engineers in Linz, Austria and Bucharest, Romania. He gave a similar lecture in Adelaide in October 1927 (see pop-out box on Krahmann in Australia).

In Chapter One (Krahmann, 1926) on methods in general, Krahmann attributes the "rapid and already quite successful development" of geophysics to "revolutionary technical

[8]Lundberg, a mining engineer and geologist, was with the Swedish American Prospecting Corporation based in New York at the time. No reference is given but it is possible it was Lundberg and Nathorst (1922), a Yearbook of the Swedish Geological Survey.

[9]E C Andrews' copy of Krahmann, 1926, has the stamp of "K. Burggraf"(*sic*), the representative of Elbof Geophysical Co. Ltd. in Australia, on the cover. Also, there is "E. C. Andrews" and "1928", presumably, in Andrews' handwriting. Figure 1 in Henderson (2013) shows this front cover.

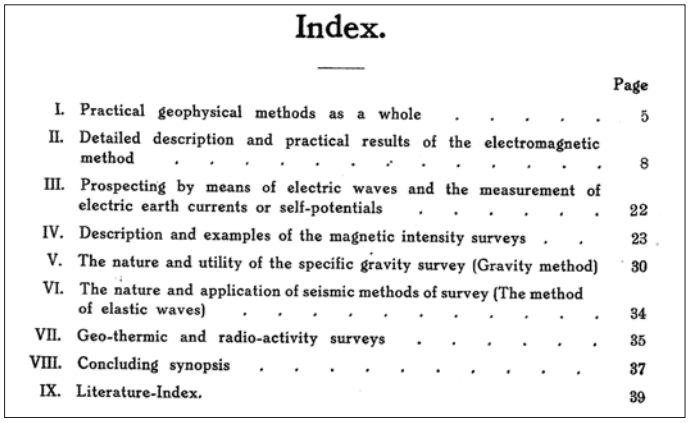

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Figure 3. *List of contents of Krahmann (1926). Note Chapter VII, rare topics at this time.*

advances", the depletion of raw materials and the general economic situation during and after WWI necessitating "cheaper and more comprehensive methods of investigation than drilling".

The references are extensive, mostly dated to the late 1890s to early 1920s, and categorised as to the type of method. One of the earliest reference is an 1833 work on the self-potential method by "Mr Fox". Thyer (1979) says, "Fox, as early as 1832 published his researches with the self potential method in the proceedings of the Royal Society". Figure 4 is a simple illustration of the principle of the self potential method whereby a natural potential surrounding some oxidised, conductive ore bodies is observed. More will be written about this method in Part 2 of this article.

Krahmann in Australia (and South Africa, briefly)

Dr Rudolph Krahmann was an engineer from Berlin. Newspaper reports put him in two states of Australia in 1927 and 1928. On 20 October 1927, as reported in the *Adelaide News* in a 103 word item, "Dr. R. Krahmann, of Berlin" gave a "lecture" at the University of Adelaide, "delivered in English and illustrated with many lantern slides". He is described in the item as "the leader of a party of highly trained investigators who have been invited to visit New Zealand and Australia to undertake researches by geophysical methods".

The newspaper then lists the methods "now in vogue" as the same as in Krahmann's book, (1926) including "geo-thomic" (sic).

The *Brisbane Courier*, on 11 April 1928, reported that "Dr. Krahmann, who represents a German company [Elbof]… *returned* yesterday to Roma to make a secondary preliminary survey of that oil field". Thyer (1979) states "Elbof succeeded in arranging a contract at Roma and work commenced in late 1928….". "Elbof used gravity (torsion balances), seismic (Schweydar seismograph), magnetic and its own magneto-inductive methods". Also in the *Brisbane Courier* item, "A director of one of the oil companies operating in the Roma area declared yesterday that he had been convinced *'against his will'* that geophysical prospecting had become an exact science".

Thyer (1979) also claims that Krahmann "commented favourably on the decision to form the IGES but said that he had found within Australia a tendency to regard *geophysics as a doubtful science"*.

de Beer (2011) informs us that Krahmann emigrated to South Africa in 1930 and became so famous there for his discoveries (using an Askania magnetometer) that the highest award now given by the South Africa Geophysical Association (SAGA) is the Krahmann Memorial Award.

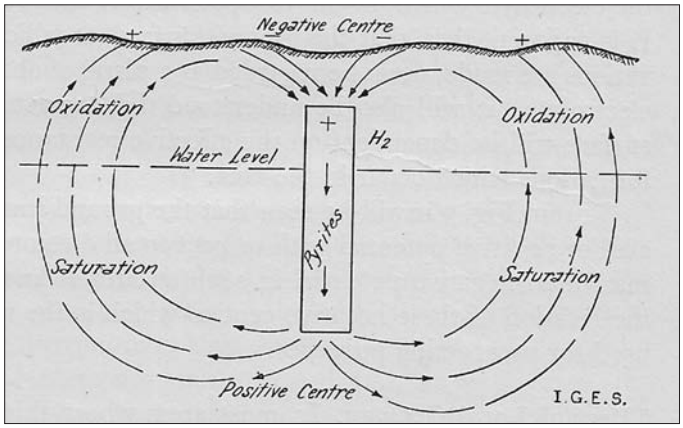


Figure 4. *A schematic of the principle of the self potential method (from Broughton Edge and Laby, 1931, Fig. 1).*

Source [4]: **Elbof, 1927**.

This work is the fourth edition of a company booklet produced by Elbof Geophysical Co. Ltd. (otherwise Piepmeyer & Co. Ltd.) Kassel, Germany. The work is 47 pages long and in six chapters describes all the methods including "geo-thermic" and radioactivity, but excluding seismic. Details of these methods will be discussed in Part 2 of this article. The illustrations and case studies are copious, and there is an extensive bibliography[10].

The Introduction, Chapter I, states that geophysical methods have been added to the "observational methods of the geologist… during the last decade". They are "not to take the place of deep boring or sinking…they are only intended to point to the best localities". And, "Recent progress has so far improved the sensitivity of the instruments that data can now be obtained at considerable depths". A combination of methods is advocated.

The chapter on "Geo-electrical exploration" begins with an extensive list of typical conductivities and an illustration of a laboratory "Sandbox" for testing the conductivities of target rocks. This sandbox is shown in Figure 5. The author has a long interest in the use of physical models and this description of a model is one of the earliest encountered (see also references to models in Mason, 1927, discussed below).

Source [5]: **Sub-Committee (for Geophysical Surveying) of the Committee of Civil Research, 1927.**

The Sub-Committee (for Geophysical Surveying) of the Committee of Civil Research was appointed to provide a report to the Empire Marketing Board (EMB) on geophysical

[10]The copy originally held by E. C. Andrews has written on the cover, in pencil, "From Co. for Scientific and Industrial Research, Melbourne". They were possibly an agent in Australia for Elbof although the 'Manager' of Elbof, as we know from above, is K. Burggraf in Sydney.

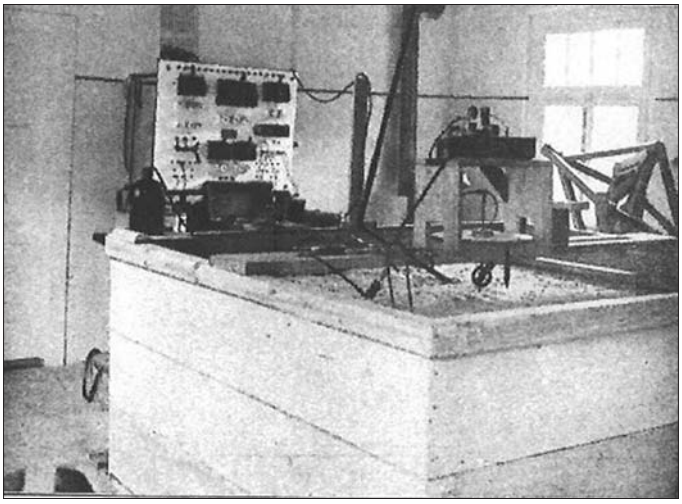
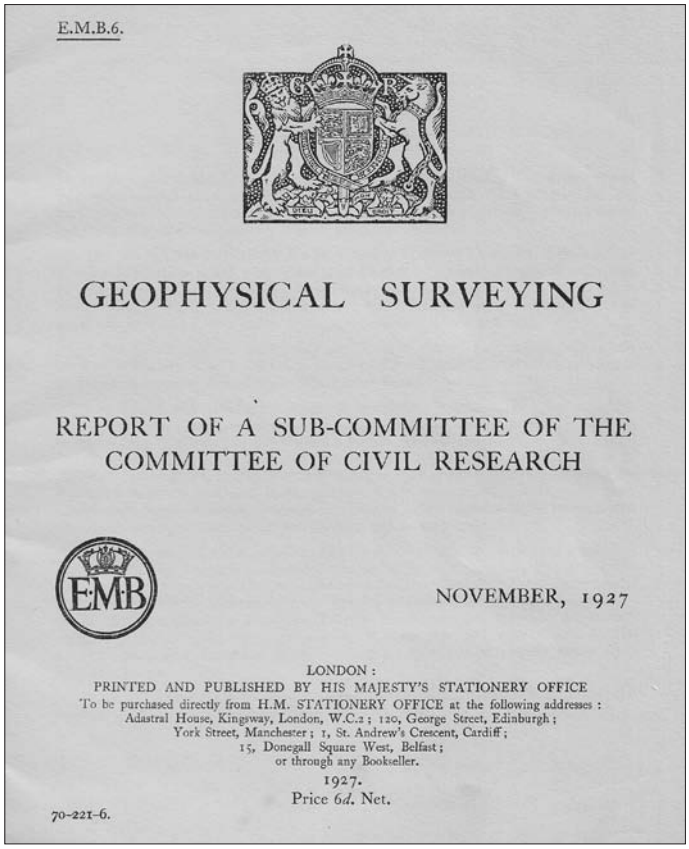


Figure 5. *The experimental sandbox in the Elbof laboratory, a physical modeling facility before 1927 (from Elbof Geophysical Co. Ltd., 1927, p. 7).*

surveying. Their report was published in November 1927 as Publication no. 6 of the EMB, and available at a cost of six pence. The title page is shown in Figure 6. At least one copy existed in Australia and was in the possession of E C Andrews in about 1928.

The Sub-Committee was appointed in April 1927, and the report was recommended to the EMB a few months later. The authors of the report consisted of seven distinguished men, many of whom were associated with well-known English institutions,


E.M.B.6.

GEOPHYSICAL SURVEYING

REPORT OF A SUB-COMMITTEE OF THE COMMITTEE OF CIVIL RESEARCH

EMB

NOVEMBER, 1927

LONDON:
PRINTED AND PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses:
Adastral House, Kingsway, London, W.C.2; 120, George Street, Edinburgh;
York Street, Manchester; 1, St. Andrew's Crescent, Cardiff;
15, Donegall Square West, Belfast;
or through any Bookseller.
1927.
Price 6*d*. Net.
70-221-6.

Figure 6. *The title page of the report on Geophysical Surveying by the Sub-Committee (for Geophysical Surveying) of the Committee of Civil Research (1927).*

together with our own Sir Edgeworth David, Professor Emeritus of Geology, University of Sydney[11].

The Introduction (Section I) of this source lists the terms of reference of the Sub-Committee and the very first of the four was to report on "What recent developments, if any, have been made in the methods employed in geophysical surveying". Section II is entitled "The various methods of geophysical surveying" with sub-headings for "Gravimetric, "Electrical", "Magnetic", "Seismic and Sonic Sounding", and "Thermal" methods. Details of these methods will be discussed in Part 2 of this article. Each sub-section describes what the Sub-Committee believed to be the latest knowledge of the methods at that time at least, it would seem, mainly in Europe. The only examples referred to outside Europe were; the employment of the gravity method (always torsion balance) on salt domes in the Texas Gulf Coast, and the electrical method at the "Britannia Mine in Canada" and another in California. "We did not…make any further enquiry into these applications in Canada and the United States". What a gap they left in their investigations!

The authors claim that with the exception of the magnetic method, which for a long time (indeed from "the middle of the 19th century") was used to map iron ore, particularly in Sweden, "these [other] methods were practically unknown until within the last twenty-five years".

The report then concludes with an interesting insight into the state of knowledge of geophysical methods at least in the British Empire (thereby including Australia and Canada but excluding the USA and the rest of Europe)[12]. "So far as the British Empire is concerned, surprisingly little use has been made of these methods…". Part 2 of this article examines how this "little use" was not true of countries outside the Empire (including USA and Scandinavia). Regarding their value, "… we believe that an extensive trial of the principal methods…would be of great interest and value to the Empire". Hence their promotion of the IGES.

Source [6]: **Gepp et al., 1927**.

In 1927, the *Proceedings of the Australian Institute of Mining and Metallurgy* published a paper titled "Geophysical Prospecting" by H W Gepp, J F Hughes and H S Elford, (Gepp et al., 1927). Butcher (1984) claims it was also "later reprinted by the Aust. Inst. Min. Metall. Eng. in pamphlet form". Also, the *Kalgoorlie Miner* reproduced the paper extensively on 22 June 1927 (Kalgoorlie *Miner*, 1927).

Some background on Herbert Gepp, particularly in relation to his involvement in geophysics matters, is given separately in the pop-out titled "About Gepp".

Little is known about John Frankland Hughes other than he is described as a geophysicist, born in Victoria, who died in 1975. His legacy is his co-authorship of this paper. Harold Stewart Elford (1902-1956) was a chemist by profession and worked, with Gepp in the Australian Development and Migration

[11]As stated above, the story of the formation of the IGES via the Empire Marketing Board is amply told by others.

[12]The British Empire at this time also included South Africa, India and various countries in Africa such as Southern Rhodesia (now Zimbabwe), for a total population of 458 million in 1922. Peter Hartcher (2014) in *The Adolescent Country*, reminds us that "Australia was content to act as a local sub-branch of the British Empire.... until 1940".

About Gepp (in particular, his relationship with geophysical interests)

Herbert William Gepp (1877–1954), also known as "Bert", was Chairman of the Australian Development and Migration Commission from 1926 and very involved in encouraging the formation of the IGES. Thyer (1979) claims Gepp "was largely responsible for establishing the… IGES" and suggests that his representations to the British Empire Marketing Board were "instrumental in Australia being selected as the location for such field tests" (that is, instead of another part of the Empire). Gepp was one of the members of the Australian Geophysical Executive Committee of the IGES (as was E C Andrews). While he showed strong commitment to the promotion of geophysics there is no evidence that he had any formal training in the subject. More on Gepp's continued belief in the value of geophysical prospecting is given in Butcher (1984), pp 33, 34 and 40.

In Gepp's biography, written by B E Kennedy (Kennedy, 1981), Gepp, a mining metallurgist, is reported to have "boundless energy, inventive mind and commitment to industrial growth". He was President of the Australasian Institute of Mining and Metallurgy in 1924, knighted in 1933, and in 1934, became Director of the Aerial Geological and Geophysical Survey of North Australian (AGGSNA), about which much has been written elsewhere. Figure 7 is a photo of Gepp taken at an unknown time.

Figure 7. *Sir Herbert Gepp at an unknown time (from Kennedy, 1981).*

Butcher (1984) suggests "Gepp, largely through his own efforts and determination, worked his way to the pinnacle of Australian society". His annual salary of £5000 was then the highest salary paid to an Australian public servant. Butcher (1984) has more information on Gepp's rise in private industry, at one stage to manager of the newly formed Electrolytic Zinc Co. at the early age of 40.

Commission as Chief Technical Officer.

The paper begins with the object to "bring before Members of the Institute the very important and much discussed question of scientifically prospecting for ores, oil, coal, etc." Its 38 pages cover the methods of "Sound-Vibration, Magnetic, Gravitometric (*sic*) and Electrical", the latter subdivided into "Equipotential, Electro-magnetic, Schlumberger, and General". Details of these methods will be discussed in Part 2 of this article. Section II, titled "General Discussion of Geophysical Prospecting", includes four tables attributed to Heiland (1926) and Sundberg et al. (1925), a bibliography, and four photos of equipment and operators in the field.

Presumably, as none of the three co-authors knew much geophysics, the paper relies heavily (in fact, 90%) on other references from which extensive quotations are reproduced, with very little attributed to the authors themselves. Also, some of the information is not very current or mainstream, as we see in the second part of this article.

Source [7]: **Mason, December 1927.**

This 32-page booklet titled Geophysical Exploration for Ores, is Technical Publication No. 45 of the American Institute of Mining and Metallurgical Engineers (AIME) and was presented to the New York section of AIME in October 1927. The paper has no list of references, although one reference is given as a footnote, and it includes a discussion. A later version published in AIME *Geophysical Prospecting*, 1929 includes an additional written discussion by K. Sundberg, of the Swedish American Prospecting Corporation, Houston, Texas.

The author of the paper, Dr Max Mason, was at the time President of the University of Chicago, Illinois, USA and also Chair of Physical Exploration Corporation of New York[13].

The methods discussed, in order, are: acoustic, gravitational, magnetic, electrical (only self potential), "electromagnetic" (as Schlumberger and Lundberg type equipotential) and 'Inductive' non-contact receiver electromagnetics. Surprisingly, Mason made no mention of the resistivity method as expounded by fellow American, Wenner, in 1915. Interpretation is declared to be the work of the physicist. Many pages discuss the 'philosophy' of interpretation, including the inverse problem and non-uniqueness, at what appears to be at an advanced level. There is a long chapter on "Use of Models", comparing field results to theoretical shapes. In one case, the model is a "sphere of about 3 ft. diameter" but its composition is not disclosed. Then, the results of all methods previously discussed are shown over the same real ore-body (the Falconbridge nickel ore at Sudbury, Ontario, Canada) simplified to a narrow, vertical conductive vein for model comparisons.

Under the heading "Underground Exploration an Attractive Field" it is stated "…we believe underground explorations in producing mines will be an attractive field for future applications…"[14].

Mason's intriguing way of anthropomorphising the geophysical process, such as shouting the question down to the ore-body and listening for an answer, is further described in Henderson (2013).

[13]In the introduction to his paper, Dr Mason explained that as a physicist he was asked by a mining company in 1923, "to review the whole question of the application of physics to ore detection…. This involved a review of the prior work on geophysics…". His paper is a report on these investigations, together with theory and special field tests.

[14]Elbof [4], for electrical methods, at least, also suggests the possibility of "work underground" (see 'Electrical methods' in Part 2 of this article).

Source [8]: **Barton, February 1928.**

This 51-page paper titled "The Eötvös torsion balance method of mapping geologic structure", is a single subject paper and covers most of the subject of theory, measurement and interpretation of results, and includes 20 figures and a half page of references. The author, Donald C Barton, was a consulting geophysicist from Houston, Texas.

The paper was published as Technical Publication No. 50 of the AIME in 1928 and a later version published in AIME *Geophysical Prospecting* in 1929 added 13 pages of discussion, which, in itself, is very informative of the state of knowledge at the time. It included written submissions from E Lancaster-Jones and H Shaw, both from The Science Museum, London, England[15].

Source [9]: **Andrews, 1928.**

A description of the level of knowledge of the various methods as reported by E. C. Andrews is given in Henderson (2013). Apart from his individual knowledge on the equipotential method as described in Andrews (1925), most of his information is derived from his visit to the USA in 1927, and from Mason (1927) and possibly Barton (1928), copies of whose papers he possessed and are reviewed above. He, like all the sources reviewed, made no mention of the specific activity taking place in South Africa at this time. Nor did he discuss the resistivity method, probably because Mason (1927) did not (see also, Henderson (2013), p. 43, on subject).

Andrews noted patents taken out in Australia for the "Schlumberger Process" in 1913 and 1914 and those of "The Lundberg and Sundberg Process". These patents were also referred to by Day (1966). Andrews is the only source to mention "submarine geological surveying" and recognised the "possibilities of geological surveying by geophysical methods". Andrews was ever the geologist with his constant reference to their indispensability to the interpretation of the geophysical results.

Andrews suggested that the work accomplished at that time in other countries "should be applicable to the case of Australia, although not so marked a degree as in North America**,** which contains a relatively intense concentration of ore deposits, including oil, coal and gas". As if to address this difference, he listed areas that he believed would be applicable to the use of geophysics, namely: "The Greater Roma District", for oil and gas; "the Hunter River Basin", for coal; and the "Broken Hill District", the Greater Cobar District and the "west coast of Tasmania" for metals. The latter area was one included in the IGES, plus another area suggested by Andrews; the Gulgong deep leads, where all four methods of the IGES, including seismic, were employed.

On lack of knowledge before the IGES

An example of how little knowledge there was in Australia before IGES and how little the Sub-Committee (for Geophysical Surveying) of the Committee of Civil Research knew of its state, was in the way that the recommendations of the Sub-Committee with regard to personnel could **not** be met by Australian graduates, with one exception. One recommendation was that "one member of the party should be *a first-class honours graduate in electricity*". Another was that "the party should contain *a first-class honours graduate in physics and mathematics,* who would be responsible to the leader for the gravimetric and magnetic surveys undertaken".

In this regard, Butcher (1984) points out that, at this time, "no physics department in any Australian university provided training or expertise in the area". E H Booth, in his Presidential address to the Royal Society of NSW (Booth, 1938) acknowledged that before the IGES, "no trained personnel, scientific or otherwise, was available in Australia, … no students had yet been trained, although it was known to be absorbing many science graduates of Continental and American universities". Also, we know that lectures on exploration geophysics did not start in Australia until 1950 (Henderson, 2016).

The position of "honours graduate in electricity" was filled by two experienced assistants of Broughton Edge; S H Shaw and J C Ferguson, both science graduates from London, "In order that the electrical investigations might be commenced in Australia with out delay" ('(Broughton Edge and Laby, 1931)', p. 3). Both these men had spent time with Broughton Edge in what was then Rhodesia.

Also, "As regards the physicist to undertake the torsion-balance survey…immediate arrangements should be made…to come to this country for….intensive study of the gravimetric method….in consultation with the Science Museum" (Sub-Committee (for Geophysical Surveying) of the Committee of Civil Research, 1927, p. 17–18). This latter recommendation, at least, acknowledged that the Australian would need training in the UK.

The "physicist" chosen as leader of the Gravimetric section in the IGES was, in fact, the Australian, N B Lewis, BSc, D Phil (Oxon), a graduate of the University of Melbourne. He was however, according to Butcher (1984), at University of Oxford, 1924-26 and the University of Uppsala, Sweden 1926–1927, so was already in Europe to undertake the training in the UK. According to the Introduction to Broughton Edge and Laby (1931), "for some months he had been undergoing his preliminary training in England". Butcher (1984) also claims that Lewis "was in fact a chemical physicist", suggesting that a "physics student in the 'pure' sense" was even less available at this time.

Conclusion to Part 1

Before the IGES, geophysical surveys in Australia numbered possibly only three and were only single method, magnetics or electrical. The gravity and seismic methods, although practiced in other countries, were not applied to metalliferous or petroleum prospects before the IGES. However, at least nine documented sources of geophysical knowledge have been identified by the author as being available before the IGES All but two sources described the gravity method and five described the seismic method.

In Part 2 of this article, which will follow in a subsequent issue of *Preview*, the information in these sources is examined in more detail by method. The reasons why exploration geophysics

[15]Both these men had their own paper in this AIME volume on the gravity method, Shaw's being more general on Gravity Surveying in Great Britain (this relates to information provided by the Sub-Committee (for Geophysical Surveying) of the Committee of Civil Research, November 1927 to follow in Part 2 of this article, 'Gravity Method').

was late in coming to Australia, as compared to other Western countries, are also discussed.

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24–26	OTC Brazil	Rio de Janeiro	Brazil
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14–19	SEG Annual Meeting	Anaheim	USA

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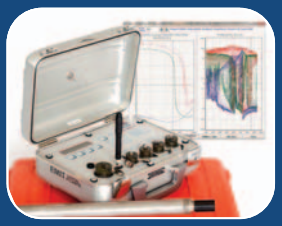

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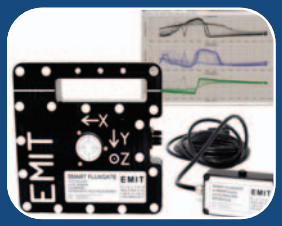

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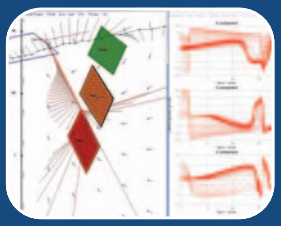

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