Australian Society of
Exploration Geophysicists

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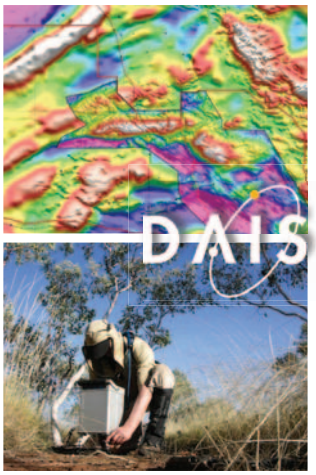
PREVIEW

NEWS AND COMMENTARY

FEATURES

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2017 ASEG CORPORATE PLUS MEMBERS

Velseis Pty Ltd
Contact:
Tel: +61 7 3376 5544
Email: info@velseis.com

2017 ASEG CORPORATE MEMBERS

Archimedes Financial Planning
Contact: Noll Moriarty
Tel: 1300 387 351
Email: Noll.Moriarty@ArchimedesFinancial.com.au

Instrumentation GDD Inc.
Contact: Pierre Gaucher
Tel: +1 418 877 4249
Email: pgaucher@gcc.ca

Santos Ltd
Contact:
Tel: +61 8 8116 5000
Web: https://www.santos.com

Southern Geoscience Consultants Pty Ltd
Tel: +61 8 6254 5000
Email: geophysics@sgc.com.au
Web: http://sgc.com.au/

Total Scan and Survey
Contact:
Tel: +61 8 6188 7688
Email: admin@tssurvey.com.au

FRONT COVER

Bernie Milton on the road with the South Australian Geological Survey seismic field crew in the 1970s. This photo is taken from Dave Isles' article on the discovery of Olympic Dam, which appears in this issue of *Preview*.

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CONTENTS

Editor
Lisa Worrall
Email: previeweditor@aseg.org.au

Associate Editors
Education: Michael Asten
Email: michael.asten@monash.edu

Government: David Denham
Email: denham1@iinet.net.au

Environmental Geophysics: Mike Hatch
Email: michael.hatch@adelaide.edu.au

Minerals Geophysics: Terry Harvey
Email: terry.v.harvey@glencore.com.au

Petroleum Geophysics: Michael Micenko
Email: micenko@bigpond.com

Geophysical Data Management and Analysis: Guy Holmes
Email: guy.holmes@katalystdm.com

Book Reviews: Ron Hackney
Email: ron.hackney@ga.gov.au

ASEG Head Office & Secretariat
Ben Williams
The Association Specialists Pty Ltd (TAS)
Tel: (02) 9431 8622
Email: secretary@aseg.org.au
Website: www.aseg.org.au

Publisher
CSIRO Publishing

Production Editor
Helen Pavlatos
Tel: (03) 9545 8472
Email: helen.pavlatos@csiro.au

Advertising
Doug Walters
Tel: (03) 9545 8505
Email: doug.walters@csiro.au

Editor's desk

This issue of *Preview* features an article by Don Emerson on the 'Conductivities of Broken Hill-style lead ores'. This article is an important contribution to our developing understanding of Australian rock properties, and I know it will be cited for many years to come. We also feature an article by Dave Isles on 'The discovery of Olympic Dam'. Dave shares some insights into the visionary and risk taking culture in the South Australian Geological Survey in the 1970s, a culture that created the right environment for discovery!

As always, our regular commentators do not disappoint. David Denham (*Canberra observed*) reviews the 2017 Federal Budget. Michael Asten (*Education matters*) teams up with Emma Brand to report on the strategic plan being developed by the ASEG Continuing Education Committee. Mike Hatch (*Environmental geophysics*) muses about the solution to familiar problem – the cost-effective recovery of information on the movement of water through agricultural landscapes. Mick Micenko (*Seismic window*) reflects on the role of the Australian Government in managing fuel prices. Terry Harvey (*Mineral geophysics*) speaks up for old data and Guy Holmes (*Data trends*) introduces us to his new digital classroom. Enjoy!

In late April I was in Europe and participated in the March for Science in London before attending the European Geosciences Union General Assembly in Vienna. A number of marchers carried banners promoting the peer review process so it was a bit of a shock to get to Vienna and to find that the Assembly was buzzing with talk about how the peer review process is being manipulated by some scientists eager to promote their own interests and ideas.

Banners held by demonstrators at the 2017 March for Science in London.

Editors and reviewers of some Copernicus and Wiley journals, very respectable journals with high impact factors, had been accused of citation stacking. Citation stacking involves applying pressure on authors (via the peer review process, which is usually anonymous) to cite particular papers with a view to improving the citation rating of individuals (H index) or the impact factor of particular journals. The accusations were proven in at least one instance, with one individual found to have used the system to dramatically increase their ranking and the ranking of a number of journals (https://static2.egu.eu/media/filer_public/07/79/07798eae-e4e4-48f2-a9d0-6b8ce0110302/egu-copernicus-report-about-citation-stacking.pdf). At the same time rumours were circulating about the appearance of 'fake' reviewers. A phenomenon highlighted in a recent letter to *Nature* (http://www.nature.com/nature/journal/v546/n7656/full/546033a.html).

The EGU Publications Committee had an open meeting to discuss how the scientific community might address malpractice, particularly as it affected the peer review process. The extent of malpractice revealed at that meeting was shocking to me but then, perhaps, I am a naïve colonial. It could be argued that human nature is such that if a system can be exploited it will be, and scientists are only human. It is clear that if the scientific community is going to maintain credibility then, to borrow a concept from industry, our quality assurance, quality control processes must be carefully and constantly scrutinised.

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

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President's piece

Andrea Rutley

The ASEG Annual General Meeting, held in Brisbane in April saw the election of new office bearers for 2017 and the departure of others. On taking over the role of President of ASEG, I would like to sincerely thank Katherine McKenna, outgoing President, for her efforts during 2016 and welcome our new Directors of the Federal Executive (FedEx) for 2017. Additionally, my sincere thanks to all members of the Federal Executive for the work that they have tirelessly continued to undertake, some for as many as 25 years.

The 2017 Directors of the ASEG Federal Executive are:

President: Andrea Rutley
President Elect: Marina Costello
Secretary: Megan Nightingale
Treasurer: Danny Burns

The evening recorded the retirement of one of the longest serving members of the Federal Executive, Koya Suto, who has served on the ASEG FedEx for 25 years. During this time, Koya has held almost every position possible and has brought enthusiasm and passion to each and every one of these. I would like to personally thank Koya for his exceptional commitment to the ASEG and wish him well during the course of his retirement. Somehow, I don't think he will ever be far from all things ASEG.

Our technical presentation for the evening was delivered by Koya and was titled 'Near-surface geophysics; geophysics for human life, geophysics in the life of a human'. This was a fascinating insight into Koya's geophysical work in the vastly different communities in which he has conducted geophysical surveys.

Past President, Katherine McKenna presenting Koya Suto with a thank you gift for his 25 years of service on the ASEG FedEx.

With Koya's presentation on community geophysics and ANZAC Day approaching, I started to think about geophysics and geophysicists in our Services and began to research the role of geophysics in wartime. I was quite surprised to find the number of articles relating to the use of geophysics in war, particularly during World War I and II. What was also interesting was that much of the technology that we are familiar with today evolved out of wartime necessity.

A couple of quick questions to the ASEG History Committee revealed an even greater depth of information. One particularly interesting article (https://medium.com/war-is-boring/how-britain-beat-germanys-wwii-magnetic-sea-mines-bfec5558704c) discusses the British and German developments of magnetic and acoustic?? mines and the associated technology that was developed to detect and remotely detonate these mines, to prevent the widespread destruction of naval and merchant shipping. The photograph that I have included in this article is a German Ju-52/3mg6e showing the electromagnetic loop used for this purpose *circa* 1939. The image is from the German Federal Archives. Whilst both modern hardware and software may have changed, the silhouette below is striking similar to our airborne systems of today, supporting evidence for the proverb that 'Necessity is the Mother of Invention'.

I hope this glimpse into history, may spark some innovative thoughts which we can share in Sydney in 2018 at the inaugural AEGC 2018 (Australasian Exploration Geoscience Conference). It combines ASEG, PESA and AIG and incorporates our 26th ASEG Conference. The theme for the conference is 'Exploration – Innovation – Integration'. I look forward to seeing you there.

Andrea Rutley
ASEG President
president@aseg.org.au

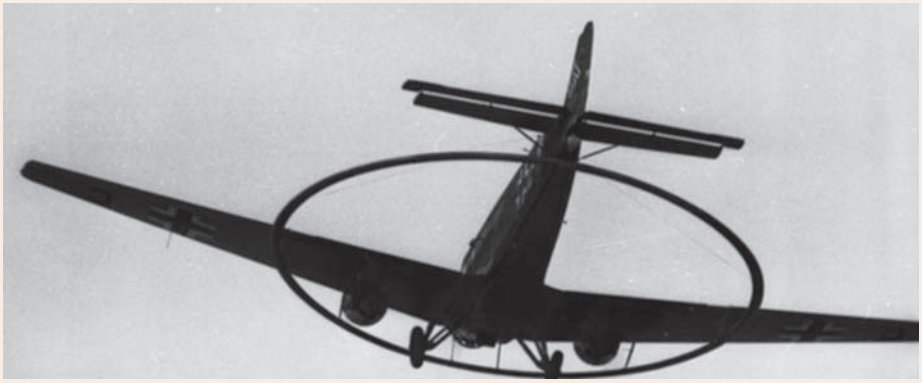

Photo of a German Ju-52/3mg6e from German Federal Archives.

Welcome to new Members

The ASEG extends a warm welcome to 33 new Members approved by the Federal Executive at its April and May meetings (see table).

First name	Last name	Organisation	State	Country	Membership type
Mohsen	Abdolghafurian	Curtin University	WA	Australia	Student
Douglass	Beck	University of Queensland	QLD	Australia	Student
Andrew	Buchel	Standard Australia	NSW	Australia	Associate
Cam	Coleman		VIC	Australia	Active
Larissa	Collins	Adelaide University	SA	Australia	Student
Mrinal	Deane	Curtin University	WA	Australia	Student
Stephen	Doughty	Macquarie University	NSW	Australia	Student
Omar	Elkhaligi	Macquarie University	NSW	Australia	Student
Daniel	Ellis	Adelaide University	SA	Australia	Student
Maddison	Fairburn	Curtin University	WA	Australia	Student
Anthony	Finn	Macquarie University	NSW	Australia	Student
Zory	Fletcher	Curtin University	WA	Australia	Student
Clifford	Ford	University of Western Australia	WA	Australia	Student
Vincent	Ganivet	CGG	WA	Australia	Active
Lauren	Harrington	University of Sydney	NSW	Australia	Student
James	Hewett	Adelaide University	SA	Australia	Student
Samuel	Jennings	Adelaide University	SA	Australia	Student
Chris	Li	University of Adelaide	SA	Australia	Student
Katelin-Rose	Morrison	Queensland University of Technology	QLD	Australia	Student
Travis	Pavley	Adelaide University	SA	Australia	Student
Snezana	Petrovic	Curtin University	WA	Australia	Student
Davina	Rabadia	Curtin University	WA	Australia	Student
Md.	Reza	Geological Survey of Bangladesh	Dhaka	Bangladesh	Corporate
James	Roughan	Adelaide University	SA	Australia	Student
William	Rowe	Adelaide University	SA	Australia	Student
Hannah	Scott	Macquarie University	NSW	Australia	Student
Bibirabea	Sedaghat	Curtin University	WA	Australia	Student
Grant	Smith	University of Queensland	QLD	Australia	Student
Sean	Standen	University of Western Australia	WA	Australia	Student
Kurt	Steffens	University of Sydney	NSW	Australia	Student
Nhat-Hoa	Troung	Adelaide University	SA	Australia	Student
Kai	Zhao	CGG	WA	Australia	Active
Joe	Zhou	CGG	WA	Australia	Active

ASEG Federal Executive 2017–18

Andrea Rutley: President (Communications and Promotions Committee Chair)
Tel: (07) 3834 1836
Email: president@aseg.org.au

Marina Costelloe: President Elect
Tel: (02) 6249 9347
Email: presidentelect@aseg.org.au

Megan Nightingale: Secretary
Tel: 0438 861 556
Email: fedsec@aseg.org.au

Danny Burns: Treasurer (Finance Committee Chair)
Tel: (08) 8338 2833
Email: treasurer@aseg.org.au

Katherine McKenna: Past President (Membership Committee, International Affairs Committee, ASEG RF)
Tel: (08) 9477 5111
Email: pastpresident@aseg.org.au

Kim Frankcombe (AGC Representative, Conference Advisory Committee and Technical Standards Committee)
Tel: (08) 6201 7719
Email: kfrankcombe@iinet.net.au

Emma Brand (Education Committee Chair)
Tel: 0455 083 400
Email: continuingeducation@aseg.org.au

Marina Pervukhina (State Branch Representative, Specialist and Working Groups Liaison)
Tel: (08) 6436 8746
Email: branch-rep@aseg.org.au

David Annetts (Web Committee Chair)
Tel: (08) 6436 8517
Email: david.annetts@csiro.au

Bob Musgrave (Publications Committee Co-Chair)
Tel: (02) 4931 6725
Email: publications@aseg.org.au

Greg Street (Publications Committee Co-Chair, History Committee)
Tel: (08) 9388 2839
Email: publications@aseg.org.au

Standing Committee Chairs

Finance Committee Chair: Danny Burns
Tel: (08) 8338 2833
Email: treasurer@aseg.org.au

Membership Committee Chair:
Katherine McKenna
Tel: (08) 9477 5111
Email: membership@aseg.org.au

State Branch Representative: Marina Pervukhina
Tel: (08) 6436 8746
Email: branch-rep@aseg.org.au

Conference Advisory Committee Chair:
Michael Hatch
Email: cac@aseg.org.au

Honours and Awards Committee Chair:
Andrew Mutton
Tel: 0408 015 712
Email: awards@aseg.org.au

Publications Committee Co-Chairs:
Greg Street and Robert Musgrave
Tel: –
Email: publications@aseg.org.au

Technical Standards Committee Chair:
Tim Keeping
Tel: (08) 8226 2376
Email: technical-standards@aseg.org.au

ASEG History Committee Chair:
Roger Henderson
Tel: 0408 284 580
Email: history@aseg.org.au

International Affairs Committee Chair:
Katherine McKenna
Tel: (08) 9477 5111
Email: vicepresident@aseg.org.au

Education Committee Chair: Emma Brand
Tel: 0455 083 400
Email: continuingeducation@aseg.org.au

Web Committee Chair: David Annetts
Tel: (08) 6436 8517
Email: david.annetts@csiro.au

Research Foundation Chair: Philip Harman
Tel: 0409 709 125
Email: research-foundation@aseg.org.au

Research Foundation – Donations: Peter Priest
Email: pwpriest@senet.com.au

Specialist Groups

Near Surface Geophysics Specialist Group
President: Greg Street
Tel: (08) 9388 2839
Email: gstreet@iinet.net.au

Young Professionals Network
President: Megan Nightingale
Tel: 0438 861 556
Email: ypadmin@aseg.org

ASEG Branches

Australian Capital Territory

President: James Goodwin
Tel: (02) 6249 9705
Email: actpresident@aseg.org.au

Secretary: Adam Kroll and Bill Jones (shared position)
Tel: (02) 6283 4800
Email: actsecretary@aseg.org.au

New South Wales

President: Mark Lackie
Tel: (02) 9850 8377
Email: nswpresident@aseg.org.au

Secretary: Sherwyn Lye
Tel: (02) 8960 8417
Email: nswsecretary@aseg.org.au

Queensland

President: Fiona Duncan
Tel: 0419 636 272
Email: qldpresident@aseg.org.au

Secretary: Mark Kneipp
Tel: 0407 308 277
Email: qldsecretary@aseg.org.au

South Australia & Northern Territory

President: Joshua Sage
Tel: 0438 705 941
Email: sa-ntpresident@aseg.org.au

Secretary: Adam Davey
Tel: –
Email: sa-ntsecretary@aseg.org.au

NT Representative: Tania Dhu
Tel: 0422 091 025
Email: nt-rep@aseg.org.au

Tasmania

President: Mark Duffett
Tel: (03) 6165 4720
Email: taspresident@aseg.org.au

Secretary: Steve Kuhn
Tel: (03) 6226 2477
Email: tassecretary@aseg.org.au

Victoria

President: Seda Rouxel
Tel: 0452 541 575
Email: vicpresident@aseg.org.au

Secretary: Thong Huynh
Tel: –
Email: vicsecretary@aseg.org.au

Western Australia

President: Kathlene Oliver
Tel: 0411 046 104
Email: wapresident@aseg.org.au

Secretary: David Farquhar-Smith
Tel: 0409 840 503
Email: wasecretary@aseg.org.au

The ASEG Secretariat

Ben Williams
The Association Specialists Pty Ltd (TAS)
PO Box 576, Crows Nest, NSW 1585
Tel: (02) 9431 8622
Fax: (02) 9431 8677
Email: secretary@aseg.org.au

Executive brief

ASEG AGM Brisbane April 2017

Overview

Andrea Rutley took over from Katherine McKenna as President, congratulations Andrea! Thank you Katherine McKenna for your hard work and enthusiasm. As Immediate Past President, Katherine will be looking at the strategic direction of the Society in the areas of membership, international relations and the research foundation. Marina Costelloe is President Elect, she will be working on policy development. Megan Nightingale is the new Secretary. Megan will continue updating our valued reading audience with the Exec Brief so if there is anything you would like to hear about please don't hesitate to contact her. We also welcomed Marina Pervukhina (State Branch Representative) and Bob Musgrave (Publications).

Thank you to Danny Burns (Treasurer) Kim Frankcombe (Australian Geoscience Council, Conference and Technical Committees representative), Greg Street (Publications and History Committees) David Annetts (Webmaster) and Emma Brand (Education Committee) for continuing their hard work for the Society. Federal Executive contact details can be found on the ASEG website www.aseg.org.au.

An extra special thanks to the Federal Executive who stood down this year; Lisa Vella (Publications), Tania Dhu (Branch Representative), Phil Schmidt (Immediate Past President) and Koya Suto (Vice President and International Relations).

Koya Suto gave a fantastic overview of his geophysical career with the technical talk at the AGM, the Society is richer for generous technical leaders and humanitarian members like Koya.

Treasurer's report

The audited financial statement for the year ending 31 December 2016 for the ASEG is presented in Table 1. The financial statement refers to the consolidated funds held by the Society as a whole, including the Branches.

In 2016 the Society made a loss of $268 353 following a profit of $180 781 in 2015. This is partly due to costs from increased publications in 2015 being paid in 2016.

The Society's funds go towards promoting the science and profession of exploration geophysics throughout Australia, achieved via our publications, *Preview* and *Exploration Geophysics*, via the ASEG Research Foundation, via meetings and events in the State Branches and via our conferences and exhibitions. Income and expenditure for the years 2008–2016 are shown in Figures 1 and 2.

The Federal Committee was very happy with the successful 2016 Adelaide Conference and Exhibition during these difficult times for the industry. However, 2017 is a non-conference year so we do expect to show a loss again this year, but look forward to receiving funds from the AEGC conference in 2018. Like the industry as a whole, the Society is working on reducing expenditure to live within our means. The Society's audited balance sheet and net assets are shown in Table 2 and Figure 3.

Table 1. Audited income and expenditure

Income	2016	2015
Membership	105 016	115 099
Meetings & Event	54 171	85 871
Education	13 437	22 074
Publication	207 996	197 790
Conference	137 331	430 543
Interest	27 724	15 393
Total Income	545 675	866 770
Expenditure	**2016**	**2015**
Membership	5 829	7604
Meetings	100 123	125 587
Education	46 386	44 754
Publication	358 826	246 934
Conference	3959	2629
Financial/Audit/Insur.	11 489	13 129
RF	100 000	100 000
Secretariat	80 993	84 940
Website	44 851	395
Other	61 572	60 015
Total Expenses	814 028	685 989
Profit/Loss	**2016**	**2015**
	–268 353	180 781

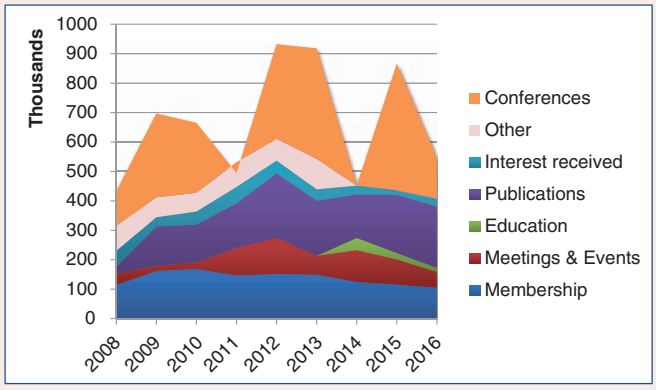

Figure 1. *Income 2008–2016.*

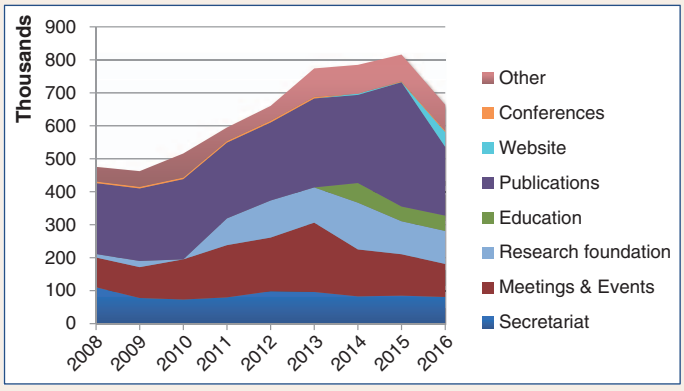

Figure 2. *Expenses 2008–2016.*

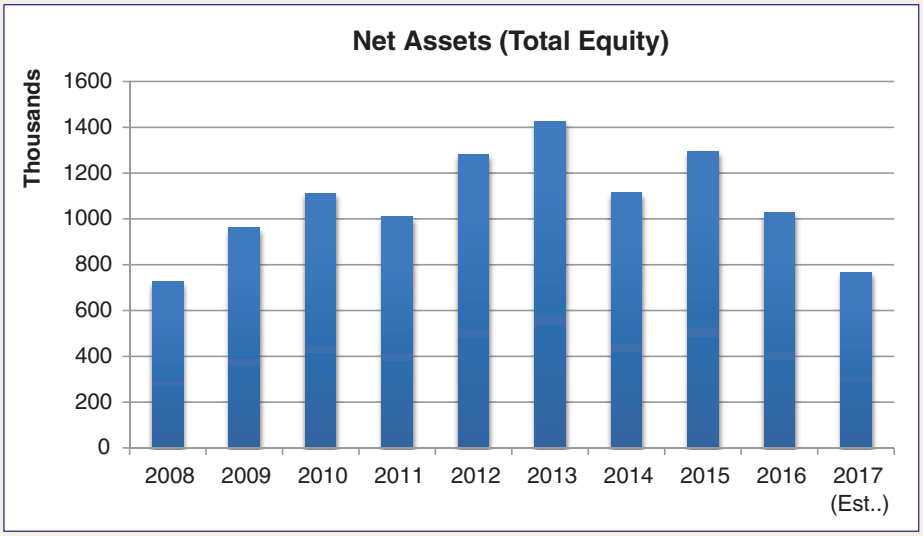

Figure 3. *Balance Sheets 2008–2017(est.).*

Table 2. Audited balance sheet

Assets	2016	2015
Cash	206 923	788 594
Term Deposits	874 396	512 878
Trade Debtors	38 981	15 572
Inventories	1536	1920
Other Assets	22 831	22 138
Intangible Assets	-	27 680
Total Assets	1 144 667	1 368 782
Liabilities	**2016**	**2015**
Trade Creditors	61 399	12 112
Income in Advance	56 146	61 195
Total Liabilities	117 545	73 307
Net Assets	**2016**	**2015**
	1 027 122	1 295 475

FedEx planning meeting Brisbane April 2017

The day after the AGM the Federal Executive got together to discuss issues facing the Society in the short and long terms. The meeting was attended by the Federal Executive, the Honorary *Preview* Editor Lisa Worrall, the Queensland Branch President Fiona Duncan and representatives from the Secretariat TAS.

The following statement guides the Federal Executive in making decisions that will affect the future of the Society:

The ASEG is the premier society for mineral geophysics, recognised as strong in petroleum, engineering, and, environmental (near surface) geophysics; we strive to be relevant across all aspects of geophysics but for the short term future we want to consolidate and build global relevance in mineral and mining geophysics.

Aspirational goals for the Federal Executive include:

a. An enhanced education programme that now includes OzStep, which in turn may become more focussed on Members' needs by means of a questionnaire being circulated to Members (June 2017);
b. Consolidation of *Exploration Geophysics* as the "go to" international journal for mining geophysics via collaboration with other societies;
c. The establishment of Specialist Groups, including groups for near surface geophysicists and for early career geophysicists
d. Greater access to news and services for Members, particularly through our education programmes and our publications and via our web site.

Key issues discussed during the planning meeting included:

- membership, both individual and corporate,
- the Society's financial position and budget,
- publications and the changes that technology will bring to this arena of Society activities,
- the 2017 membership survey, which you should have as this edition of *Preview* goes to print,
- communication and promotion
- education
- 50th anniversary preparations
- the 2018 Sydney conference
- the Research Foundation
- the updated website

The Federal Executive would like to thank the Queensland Branch for their assistance in organising and hosting the 2017 AGM and specifically we would like to thank Energeo for hosting the planning meeting in their Brisbane office.

On a final note, please help us build an exciting programme of speakers for Branch meetings by letting us know if you have heard an amazing talk or read an innovative new paper. Also please consider filling in the membership survey when it arrives in your inbox.

Thank you for reading,

Marina Costelloe (and Megan Nightingale)
Secretary
fedsec@aseg.org.au

Meet your new 2017–2018 Federal Executive

Directors

President

Andrea Rutley
president@aseg.org.au

The President of the ASEG is one of the four Directors of the Society as recognised by Australian Securities and Investment Commission (ASIC), and has legal obligations to ASIC under the Corporations Act 2001 for the proper running of the Society. The President oversees the general running of the ASEG Federal Executive (FedEx), chairs FedEx meetings, General meetings and the ASEG Council meeting held at the ASEG conference. In addition, the President represents the Society at the ASEG annual conference and at international meetings. A candidate for President is expected to serve for a minimum of 3 years; the first as President Elect learning the ropes, then a year as President and finally a year as Past President acting as a mentor to the President and President Elect. There is no requirement to resign after 3 years if one still has energy and enthusiasm for the job and the support of the FedEx. The 3 year term allows the President to take on projects and see them through to completion, therefore it is not uncommon for the Past President to be running with projects they started, or which were started during their term as President. Both the President Elect and President are Directors of the Society and responsible to the Members as well as ASIC.

President Elect

Marina Costelloe
presidentelect@aseg.org.au

The President Elect's role is to support the President and act on their behalf when required, and also to work with the standing committees when the opportunity arises. The President Elect has 12 months to become familiar with the issues facing the Society so they will be able to implement plans the following year.

Treasurer

Danny Burns
treasurer@aseg.org.au

The Federal Treasurer is elected at the Annual General Meeting as a Director of the Society. This role requires the Treasurer to be responsible for all of the Society's accounts and finances (federal and state) and to be accountable to the relevant regulations under ASIC. The Treasurer is also the Chair of the Finance Committee, which advises the FedEx on longer term financial matters.

Secretary

Megan Nightingale
fedsec@aseg.org.au

The ASEG has a professional Secretariat that undertakes many of the traditional roles of an Honorary Secretary. This has allowed the ASEG's Secretary to focus on improvement of old policies, and the development of new policies that describe how the Federal Executive puts into practice the Society's Constitution. The Secretary organises FedEx events such as the Annual General Meeting and meetings of Council. They also maintain the Society's Strategic Plan. The Secretary is elected each year and is a Director of the ASEG.

Non-Directors

Immediate Past President

Katherine McKenna
pastpresident@aseg.org.au

The position of Immediate Past President is filled by the President of the previous year. The role of Immediate Past President is to provide continuity in the activities of the ASEG FedEx. The Immediate Past President is expected to advise the current President about the status of standing projects and issues, past resolutions and contacts in foreign societies. Katherine will also chair the Membership and International Committees and represent the ASEG Federal Executive on the ASEG Research Foundation.

Publications Committee Chairs

Greg Street

Bob Musgrave
publications@aseg.org.au

The Publications Committee Chair's role is to coordinate the Publication Committee's efforts to deliver the Society's publications on time and on budget. This requires dealing with the publisher (currently CSIRO Publishing) to address changing Society needs, new technologies and interfacing between the publisher and the Committee. The Publications Committee comprises the Chair, the Publications Officer and the Editors-in-Chief of *Exploration Geophysics* and *Preview*.

Bob Musgrave is a new appointment to the Federal Executive and is being groomed to take over from Greg Street as Publications Committee Chair. Bob is a Research Geophysicist with the Geological Survey of NSW. Bob's initial interest in palaeomagnetism has broadened over the years into a diverse range of applications, from magnetostratigraphic dating and tectonics, to magnetic petrophysics studies of hydrocarbon migration, gas hydrate accumulation, and the relationship of mineralisation processes to remanence-dominated magnetic anomalies. His work with GSNSW has emphasized applications of magnetic and gravity studies, including novel data filtering and presentation, long-wavelength interpretation and integration with passive seismic datasets, and joint magnetic and gravity inversion of complex tectonic settings.

AGC Representative

Kim Frankcombe (2011 – present)
kfankcombe@iinet.net.au

The Australian Geoscience Council (AGC) is a body representing the Geoscience Learned Societies. As well as the ASEG it includes the AIG, AusIMM, PESA, GSA, IAH, AGIA and AAG. Representation and voting power is determined by each society's size. Its main role is in lobbying and focusing geoscience agendas for the benefit of its members. Kim represents the ASEG on the Australian Geoscience Council and serves on their Organising Committee for the 2018 AGC Convention – Big Issues and Ideas in Geoscience.

Kim is a past President of the ASEG and acts as the Executive's representative on the Conference Advisory Committee, chaired by Mike Hatch and the Technical Standards Committee, chaired by Tim Keeping. He's waiting for the Grays Online valued customer gold card.

Continuing Education Committee Chair

Emma Brand
continuingeducation@aseg.org.au

The Continuing Education Committee aims to help meet the needs for the ongoing education of Members and to help to promote geophysics as a career. This is achieved by arranging for visiting lecturers from overseas societies to present at State Branch meetings, and by providing 1-day courses e.g. SEG Distinguished Instructor Short Courses, EAEG Education Tours and the ASEG OZSTEP courses. The aim is to deliver one minerals and one petroleum course per year. In the future more educational material will be presented online and the Society is developing a strategy to facilitate this.

State Branch Representative

Marina Pervukhina
branchrep@aseg.org.au

State Branches hold a key role in delivering services to local Members. The State Branch Representative liaises between the Branches and the FedEx, communicating relevant issues between the Federal and Branch levels of the Society.

Marina is also responsible for liaison with Specialist and Working Groups.

Marina is a Petrophysics and Geophysics Team Leader at CSIRO Energy, working on rock physics and petrophysics of sandstones, carbonates as well as unconventional and seal shales. She specialises in stress field analysis, petrophysics, modelling of shale elastic properties. Marina's special interest is an intrinsic VTI anisotropy of shales and effects of different clay mineralogy on shale elastic properties. She is also an Associate Editor of *Exploration Geophysics*.

Web Committee Chair (Webmaster)

David Annetts
webmaster@aseg.org.au

The Web Master chairs the Web Committee and works with them, designers, the Secretariat and other Committees to design, maintain the ASEG's website. The Web Committee works on strategies to allow for continuous improvement to the web site, thereby improving its value to ASEG Members and helping to promote the ASEG and exploration geophysics in the wider community.

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News from the ASEG Research Foundation

2017 ASEG RF grants announced

This year the ASEG Research Foundation received eight excellent applications for grants to support post graduate research. Of these I am pleased to announce that five have been chosen, three PhD projects, one MSc project and one honours project, covering a range of interesting topics.

The total commitment by the Foundation is $57 350 over a total of three years. This is on top of the ongoing projects that the Research Foundation is already supporting. The funds for these projects are made up of a generous donation of $50 000 from the ASEG as well as additional monies donated by companies and individual Members both at the ASEG conference and through the ASEG website.

I would like to congratulate all of the recipients of grants and look forward to hearing of their progress in the future; through *Preview*, *Exploration Geophysics* and at our conference and regular Branch meetings.

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

Institution	Supervisor	Student	Degree	$	Years	Topic
Monash University	Dr Robin Armit	Mr Khumo Leseane	PhD	$18 600	2	Evolution and mineral systems analysis of the Macquarie Arc constrained from potential-field data
University of Western Australia	Prof Mark Jessell	Mr Jeremie Giraud	PhD	$5500	1	Geophysical joint inversion for uncertainty reduction and lithological reconstruction through integration of statistical geological modelling and petrophysical measurements
University of Adelaide	Prof Graham Heinson	Mr Ben Kay	BSc	$4900	1	Testing the UNCOVER paradigm: Imaging crustal fluid pathways in the Curnamona Province
University of Western Australia	Prof Mike Dentith	Mr Sean Standen	MSc	$5000	1	Geophysical Characterisation of Earthquake Fault Scarps in Southwestern WA
Curtin University	Prof Anton Kepic	Ms Seda Rouxel	PhD	$24 350	3	A framework towards integrated quantitative Earth models

News from the ASEG Young Professionals Network

I am looking for ASEG Members who wish to be in the Young Professionals Network (YPN). The YPN is aimed at, but not restricted to, the under 35s or people relatively new to the industry with less than 5 years' experience. If you'd like to sign up, please register your interest by emailing ypadmin@aseg.org.au with your name and preferred email address.

If you join the YPN you will be added to a mailing list where you can expect to receive updates on the YPN objectives and upcoming events held exclusively for the YPN.

The YPN is also in need of volunteers to assist with the running of the network. Responsibilities would include providing input into group objectives as well as helping with the organisation of events. Being in the YPN provides a great opportunity to network with peers and experienced industry professionals. Volunteering allows you to have active input into the activities run by the group, which are designed around networking and professional development; making you industry ready or giving you a competitive edge.

Ideally it would be good if each State were represented.

If you'd like to volunteer to assist with the running of the Young Professionals Network, email ypadmin@aseg.org.au with your name, preferred contact email and State.

Finally, I would like to thank those people who have already responded to me; especially those who have volunteered to assist with mentoring. The greater the contribution from more experienced geophysicists within the ASEG the greater the success of this Young Professionals Network.

Thanks!

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

News from the ASEG Technical Standards Committee

The ASEG Technical Standards Committee has begun investigating passive seismic file formats. Kim Frankcombe, Mark Duffy and Dave Howard have pointed out the enormous data files being collected in WA recently of up to 120GB per day. Besides posing a new archive storage challenge for public institutions, several formats are in use according to purpose. An informal working group has formed and is canvassing government, academia, private industry and manufacturers for their products, opinions and expectations. We welcome all input on this exciting technique and strongly encourage you voice any thoughts or opinions with the Technical Standards Committee.

Thank you.

Tim Keeping
ASEG Technical Standards Committee Chair
technical-standards@aseg.org.au

ASEG Branch news

South Australia & Northern Territory

Since the last update in *Preview*, the SA/NT Branch has held two events for local Members. Our focus on students, which began with **Dr Graham Heinson**'s excellent wrap up of the inaugural year of the National Exploration Undercover School (NExUS) initiative, continued in March with our annual Pizza Night. The event was held in conjunction with the Adelaide University Geological Society at the University of Adelaide, where we were fortunate enough to be joined by **Matt Zengerer** and **Selina Wallace**. With all the pizza devoured, and the students with beers in hand, Matt and Selina shared their experiences of university and their geophysical careers. They talked about some of the places they have been to and some of the companies they have worked for. They were both great speakers, and at times they were quite candid, not only emphasising the great aspects of working within our industry and the good times that can be had, but also being realistic about the downs that we will all inevitably encounter at times. Certainly a topic that was rarely, if ever, broached during my time at university – a time when everyone thought the mining and oil and gas booms would never end! Forewarned is forearmed.

April saw the Branch return to our more traditional technical evening format. Amongst the seemingly never ending holidays and four day weeks, we were joined by **Richard Hillis**, CEO of the Deep Exploration Technologies CRC, to hear about the exciting technology that his group have been developing. As usual Richard did not disappoint, spelling out the cost savings, speed, and real time targeting and vectoring benefits of their newly developed coiled tubing rig. Naturally these benefits can only follow on from interpretation and prospect generation resulting from deploying the sharp end of the spear; the exploration geophysicist!

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. 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 will also be hosting this year's SEG DISC, **Dr Doug Oldenburg**. His one day course on Electromagnetics Fundamentals and Applications is scheduled for 2 August at the Hotel Richmond. Further details will come so please keep an eye out for pricing and bookings on the SEG website. 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/NT Branch President)
sa-ntpresident@aseg.org.au

Tasmania

Anton Rada continues to be in great demand in south-east Asia, so the presentation on the UAV magnetic survey system that he has developed has been postponed once again – this time indefinitely. Local ASEG Members will be advised by e-mail if Anton's presentation can be scheduled before the next edition of *Preview*, or if any other opportunities for technical presentations arise in the meantime.

The ASEG Tasmania branch would also like to express sympathy to the colleagues, friends and family of **Dr Garry Davidson** following his untimely death from cancer in April. Garry had been, among many other things, for last several years the Chair of ASEG Tasmania's considerably larger sibling, the Tasmania Division of the Geological Society of Australia. During his tenure he was invariably welcoming and supportive of joint activities with ASEG. More broadly he had great respect and understanding for the complementary information that geophysics could bring to bear on his wide range of geological interests. He will be greatly missed by the Tasmanian geoscientific community.

An invitation to attend Tasmanian Branch meetings is extended to all ASEG Members and interested parties. Meetings are usually held in the CODES Conference Room, University of Tasmania, Hobart. Meeting notices, details about venues and relevant contact details can be found on the Tasmanian Branch page on the ASEG website. Interested Members and other parties should also keep an eye on the seminar program of the University of Tasmania's School of Earth Sciences, which regularly delivers presentations of geophysical as well as general earth science interest. Please contact ASEG Tasmania Branch President **Mark Duffett** with any queries.

Mark Duffett
taspresident@aseg.org.au

Victoria

On 16 March 2017, the Victorian branch of the ASEG held its Annual General Meeting. **Seda Rouxel** will continue as Branch President and **Greg Walker** will continue as Branch Treasurer. **Thong Huynh** was elected to the position of Branch Secretary. **Dorte Macrae** is thanked for her invaluable contributions to the Society as Secretary in the past year.

Our AGM was followed by a presentation from **Warren Gray**, Technical Director of Seisintel. His talk, titled 'Three years in the marine exploration world', gave us an insight into the ways marine seismic acquisition trends have evolved during the depressed oil-price environment the industry has experienced over the past few years.

The Victorian Branch typically pauses during the month of April, when the annual Melbourne International Comedy festival rolls into town and takes precedence at our regular choice of venue. However, May was a new month, and we had the pleasure of welcoming FAR Ltd's Chief Geologist**, Jon Keall** as our presenter on the 24th. Leveraging off FAR's incredible string of successes in the region, Jon presented on 'Petroleum systems of the Mauritania-Senegal-Guinea Bissau-Conakry Basin: why this region has emerged as a global exploration hotspot'.

Things are also starting to move with our classical technical nights! Acting on a suggestion from PESA, the ASEG and SPE societies are currently in the early stages of planning a mentoring program for local young professionals. So, if it is a topic of interest to you either as a potential mentor or as a mentee, then stay tuned! More information will be provided over the coming months.

During the last quarter, the Committee also engaged in talks with a world-leading expert about the possibility of delivering a short course on potential field interpretation methodologies, with specific case studies covering both the minerals and oil and gas industries. Once expressions of interests are received, we anticipate the course will be run in the third quarter of 2017.

Seda Rouxel
vicpresident@aseg.org.au

Western Australia

The WA Branch continues to be very active with Tech night presentations. In May the Branch hosted **Andreas Pfaffhuber** from NGI, who presented on 'Geophysics, the disruptive innovation for the geotechnical industry'. Andreas' presentation was very well attended with nearly 60 Members in the audience. It is great to see our attendance numbers growing again after a drop off in 2016.

The WA Branch's Tech nights are sponsored by the following companies: Globe Claritas (Platinum), Resource Potentials, Western Geco, CGG, Atlas Geophysics, First Quantum Minerals Inc, GPX Surveys, Paradigm (Gold), Geosoft, ExploreGeo, and Southern Geoscience (Silver). The Branch could not put together its wide range of technical activities without the support of our Platinum, Gold and Silver sponsors, and we look forward to a long standing partnership with these companies. Sponsorships are due for renewal in May so if you are interested in sponsoring the Branch please contact the Branch President on wapresident@aseg.org.au.

The calendar for 2017 is filling up. Our Tech night program has presenters lined up through to August with the following presenters:

- June – **Darren Hunt** (Teck) presenting on the use of seismic reflection at the Teena deposit;
- July – **Tim Munday** (CSIRO) presenting on the use of airborne EM to target groundwater resources in the Murchison region of WA;
- August – **Sarah Monoury** (SRK) presenting a case study of geophysics at the Mt Magnet gold camp;
- October – **Bill Peters** (SGC) 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

Thank you to everyone who attended the 2017 ACT Branch AGM in March. We would like to congratulate the office-bearers who were elected at the AGM. This year we have a new President, **James Goodwin**. **Adam Kroll** returns as co-secretary, this time with **Bill Jones** as his partner in crime and, for the fifth year, **Ross Costelloe** returns as Treasurer. **Marina Costelloe**, **Ned Stolz, Phillip Wynne**, **Laurence Davies** and **Leonie Jones** form the ACT Branch's General Committee.

James Goodwin chairing the 2017 ASEG Branch AGM after being voted in as the new President.

A special thanks to our outgoing committee members; **Ned Stolz**, **Ray Tracey**, **Millicent Crowe** and **Neil Symington**, thank you all for your efforts over many years.

The AGM guest speaker, **Ron Hackney,** presented an awesome talk titled 'From geophysics to deep stratigraphic drilling for tectonics, climate and ancient life in northern Zealandia'. Several Branch awards were also handed out; Ross Costelloe for being the Treasurer (again); **Alison Kirkby** in recognition of her ASEG conference Laric Hawkins Award; **Phillip Wynne** for his consistent reliable and practical support of the Branch over many years; and Ned Stolz, outgoing

Andreas Pfaffhuber presenting to the WA Branch.

Ron Hackney presenting to the ASEG ACT Branch.

ASEG news

President, for being instrumental in securing a number of important guest speakers and ensuring that the good work of the ACT Branch continued.

Marina Costelloe on behalf of James Goodwin
actpresident@aseg.org.au

New South Wales

In March, **Juan Carlos Afonso** from Macquarie University spoke about multi-observable probabilistic inversion for the physical state of the lithosphere. Juan discussed the new concept of multi-observable probabilistic tomography and how this new kind of joint inversion is particularly designed for studies of the fundamental thermodynamic variables of the Earth's lithosphere, namely temperature, pressure and chemical composition. Juan outlined how he went about utilising multiple datasets to maximise the physical consistency of his Earth models.

In April, **Kate Selway** from Macquarie University spoke about 'Magnetotellurics: What it is, what it can tell us, and what we're doing with it in Australia'. Kate outlined the basics of MT and then discussed a number of examples describing using MT to image zones of metasomatism and past fluid events. Kate outlined how MT can be used in the exploration for giant mineral deposits. As well Kate introduced the AusLAMP project and how MT data was going to be acquired over all of Australia. Many questions and much discussion followed Kate'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

The Queensland Branch meeting joined with the Federal AGM for April. **Koya Suto** was a fitting speaker at this event. After many years of involvement he was officially resigning from the FedEx. In his presentation Koya shared the more human side of geophysics with entertaining anecdotes.

Our Branch meeting was on 23 May with **Kate Hine** presenting on 'Geophysics maketh the mine!'

The Queensland Branch now has a new Secretary **Mark Kneipp**. We would like to welcome Mark to the position. Mark began his career in Australia's Cooper Basin and spent several years as a seismic crew manager and bird dog, acquiring seismic across nearly every onshore basin in Australia. Mark has consulted to most Australian petroleum companies and has held leadership roles in Australia and the Middle East. He is a qualified project, program and portfolio manager with over 15 years of experience in onshore oil, gas and mineral seismic exploration and is now Vice President Exploration for Synterra Technologies.

Our outgoing secretary **Megan Nightingale** is now the FedEx Secretary and President of the Young Professionals Network. We would like to thank her for all her hard work, organisation and efficiency. She has held the position since 2012 and has played an integral role in the success of QLD Branch events for the past 5 years.

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, 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

ASEG national calendar: technical meetings, courses and events

Date	Branch	Event	Presenter	Time	Venue
23 May	QLD	Tech night	Kate Hine	1730–1900	XXXX Brewery, corner of Black Street and Paten Street, Milton
24 May	VIC	Tech night	Jon Keall	1730–1900	The Kelvin Club, 14-30 Melbourne Place, Melbourne
14 Jun	WA	Tech night	Darren Hunt	1730–1900	TBA
21 Jun	NSW	Tech night	TBA	1730-1900	99 on York (99 York Street, Sydney)
Jul	ACT	SEG DISC	Doug Oldenburg	TBA	TBA
12 Jul	WA	Tech night	Tim Munday	1730–1900	TBA
19 Jul	NSW	Tech night	TBA	1730–1900	99 on York (99 York Street, Sydney)
27 Jul	WA	SEG DISC	Doug Oldenburg	TBA	TBA
02 Aug	SA	SEG DISC	Doug Oldenburg	0900–1700	Hotel Richmond, Rundle Mall
07 Aug	QLD	SEG DISC	Doug Oldenburg	TBA	TBA
09 Aug	WA	Tech night	Sarah Monoury	1730–1900	TBA
16 Aug	NSW	Tech night	TBA	1730–1900	99 on York (99 York Street, Sydney)
11 Oct	WA	Tech night	Bill Peters	1730–1900	TBA
08 Nov	WA	Student presentations	Various	TBA	TBA

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

ASEG Gold Medal awarded to Richard Lane, Canberra, ACT, 2017

Richard Lane

ASEG Gold Medal Award citation:

The ASEG Gold Medal is awarded from time to time for exceptional and highly distinguished contributions to the science and practice of geophysics by a Member, resulting in wide recognition within the geoscientific community. The ASEG President and Federal Executive are pleased to announce that the ASEG Gold Medal will be awarded in 2017 to Richard Lane.

Specifically, this award recognises Richard's significant and distinguished contributions to the profession of geophysics in Australia and overseas through his widely recognised practical research and contributions to the understanding and application of geophysical methods in both mining and petroleum, for his frequent contributions at conferences both in Australia and overseas, and through his outstanding professional work in applied geophysics for over 30 years.

Richard Lane obtained a B.Sc. (Honours) in Geology and Geophysics from the University of Melbourne in 1983. He joined CRA Exploration (subsequently Rio Tinto Exploration) as a graduate geophysicist in 1984. Over the following 12 years, he worked for CRAE on Australian and overseas projects, based in Adelaide, Perth, Canberra, Thailand/Laos, Alice Springs, Melbourne, Brisbane and Mount Isa. Richard had several different roles in CRAE and its petroleum exploration subsidiary Pacific Oil and Gas, before deciding to pursue other opportunities in 1996. During his time in CRAE Richard contributed to a variety of exploration activities, including both hard rock minerals and petroleum. He attended and presented at several overseas meetings, including Moscow and Toronto, and gained a broad understanding of geophysical applications for various commodities and in a wide range of field conditions. His keen analytical mind and deep practical understanding of the geophysical profession and exploration industry impressed all those who worked with him, and he built a wide circle of contacts in both industry and academia.

From 1996 To 2001 Richard worked with World Geoscience Corporation/Fugro Airborne Surveys, based in Perth as Chief Geophysicist Product Development. His primary responsibility was to oversee the development of the TEMPEST Airborne EM system, a role which required him to integrate engineering, geophysical and software development. He was Program Leader of the Airborne EM Systems Program of the Cooperative Research Centre for Australian Mineral Exploration Technologies (CRCAMET) from 1997 to 2000, during which time the TEMPEST AEM system was successfully developed and commercialised. TEMPEST became operational in 1999 as a state of the art AEM system with innovative technology which is still evolving in 2017.

In 2001, Richard joined the Australian Government geoscientific agency, Geoscience Australia (GA), based in Canberra. In the role of Senior Geophysicist in the Onshore Energy & Minerals Division (OEMD), he has made an outstanding contribution to national geophysics. His principal achievements at GA have been establishing 3D potential field inversion methodologies, which now underpin all regional geophysical interpretation projects. He also demonstrated the application of AEM methods to groundwater projects and instigated large regional AEM surveys as part of the 2006 Onshore Energy Security Program.

Richard was instrumental in the development of the Geomodeller 3D geological modelling package since 2005, and has been intimately involved in the work to restructure and expand the GeoModeller geophysical modelling capabilities. Richard's other ongoing activities at GA include leadership of the OEMD efforts to develop a national rock property database, input into the development of the GeoSciML information model and data interchange format (with the goal of facilitating the exchange of geoscience information and processing services), and championing the use the high performance computing (HPC) facilities (multicore computers, internal distributed and parallel computer networks within GA, external GRID, and Cloud facilities, etc.) for geophysical processing and modelling.

He received a Geoscience Australia Individual Award for Achieving Results in Geoscience in 2004, and was the recipient of the Sir Harold Raggatt Award for Distinguished Geoscience Australia Lecturer in 2004

In conjunction with his role at GA, Richard has organised numerous pertinent and timely industry seminars for industry geoscientists, as well as mentoring many younger scientists and graduates in the application of numerical methods for geoscientific problems. Richard has played a major role in the conduct of three airborne gravity workshops at ASEG conferences in Sydney (2004), Sydney (2010) and Adelaide (2016). In each case Richard undertook the role of technical editor, resulting in a comprehensive proceedings volume which was, or is being, published by Geoscience Australia. These have become significant international records of the 'state of the art' in airborne gravity, and they are widely recognised around the world. He also undertook a similar role for a 'Natural Fields EM' workshop/forum, held at the ASEG conference in Brisbane in 2012.

He is a member of the Society of Exploration Geophysicists (SEG), Australian Society of Exploration Geophysicists (ASEG), Environmental and Engineering Geophysical Society (EEGS), American Geophysical Union (AGU), and International Association for Mathematical Geology (IAMG). He was recognised by SEG as an 'outstanding reviewer' in 2007 and was nominated as an SEG Honorary Lecturer in 2011. He toured extensively in this role, throughout Australia and the South Pacific.

Richard is an inspiring scientific leader, widely recognised throughout the global geophysical community for his keen intellect and insight into geophysical methods in both mining and petroleum, and for his frequent contributions at conferences both in Australia and overseas. Throughout his career Richard has set a benchmark in terms of technical excellence. His service to the industry has been truly significant and he is widely regarded as a substantial pillar of our discipline. It is fitting that Richard's distinguished career encompassing a broad range of technical achievements, combined with his positive influence on other members of the profession, should now be recognised with the award of the ASEG Gold Medal.

Update from the AEGC 2018 Conference Organising Committee

At the time of writing there are only 10 months until the AEGC 2018 conference and there is still a lot to do. Abstracts are being lodged, workshops are being 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.

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

We will have reviewed all initial abstracts by mid-June and the programme subcommittee will be in the middle of deciding on the draft programme. Extended abstracts will need to be submitted by the end of August.

The programme subcommittee have invited several more keynote speakers. All keynote speakers are listed in Table 1 and the conference website contains photos and a short biography.

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

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Webpage: www.austhaigeophysics.com

Changing of the guard at GGSSA

The Ground Geophysical Survey Safety Association (GGSSA) was formed in 2011 by a passionate group of people from CGG Ground Geophysics, GPX Surveys, Search Exploration Services, Zonge Engineering & Research Organization and Riotinto Exploration. The original aims of the Association were to develop industry guidelines for the conduct of electrical geophysical surveys and to foster a culture of safety awareness in the mineral geophysics industry.

The founding members of the executive committee of the GGSSA (pictured below) were Kelly Keates, Theo Aravanis, Katherine McKenna, Phil Palmer and Kathlene Oliver, all of whom gave their time generously to the fledgling Association and created a strategy for it to grow and deliver on its aims.

The founders of the GGSSA have now all retired from the active management of the Association, after significant contributions, in order to pursue their busy careers and to make way for a new executive committee. The current Executive Committee and Members of the GGSSA would like to take this opportunity to thank them for their hard work and service to our profession. Our vision is to build on the legacy of the founders and continue to have a positive influence on the safety of all workers in the exploration/mining geophysics profession.

If you think your company might be interested in becoming a member of GGSSA …

Membership fees for the GGSSA are inexpensive and are designed to cover the costs of collecting monthly safety statistics from our industry and distributing them (in an anonymous, de-identified format) to our membership.

The Association has also developed substantial guidelines for electrical geophysics for its Members and has prepared information briefings on important subjects relating to safety in mineral geophysics operations. If you would like to be part of the GGSSA – to help develop new guidelines, or to get help with your own operating procedures – please contact us.

GGSSA Executive Committee
Mike Enright (Chair, Rio Tinto Exploration)
Greg Cant (Anglogold Ashanti)
Andrew Duncan (ElectroMagnetic Imaging Technology)
Trent Retallick (Gap Geophysics)
www.ggssa.org
info@ggssa.org

The founding executive of the GGSSA: (L to R) Kelly Keates, Theo Aravanis, Katherine McKenna, Phil Palmer and Kathlene Oliver.

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 8 May 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 (km²)	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	TBA	Contract executed by GA 12 Jan 2017. The survey is 86% complete to 8 May 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	TBA	Contract executed by GA 12 Jan 2017. The survey is 82% complete to 8 May 2017	183: Aug 2016 p. 34	TBA
Andamooka	GSSA	GA	Sander Geophysics	23 Feb 2017	81 396	200 m 60 m EW	14 560	TBA	Contract executed by GA 17 Jan 2017. The survey is 70% complete to 8 May 2017	183: Aug 2016 p. 34	TBA
Barton	GSSA	GA	Thomson Aviation	22 Jan 2017	111 758	200 m 60 m EW	20 560	TBA	Contract executed by GA 12 Jan 2017. The survey is 99% complete to 8 May 2017.	183: Aug 2016 p. 34	TBA
Fowler	GSSA	GA	Thomson Aviation	18 Feb 2017	95 009	200 m 60 m EW	17 360	TBA	Contract executed by GA 12 January 2017. The survey is 80% complete to 8 May 2017.	183: Aug 2016 p. 34	TBA
Torrens	GSSA	GA	Sander Geophysics	4 Mar 2017	79 990	200 m 60 m EW	14 800	TBA	Contract executed by GA 17 Jan 2017. The survey is 67% complete to 8 May 2017.	183: Aug 2016 p. 34	TBA
Coonabarabran	GSNSW	GA	UTS Geophysics	15 May 2017	50 827	250 m 60 m EW	11 000	TBA	TBA	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	TBA	TBA	Estimated 120 000	100 m 50 m EW	11 000	TBA	TBA	Figure 1, this issue	The Quotation Request closed on 2 May 2017

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	TBA	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.	TBA
East Kimberley Airborne Gravity Survey	GSWA	GA	Sander Geophysics	8 Oct 2016	38 000 line km	2500 m line spacing	82 690	3 Dec 2016	14 Jan 2017	184: Oct 2016 p. 24	23 Feb 2017
Coompana – PACE area	GSSA	GA	Atlas Geophysics	30 Jan 2017	13 801	Regular grid of 2, 1 and 0.5 km	100 000	4 Mar 2017	24 Mar for preliminary final data	183: Aug 2016 p. 34	TBA
Tanami-Kimberley	GSWA	GA	TBA	TBA	Up to 50 000	2500 m line spacing	110 000	TBA	TBA	187: Apr 2017 p. 22	Contract being drafted by GA with the preferred supplier
Kidson Sub-basin	GSWA	GA	TBA	TBA	Up to 70 000	2500 m line spacing	155 000	TBA	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 standard 1:250 k map sheet areas
South Nicholson	GA	GA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	The proposed survey area covers parts of the Mount Drummond, Ranken and Avon Downs Standard 1:250 k map sheet areas	GA and NTGS are in discussion to refine the survey extents

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
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	Preliminary final data were supplied to GA on 12 Jan 2017
AusAEM (Year 1)	GA	GA	TBA	TBA	<50 000	20 km with areas of infill	TBA	TBA	TBA	186: Feb 2017 p. 18	The Quotation Request closed on 15 May 2017
Ord-Keep River	GA	GA	TBA	Apr 2017	6146	Variable	TBA	TBA	TBA	TBA	The contract was executed by GA on 25 Nov. The survey mobilised on 15 May 2017
Surat-Galilee Basins QLD	GA	GA	TBA	TBA	4477	Variable	TBA	TBA	TBA	Figures 2-4, this issue	The Quotation Request was released on 11 May 2017 and closed on 24 May 2017
Stuart Corridor, NT	GA	GA	TBA	TBA	8626	Variable	TBA	TBA	TBA	Figure 5-8, this issue	The Quotation Request was released on 11 May 2017 and closed on 24 May 2017

TBA, to be advised.

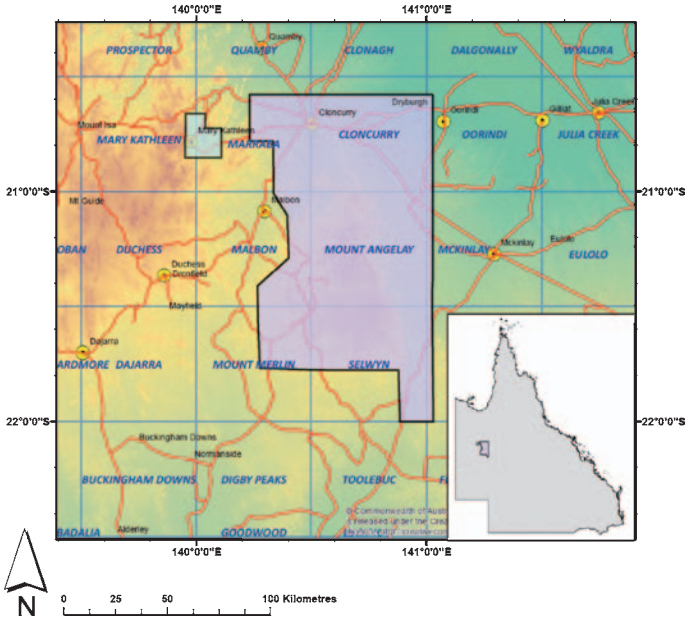

Figure 1. *Location of the Isa Region airborne magnetic and radiometric survey.*

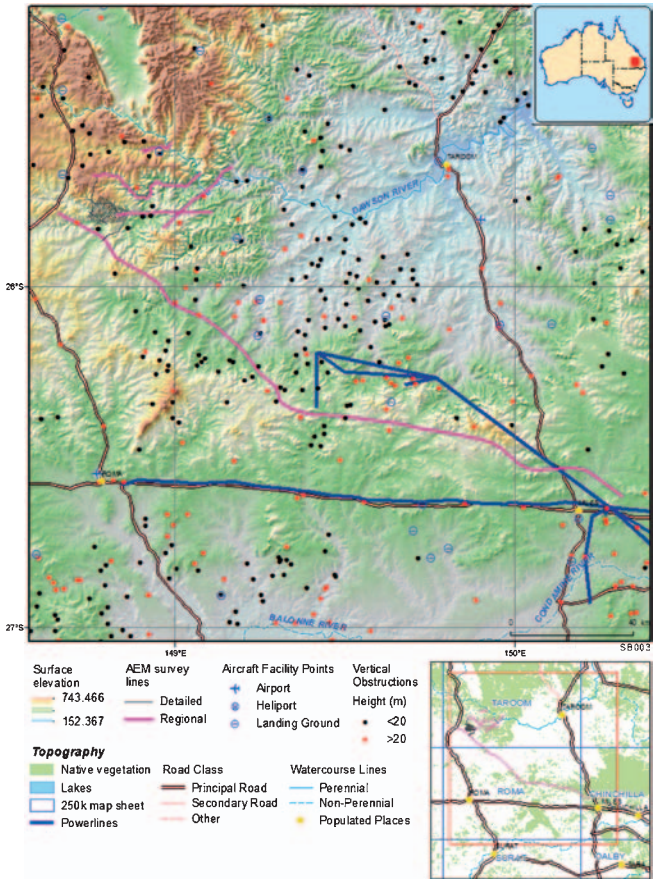

Figure 3. *Location of the Surat-Galilee Basins AEM survey Area 2/3.*

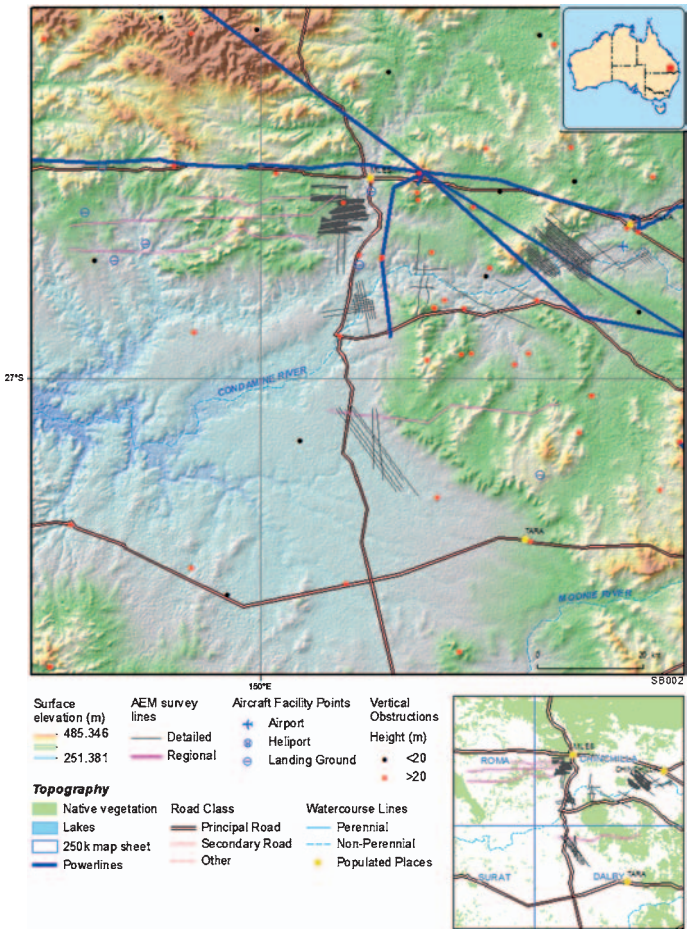

Figure 2. *Location of the Surat-Galilee Basins AEM survey Area 1/3.*

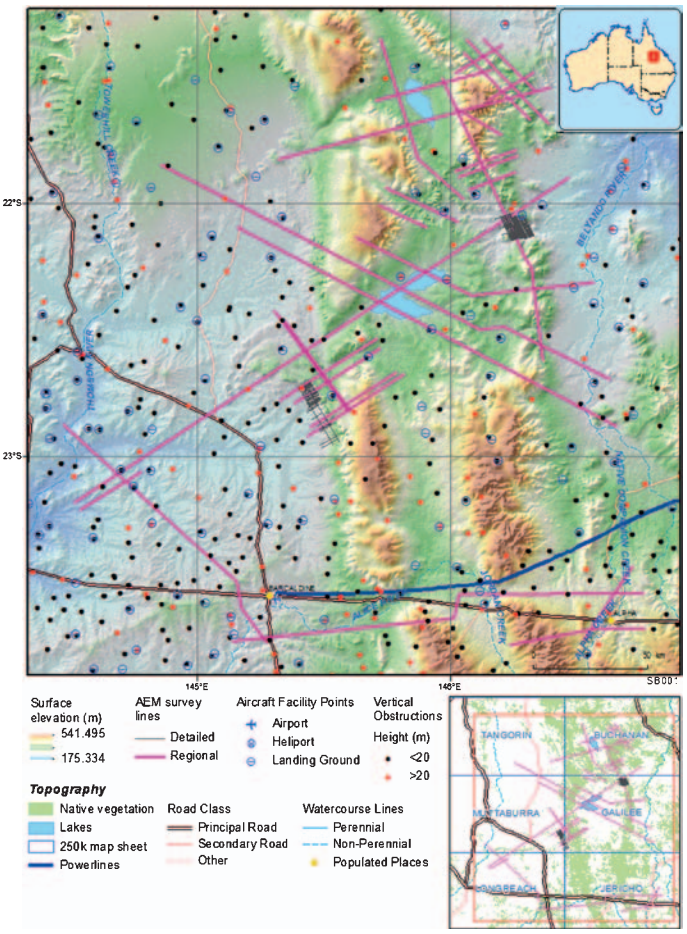

Figure 4. *Location of the Surat-Galilee Basins AEM survey Area 3/3.*

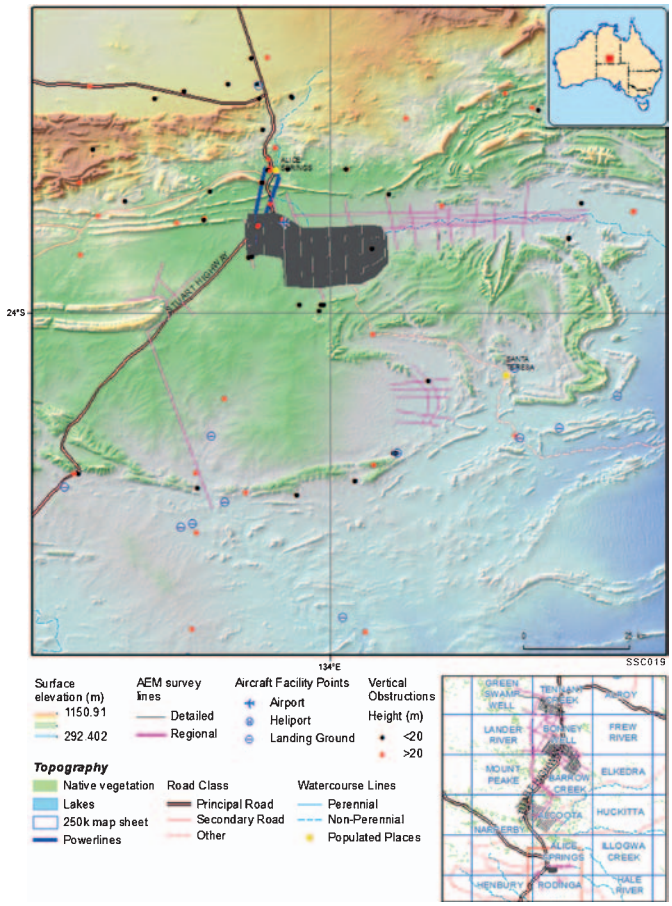

Figure 5. *Location of the Stuart Corridor AEM survey Area 1/4.*

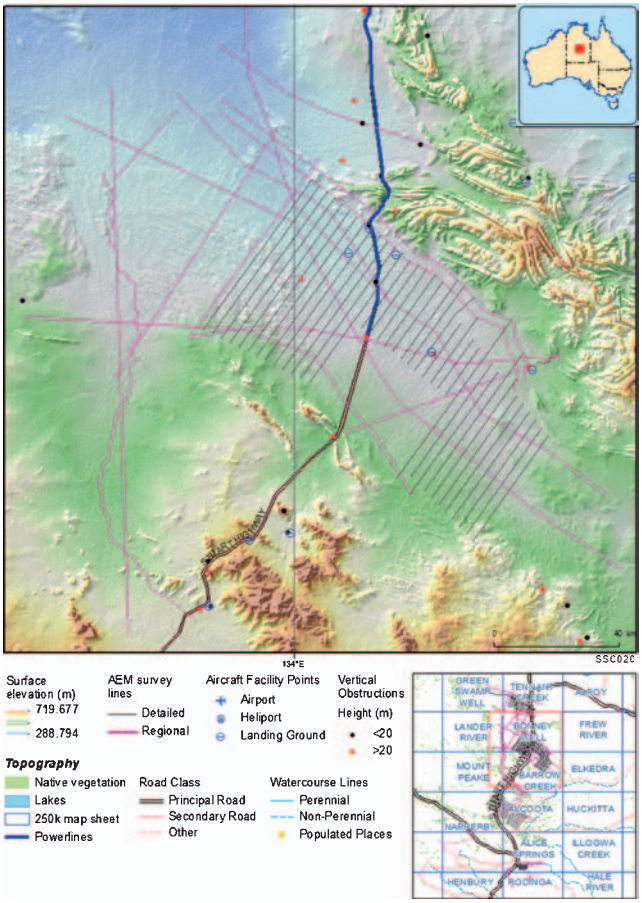

Figure 7. *Location of the Stuart Corridor AEM survey Area 3/4.*

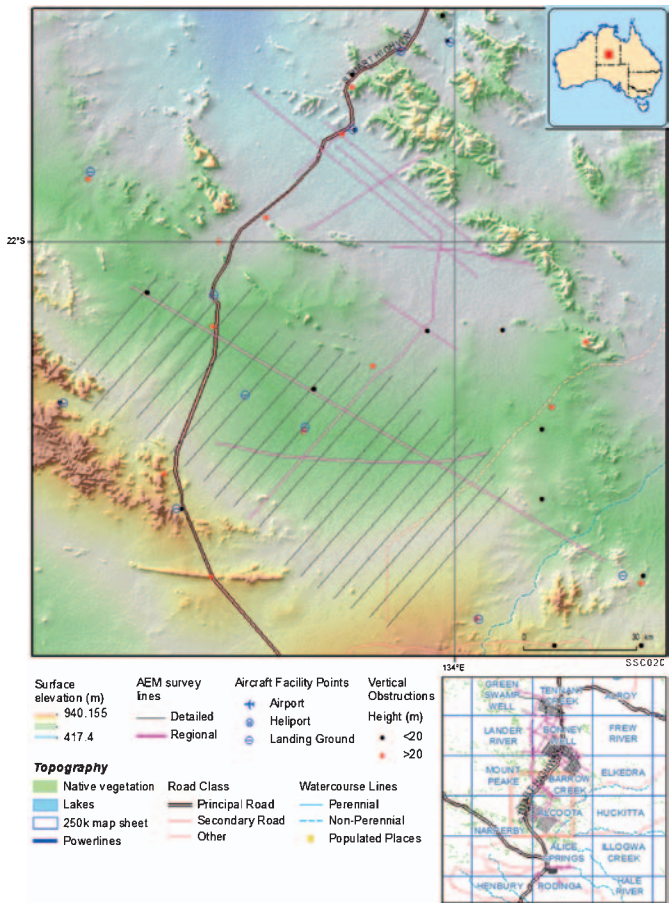

Figure 6. *Location of the Stuart Corridor AEM survey Area 2/4.*

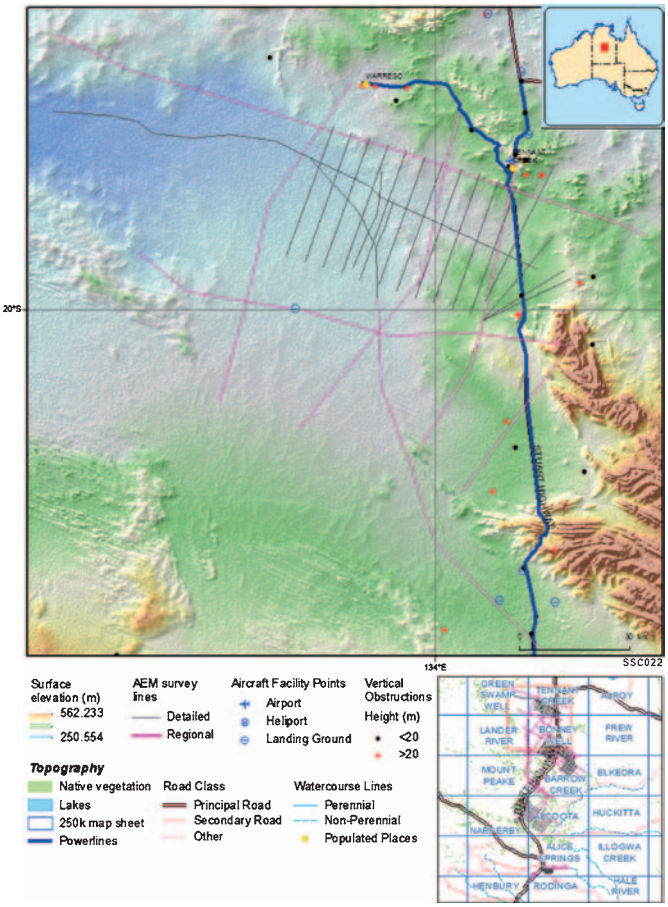

Figure 8. *Location of the Stuart Corridor AEM survey Area 4/4.*

Geological Survey of South Australia: the PACE Copper Coompana gravity survey

The Coompana gravity survey, part of the Far West Discovery Program of the PACE Copper Initiative, was acquired by Atlas Geophysics between 23 January 2017 and 4 March 2017. The survey is comprised of 15 498 gravity readings (13 792 individual stations) acquired on regular grid patterns at 500 m, 1 km, and 2 km scales (Figure 1). The survey extends from the Western Australian border to well into the Gawler Craton. The survey was conducted using two R44 helicopters. Three Scintrex CG5 gravity meters were used, as well as the Leica Geosystems GPS1200 system for post-processed kinematic (PPK) centimetre level positional accuracy.

The Coompana gravity survey provides an exciting new insight into the buried basement geology of the Coompana Province. As 300–500 m of sedimentary cover blankets the Precambrian geology, this detailed gravity survey is key in understanding the hidden structure and compositional variations of the region. Whilst major density highs and lows appear to be due to differing compositions within the basement, vertical gradient images reveal possible palaeochannels or drainage features thought to be associated with the cover-basement unconformity. A low density response from the enigmatic Coompana Anomaly (previously defined by magnetics, e.g. Wise et al., 2015) compared with high amplitude density responses associated with similarly magnetized satellite bodies add to the intrigue of this frontier region.

The data have not yet been incorporated into the statewide gravity image, however the survey is available to download via SARIG. Simply navigate to SARIG, and click on the 'Spatial Search' option. Select 'Geophysical data' from the dropdown menu and 'Draw Area' before drawing a box around the Coompana area. Then click on 'Advanced search' and follow the prompts to download the gravity ASCII data (or grid). The survey has been designated as 2017A1 in the SA Geodata database.

Reference

Wise, T.M., Pawley, M.J., and Dutch, R.A., 2015, Preliminary interpretation from the Coompana aeromagnetic survey: *MESA Journal*, **79**, 22–30.

Philip Heath and Tom Wise
Geological Survey of South Australia
Philip.Heath@sa.gov.au

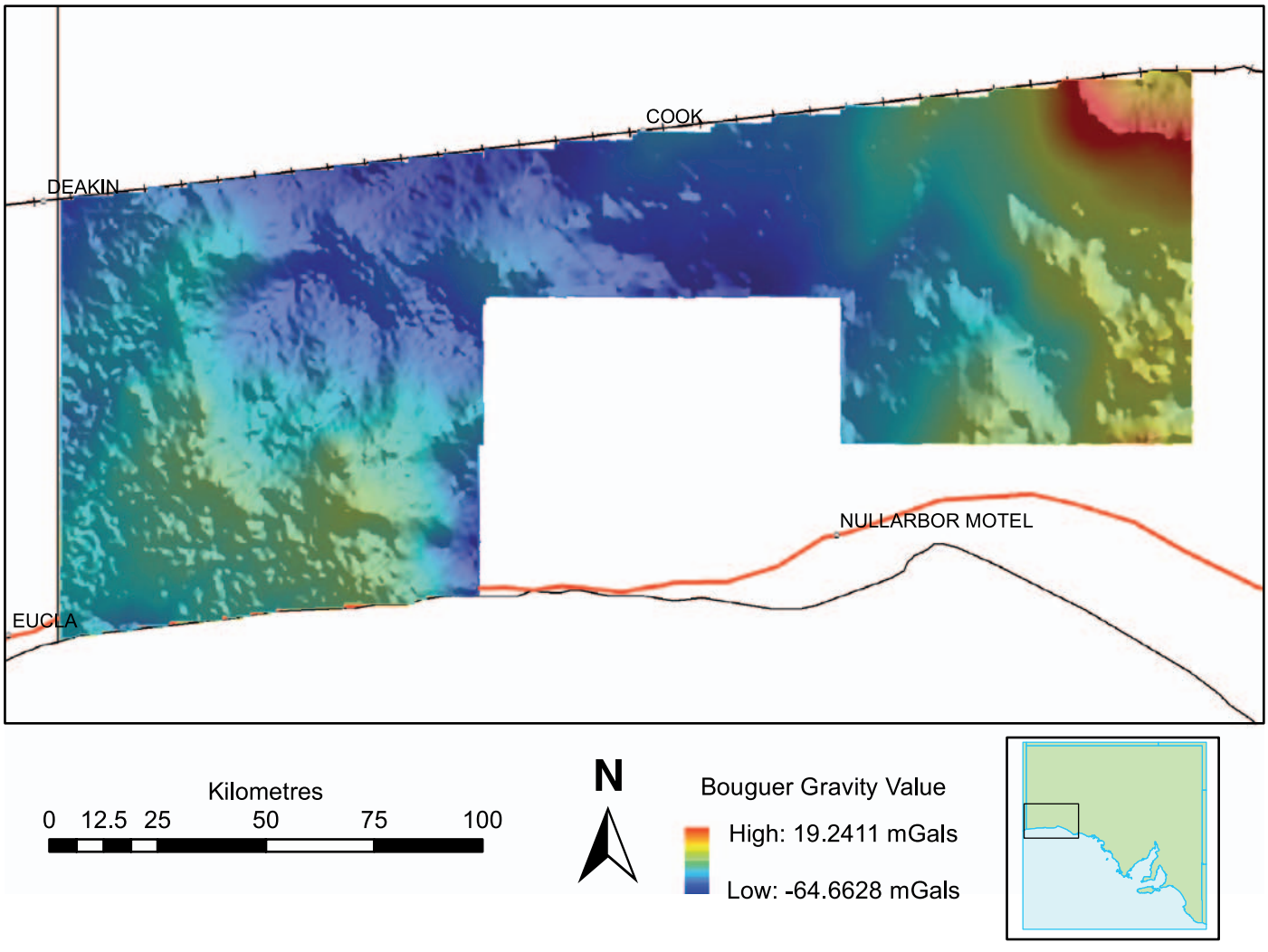

Figure 1. *The PACE Copper Coompana gravity survey.*

Geological Survey of Queensland: new geophysical data sets available for North-West Queensland

With the final year of the Future Resources Program nearing completion new pre-competitive geophysical datasets collected under the Mount Isa Geophysics Initiative have been recently released (Figure 1).

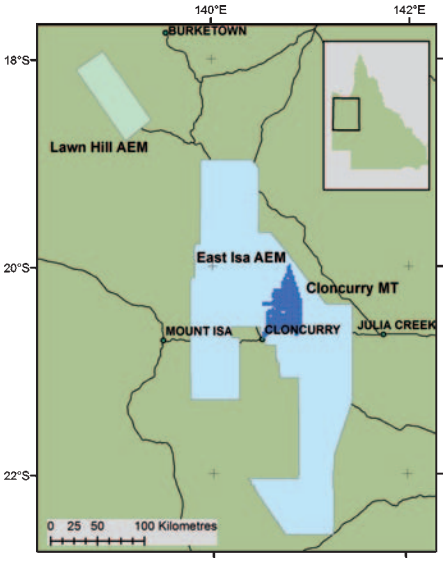

Figure 1. *Location of newly released GSQ datasets.*

Data for the East Isa regional airborne electromagnetic (AEM) survey was released in April 2017. The VTEM Plus survey covers a large region of outcropping and shallowly buried prospective Mount Isa Eastern Succession geology. A total of approximately 15 700 line kilometres was collected at a variable line spacing of between 2 and 2.5 km. The Lawn Hill AEM survey was released in May. This survey followed on from the East Isa AEM survey and totalled 1681 line km of 2 km spaced VTEM Plus data.

Data from these surveys will provide explorers in the region with new information on both the distribution and thickness of cover sequences that obscure the basement geology and the Proterozoic basement geology and structure. The data may aid with the definition of new areas of resource prospectivity in the highly endowed Mount Isa region.

The digital data for both AEM surveys is available online from QDEX Data and includes electromagnetic and magnetic databases, conductivity imaging products and multi-plots (Figure 2), as well as the gridded geophysical products, the contractor-supplied logistics report and ancillary data (VTEM waveform etc.).

Data has also recently been published from the Cloncurry Magnetotelluric Survey, which was conducted over the prospective geology to the north of Cloncurry, surrounding Ernest Henry. The survey of approximately 500 stations with a gridded station spacing of 2 km was designed to improve the understanding of the nature of the basement structure, the interaction between the intrusive and extrusive units, and to assess the nature of the Gidyea Suture Zone imaged on the 2007 IG1 seismic line. 3D inversion and modelling is ongoing for this dataset with products expected to be released late 2017.

The final product of the Mount Isa Geophysics Initiative will be a high resolution 100 m airborne magnetic and radiometric survey in the Cloncurry area. This tender process for this survey is currently being finalised and flying will commence soon.

The geophysics team at GSQ is continuing to add more open-file data to the growing QDEX Data system. This system houses large geoscientific datasets including airborne geophysical data, hyperspectral data, seismic data, wireline log data and geochemistry. New data will be published online at http://qdexdata.dnrm.qld.gov.au/ as soon as it becomes available.

Matthew Greenwood, Janelle Simpson and Roger Cant
Geological Survey of Queensland
Geophysics@dnrm.qld.gov.au

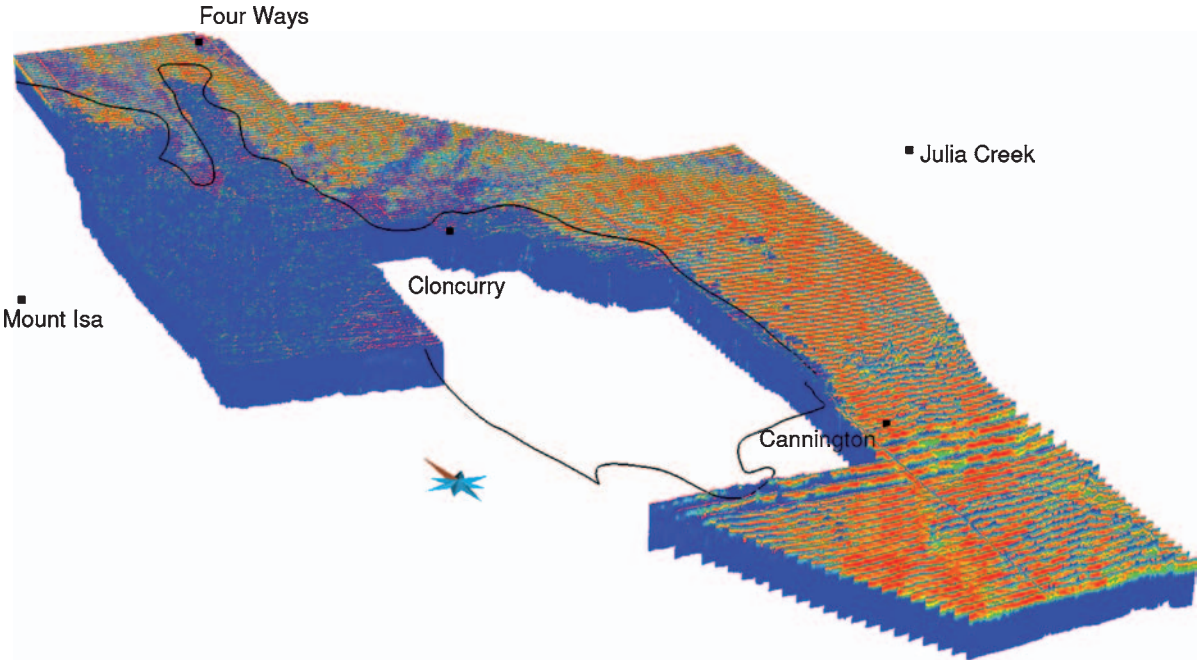

Figure 2. *3D view of East Isa AEM CDI sections viewed from SW perspective.*

Geological Survey of Victoria: Victorian Gas Program and ground gravity data for the Stavely Project

Victorian Gas Program

The Victorian Government has allocated $42.5 million over four years in the State Budget 2017/18 to deliver the Victorian Gas Program.

The Victorian Gas Program will run from 2017 to mid-2020. It will deliver a comprehensive program of geoscience and environmental studies and related activities, including resource planning and regulatory improvements for onshore conventional gas, offshore gas and underground gas storage.

The program will look closely at Victoria's gas prospectivity and the issues associated with gas exploration and development to inform future decisions by the Victorian Government.

The program has three major components:

- Onshore conventional gas – geoscience and environmental studies. This program will deliver extensive scientific, technical and environmental information on the risks, benefits and impacts of onshore conventional gas as outlined in *Preview* 187. The work will initially focus on the area considered by the Geological Survey of Victoria to be most prospective for conventional gas in the Otway geological basin, between Port Campbell and Warrnambool.
- Offshore gas geoscience program. The offshore gas geoscience program will support the commercial exploration for further offshore gas discoveries in Victorian waters. This work will acquire new geoscientific information to identify areas off the Victorian coast, specifically the Otway coast, that are likely to be prospective for offshore gas. The offshore gas geoscience program will improve the understanding of gas prospectivity under Victorian waters at a sub-basin scale through geophysical surveys (e.g. airborne gravity gradiometry surveying).
- Underground gas storage investigations. This program will focus on the onshore Otway geological basin and investigate the potential for further underground gas storage sites. The program incorporates analysis and modelling of geoscientific information to assess the potential of known subsurface geological structures for underground gas storage, including rock characterisation studies (e.g. porosity, permeability). The program will also assess the economic potential of these geological formations.

All study results will be made publicly available. For more information on the Victorian Gas Program visit http://earthresources.vic.gov.au/earth-resources/victorias-earth-resources/petroleum/victorian-gas-program or contact Paul McDonald, Director, Geological Survey of Victoria at vgp@ecodev.vic.gov.au

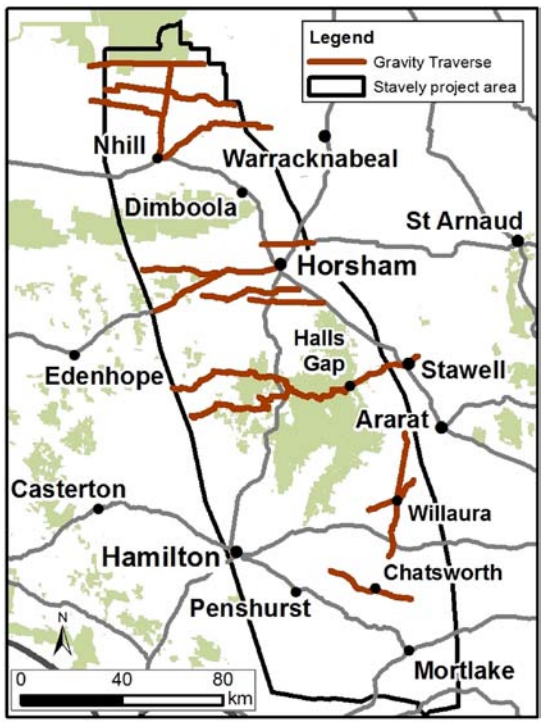

Figure 1. *Location of the Stavely Project ground gravity traverses.*

Stavely Project – ground gravity traverses

The Stavely Project is a collaborative geoscience research project between Geoscience Australia and the Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR, represented by the Geological Survey of Victoria). The aim of the Stavely Project is to improve the understanding of the regional geological architecture and mineral prospectivity of western Victoria, in particular the Cambrian-aged Stavely Arc.

A total of 3562 new ground gravity measurements were acquired by Atlas Geophysics at a station spacing of 200 m along 19 traverses in western Victoria in December 2016 (Figure 1). This acquisition program represents the Stavely Project - ground gravity traverses 2016 survey. Data were acquired along 724 km of road reserves across the Stavely Project area. The new gravity data will be used by the Geological Survey of Victoria to improve the geological understanding in key areas of the region and refine a digital three dimensional (3D) geological model for the Stavely Project area.

A report describing the survey, including appended digital gravity data, survey summary and operations report, is available from DEDJTR's Earth Resources website (http://earthresources.vic.gov.au/earth-resources). The digital data are also available for download from Geoscience Australia's Geophysical Archive Data Delivery System (GADDS; www.ga.gov.au/gadds).

Suzanne Haydon
Geological Survey of Victoria
Suzanne.Haydon@ecodev.vic.gov.au

Canberra observed

David Denham AM
Associate Editor for Government
denham1@iinet.net.au

Budget 2017: masterly politics, questionable economics

Abbott and Shorten neutralised

In one fell swoop Prime Minister Turnbull has sidelined the Abbott-Abetz faction of the Liberal Party and limited Bill Shorten's opportunities to present different policy options. Who would have thought that a Coalition Government would have embraced the architecture of the Gonski 'needs based' model for schools, set up a new review led by none other than David Gonski, and promised an additional $18.6 billion in schools funding over the next decade? It reads like a policy Bill Shorten could have launched. Then there is the $10 billion deal with doctors, pharmacists and the pharmaceutical industry to cut the price of medicine and reduce general out-of-pocket expenses covered by Medicare. Labor will no longer be able to accuse the Coalition government of trying to destroy Medicare.

The debt keeps on growing

Big government is back! $75 billion will be spent on transport infrastructure over seven years, and $5 billion to buy back the 87% of the Snowy Hydro Scheme, currently co-owned with New South Wales and Victoria. The Defence budget, which hardly rated a mention in the newspapers, increases from $37.9 billion in 2015–16 to $40.7 billion in 2017–18 and to $48.7 billion in 2020–21. No one in the Coalition or the Labor party wants to question why we still need 12 new submarines ($60 billion total) or 72 Lockheed Martin F-35A strike aircraft ($17 billion total). Furthermore, there will be the tax cuts for businesses with an annual turnover of less than $50 million.

How will this all be paid for? The Medicare levy will be increased to pay for the National Disability Insurance Scheme, but that does not apply until 2019; the five largest banks will be milked for $6.2 billion over four years; foreign aid will be slashed by another $300 million, making a total decrease of $11 billion since 2013, and the tertiary education sector will be slugged by a 2.5% efficiency dividend ($2.8 billion over four years). These measures are just playing at the edges.

In the meantime, on 1 July 2017 the 2% 'temporary' debt levy for those earning more than $180 000 per annum will be abolished – even though the Government debt/GDP ratio has been climbing relentlessly from 10% in 2007 to 42% in 2017. Consequently, in 2019 those on more than $180 000 per annum will be better off than they are now, and those on less than $180 000 will have to pay more. The rich get richer and battlers have to battle harder. Not a good way forward.

Science and technology hardly rates a mention

The only mention of science in the budget speech was the rather cryptic statement:

> *For the past year we have been delivering our national economic plan for jobs and growth. The first phase of our enterprise tax plan is now law. Our export trade deals are bearing fruit, with additional access secured. And our investments in science and innovation and our defence industries are breaking ground.*

Hardly an enthusiastic endorsement of the importance of science and innovation. No wonder the government has seen fit to cut university funding and increase student fees.

My cynicism tells me that there will be more votes for the Coalition in improving the school education system than there will be for encouraging more students to attend universities. John Howard is quoted as saying: 'Don't spend money on them [universities], the people there don't vote for us'. This may be correct, but it's hardly the way to improve our national skills and research capabilities and capacities. Perhaps a change in policy might produce a better outcome as well as more votes.

For 2017–18 the changes in the government's investment in science and innovation have been small and the table below (Table 1) indicates the operational funds provided. The Budget includes no allocations for capital expenditure on major national research infrastructure.

I won't comment on the numbers for each agency, but you can see that the funding for some of them is unlikely to

Table 1. Science Agency funding 2014–2020

Agency	Government appropriation in $M and (average staff numbers)[A]					
Financial year	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
AIMS	39	40 (208)	42 (221)	42 (223)	44	45
ANSTO	170	181 (1257)	183 (1277)	198 (1303)	206	212
ARC	904	821 (128)	778 (128)	789 (136)	790	817
BOM	220	227 (1581)	228 (1602)	230 (1565)	222	219
Antarctic Division	171	158	179 (383)	177 (378)	165	173
Geoscience Australia	180	121 (584)	143 (590)	151 (600)	157	141
CSIRO	717	750 (5056)	787 (4995)	794 (5063)	828	835
NHMRC	949	934 (185)	927 (179)	938 (177)	939	916
ABS	396	489 (2871)	622 (2894)	431 (2486)	401	413
CRCs	150	141	150	161	163	191
Defence Science TG	483	464	447	473	475	406

[A]*The numbers in the table are from the Portfolio Budget Statements (http://budget.gov.au/2017-18/content/).*

keep pace with inflation and the Bureau of Meteorology seems to be going backwards.

Some of the main science related features in the budget are listed below[1]:

- investment in new medical research and treatment facilities, with $68 million invested in South Australia to develop the first Proton Beam facility in the Southern Hemisphere
- increased support for women to enter high-skilled STEM professions through the Australian Mathematical Sciences Institute internship programme, as promised in Mid-Year Economic and Fiscal Outlook
- the commitment of $49.8m over 11 years to ensure year-round operation of the research facilities on Australia's sub-Antarctic Macquarie Island which lies between Tasmania and Antarctica (Antarctic Division).
- funding of $14.3m over three years to establish a whole-of-government educational data framework that will allow better understanding of educational pathways and programme efficacy in STEM as well as other disciplines
- a small increase in funding for Geoscience Australia, with a particular focus on realising the opportunities presented by satellite and other geographical data.
- $100m to establish the Advanced Manufacturing Fund to boost innovation, skills and employment through a growth fund and centre, a Cooperative Research Centre.
- $26.1m for astronomy through a strategic partnership with the European Southern Observatory (astronomical research and instrumentation) – ongoing annual indexed commitment of $12m to 2027–2.8
- $7m increase in Business Research and Innovation Initiative.
- Medical Research Future's Fund starting disbursements as expected with $65.9 million in year one for preventative health, advanced health translation, clinical trials and breakthrough research investments.
- $115 million for mental health research and services over several years.

[1]Taken from: https://www.science.org.au/news-and-events/news-and-media-releases/science-and-research-federal-budget/ and https://scienceandtechnologyaustralia.org.au/2017-2018-budget/.

Finally, the budget papers contained this little gem:

> *In 2017–18, the Environment and Energy portfolio will work with the Industry, Innovation and Science portfolio to roll out the Australian Government's new $86.3 million Gas Supply and Affordability measure. This measure is part of the Australian Government's Energy for the Future Package which takes significant steps to ensuring all Australians including those in regional communities, can access secure, reliable and affordable power as we transition to a low emissions future. The measure will deliver important reforms across Australia's gas market to secure reliable and affordable energy for Australian consumers.*

If you go to the link below you can read the Minister's media release on this issue, but it is also short on the details: http://www.environment.gov.au/minister/frydenberg/media-releases/mr20170509.html

A spokesperson from the Department of Environment and Energy said:

> *The Government will extend funding by $30.4 million for the world leading Bioregional Assessments programme to assess any potential impacts on waterways and aquifers from unconventional gas projects. Over the next three years the expanded programme will examine new gas reserves and provide independent scientific advice to governments, landowners and the community, business and investors on future secure and reliable gas supply. The majority of the work will be undertaken by the Department of the Environment and Energy. Other measures will be led by the Department of Industry, Innovation and Science, the Australian Energy Market Operator and the ACCC. Geoscience Australia will be involved in the geological and bioregional assessments to assist the Department in prioritising basins to be assessed by the programme and provide geological information to the assessments. CSIRO will also be involved in the assessments for the provision of water modelling and related activities.*

So now you know!

21 areas identified in 2017 petroleum exploration acreage release

The Government's 2017 acreage release comprises 21 areas located across eight sedimentary basins in Commonwealth waters offshore of Northern Australia, Western Australia, Tasmania, Victoria and the Ashmore and Cartier Islands (Figure 1). Twenty areas are available for work programme bidding and one area for cash bidding.

The areas comprise: 10 areas off Western Australia, two areas off the Northern Territory, three areas off Victoria, two areas off Tasmania and four areas in the Territory of Ashmore and Cartier Islands. The areas are located in water depths ranging from 25 to 4200 m and vary in size from 161 to 2465 km^2. All areas are supported by pre-competitive geological and geophysical data and analysis undertaken by Geoscience Australia.

Further information on the release areas and the basins of interest, is available from www.petroleum-acreage.gov.au.

All release areas have been nominated by industry, assessed and considered by governments and selected to offer the petroleum exploration industry a variety of investment opportunities. The acreage release provides the petroleum industry with access to pre-competitive geological and geophysical datasets and ensures the provision of quality information on third party issues that may impact on successful applicants when conducting exploration work programmes.

Table 1 gives more details of the areas that are being released. Table 2 shows four areas of the 2016 release programme that have been re-released.

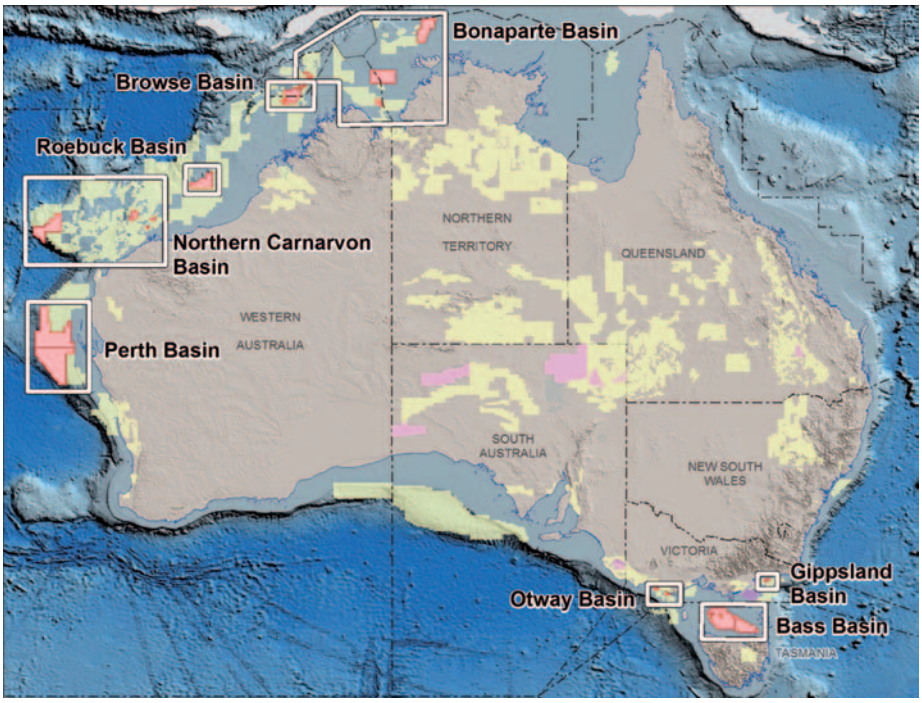

Figure 1. *Locations of the 21 areas in the Government's annual 2017 acreage release programme (in pink).*

Table 1. 2017 release areas and closing rounds

Rounds	Release Areas	Closing date for bids
Cash bid prequalification	W17-6	5 October 2017
Round One – work programme	AC17-2, AC17-3, NT17-1, T17-1, T17-2, V17-1, V17-2, V17-3, W17-4, W17-5, W17-8	19 October 2017
Cash bid auction	W17-6	8 February 2018
Round Two – work programme	AC17-4, AC17-5, NT17-2, W17-1, W17-2, W17-3, W17-7, W17-9, W17-10	22 March 2018

Table 2. 2016 re-release areas and closing rounds

Rounds	Release Areas	Closing date for bids
Round 2 of 2016 release	W16-5, W16-6, W16-9, W16-24	19 October 2017

New CEO for Geoscience Australia

James Johnson has been appointed the new Chief Executive Officer (CEO) of Geoscience Australia (GA). He replaces Chris Pigram, who was CEO between 2011 and 2016.

Dr Johnson has more than 30 years' experience in the geoscience sector, including 11 years as a Division Chief at GA; leading the organisation's energy and minerals activities. He has also been Geoscience Australia's Deputy CEO for the past six years. His contributions to Geoscience Australia include overseeing the development of the current $100 million Exploring for the Future Programme. He also shepherded the $59 million Onshore Energy Security Program (2006–2011), which discovered a new sedimentary basin with energy hosting potential in north Queensland, produced the first national radiometric map of Australia, and resulted in an estimated additional $300 million industry exploration expenditure during the life of the programme.

Before joining Geoscience Australia Dr Johnson led successful exploration teams in the minerals industry, working in Western Australia, Victoria and Canada, overseeing the discovery of new resources worth more than $800 million.

In accepting the role, Dr Johnson said 'I am excited by the opportunity to work with Geoscience Australia's knowledgeable and passionate experts to shape the future directions of the organisation to deliver benefits to the nation'. As a top priority, he will meet with Geoscience Australia's key stakeholders in the private and public sectors, to 'deepen his understanding of our stakeholders' needs when it comes to geoscience knowledge and capability'.

Education matters

Michael Asten
Associate Editor for Education
michael.asten@monash.edu

Emma Brand
Chair of the ASEG Continuing Education Committee
continuingeducation@aseg.org.au

Professional development is the ASEG Continuing Education Committee's highest priority

This month we take the opportunity to meet Emma Brand, the Chair of the ASEG Continuing Education Committee, and learn about the forward plans set out for the education portfolio.

Emma is Project Manager for Geophysical Operations for Origin Energy, operating in the 'upstream' end of this national gas and electricity energy supplier. She also looks after a portfolio of training tasks in the Company, chairing a committee responsible for graduate training and oversight of student interns. Last June, Emma took on the important ASEG roles of Chairman of the Continuing Education Committee and member of the Federal Executive.

The ASEG Education Committee is tasked with ensuring the continuing education of ASEG Members and liaising with students and academic staff. Under Emma's management the Committee has developed a strategic plan that is focused on offering more professional development courses for ASEG Members.

The Committee's priorities (in decreasing order of importance) are as follows:

1. **OzStep** and **OzLeap** courses, targeted respectively at young professionals, and at all professionals seeking a deeper insight into particular geophysical methods.
2. International visiting lecturers via SEG and EAGE Courses (including DISC, DL, HL and EET)
3. ASEG courses and lectures
4. Support of wider education programmes in schools, universities and the community, such as TESEP, ESWA, Augen, ACARA.
5. Promotion of geophysics.

The Committee operates with the following assumptions:

1. Any courses should be run on a cost neutral basis to the ASEG.
2. Topics should align with the membership base.
3. Courses should be held in each state/territory every year.
4. The Education Committee is responsible for facilitating courses, not running them.
5. Courses should broadly align with the following themes:

    a. Case studies
    b. Bridging courses for young geophysical professionals (OzStep)
    c. Deep technical courses (OzLeap)
    d. Other broadening subjects, such as technical writing, project management etc.

The strategy of the Committee over the next 12 months is, therefore, to:

1. Continue to facilitate SEG/EAGE courses.
2. Continue to support as required state branch, one-off monthly presentations.
3. Built a portfolio of case studies on topics that align with ASEG's goal of being more proactive in Geoscience debates. Such topics shall include monitoring of fracking in gas reservoirs, use of the seismic in marine environments and the social license to operate these technologies.
4. Support the development of a postgraduate, industry-focused short courses to help prepare young geophysical professionals.
5. Build a portfolio of deep technical courses across a range of topics of interest.
6. Build a portfolio of broadening topics and presenters.

To enable this strategy we need help building these portfolios of topics, and we're looking for representatives across other fields of interest, specifically coal, non-seismic acquisition, petrophysics, research and education, solid earth geophysics and geotechnical. If you are interested in being on the Committee, or giving a presentation or course on any of these topics then please reach out – your Society needs you!

SEG 2017 Distinguished Instructor Short Course: Doug Oldenburg

Geophysical electromagnetics: fundamentals and applications

Doug Oldenburg

Summary

Electromagnetics has applications in oil and gas exploration and production, mineral exploration, groundwater exploration and monitoring, geotechnical and environmental industries. Although it has widespread applications as a geophysical technique, it is not generally understood by the geoscience community. As a result it is underutilised, and in some cases misused, as a technology.

The aim of this course is to provide a fundamental understanding about EM geophysics so that practitioners can decide if an EM technique can help solve their problem, select which type of survey to employ, and set realistic expectations for what information can be gleaned. Case histories, spanning applications from many areas in the geosciences, are used as an underlying framework to bind the material together. For more information, see the online resources at http://disc2017.geosci.xyz.

Fundamentals and applications

Case histories pertain to problems in resource exploration, including oil and gas, minerals, water, environmental, and geotechnical areas and are contributed by experts worldwide. (http://disc2017.geosci.xyz/).

These include:

1. resource detection (e.g. methane hydrates) or de-risking (e.g. offshore-hydrocarbons),
2. imaging SAGD steam chambers or monitoring hydraulic fracturing,
3. mineral exploration (on land, on the ocean floor sea floor massive sulfides),
4. water issues (e.g. monitoring salt water intrusion, imaging aquifers),
5. imaging geothermal systems,
6. detecting and discriminating unexploded ordnance,
7. geotechnical characterisation, including slope stability, and more (see http://em.geosci.xyz/content/case_histories/index.html for a growing list).

These applications are motivation for investigating fundamentals of electromagnetics. Applications successively investigated include those that make use of:

1. steady state fields (e.g. DC resistivity, induced polarisation),
2. frequency domain EM (e.g. marine CSEM, airborne surveys),
3. time domain EM (e.g. airborne, ground, borehole surveys),
4. natural source EM (e.g. magnetotellurics, Z-Axis Tipper/ZTEM).

Each case history is presented in a seven-step process that begins with the description of the geologic or geophysical problem to be solved and ends with the impact of the EM geophysical survey to help solve the problem. At points in the middle, the details of the particular EM survey are investigated, together with some fundamentals of electromagnetic induction, and techniques for processing/inverting the data. The ability to move seamlessly between these different levels of information, so that relevant questions or concepts can be addressed, is facilitated by new open-source numerical software, interactive simulations, and the 'textbook' resource http://em.geosci.xyz. Although we work continually with Maxwell's electromagnetic equations, the presentations are mathematically 'light' and the learning aspect is facilitated by the use of open-source, interactive numerical software and visual aides.

The site http://disc2017.geosci.xyz contains further details on the course, its goals, links to the open-source resources that will be used, and ways to get connected!

Who should attend?

Geophysicists and any geoscientists who have the potential to use, or be associated with, electromagnetic data. The 2017 DISC is designed to be of interest to a broad audience, including researchers, practitioners, and industry geoscientists, and accessible to those with little background in EM.

Biography

Doug Oldenburg's 40-year research career has focused upon the development of inversion methodologies and their application to solving applied problems. He, with students and colleagues at the University of British Columbia Geophysical Inversion Facility (UBC-GIF), have developed forward modelling and inversion algorithms for seismic, gravity, magnetic and electromagnetic data. The inversion techniques and software are widely used in resource exploration problems. In recognition for his work building collaborative interactions between industry and academia, he was awarded the NSERC Leo Derikx and the AMEBC Special Tribute awards as well as the J.Tuzo Wilson medal. In 2011, Doug was the SEG Distinguished Lecturer; his presentation was entitled 'Imaging the Earth's near surface: The why and how of applied geophysics for the 21st century'.

Doug is currently a Professor at UBC, Director of UBC-GIF and holder of the TeckCominco Senior Keevil Chair in Mineral Exploration. He is an honorary member of the CSEG, SEG and a Fellow of Royal Society of Canada.

Doug Oldenburg's DISC is scheduled for:
27 July – Perth
2-3 August – Adelaide
7-8 August – Brisbane
Registration online at: http://seg.org/Education/Calendar

Environmental geophysics

Mike Hatch
Associate Editor for
Environmental Geophysics
michael.hatch@adelaide.edu.au

Mapping water movement through agricultural landscapes

Welcome readers to this issue's column on geophysics applied to the environment. I'm back to thinking about some of the holy grails of environmental geophysics – and one forcibly presented itself to me this week. It came in the form of a query about pricing from an environmental consultant I work with every now and then. His client was a farmer who has a sizeable farm (seems sizeable enough to me – about 2.5 km x 3 km) not too far from Adelaide. The goal of the project was to understand the extent of the unconfined aquifer and the volume of water contained in the subsurface on his land so that it could be sustainably used. This would (if possible) include understanding recharge and discharge pathways to/from the aquifer (aquifers?) every year, and how these flows varied seasonally. I guessed that the budget for this work would not be large, but decided to see what I could come up with – based on 'commercial' rates.

The groundwater in the area is both shallow (<20 m in most places) and pretty fresh, so an easy target for EM/resistivity in some ways (being shallow), but tough in others (not likely to be much contrast between the relatively resistive host and the good quality water). So maybe I wasn't too imaginative, but I went with what I know. I decided that the best approach in this situation would be to start with an EM survey to capture information about local shallow structure and, perhaps, to start mapping the location of the groundwater. Then, to help remove some of the response ambiguity that is always part of an EM survey, I wanted to map the groundwater directly with a programme of NMR soundings (and in the process get an understanding of unit porosity/permeability). In my experience with groundwater studies, resistivity/EM rarely provides enough information to unambiguously identify the depth to groundwater. I think that additional information is almost always needed, whether from a relatively dense network of bores, or from other (complementary) geophysical techniques.

So, for the shallow EM part of the project, I started by thinking about the costs of a ground survey that would cover the entire area (most of you already know that this will be expensive, but just go with it for now). Let's say a crew of two costs something like $3000 per day (including expenses and processing), and that they are able to collect 50 stations of shallow TEM in that day. At a 20 m station spacing that is $3000 per line km. For the 2.5 km × 3 km survey, with a 200 m line spacing (perhaps a bit coarse) you would collect data on 12 × 3 km long lines; so a total of 1800 stations, and all 12 lines would take about 36 days to finish – already up to a staggering $108 000.

Alternatively, you could go with a high resolution helicopter-based airborne EM survey (AEM) and cover the area in less than a day for something like $100 000 (including processing, QA/QC, etc.). For that price you would probably be able to collect 500–600 line km in two days. I've been reliably told that this is the minimum time that you should think of hiring an AEM system and you would therefore try to get other farmers in the area involved so that the costs could be spread between you and the neighbours. If that worked you might be able to survey over five adjacent farms and then get the price down to $20 000 per farm. There are other options – some of the mobile EM surveys that companies like Groundwater Imaging run might help with the price, getting close to AEM productivity by driving/towing an EM frame over the farmer's ground.

For the NMR I thought that ultimately the best strategy would be to collect the complete EM data set first and then to decide on where to position the NMR sites based on EM results. Nevertheless, for budgeting purposes, I figured that 40 soundings over this 2.5 × 3 km area might be enough. In good, electrically quiet conditions (as anticipated on a relatively remote farm) a crew should be able to get four stations per day – for a total reading time of 10 days. If we assume the same crew cost for the NMR this comes to $30 000. So our total for data acquisition and data imaging could come in at ~$140 000 and we haven't even started interpreting the data sets. Of course the price would go down if you could get some of the neighbours to go in on an AEM survey, or used larger loops for the TEM, or if a faster more mobile EM system was used. But then add on the interpretation costs.

I didn't expect that my consultant friend would be too impressed with these numbers, but sent them to him anyway to see what he would say. Remember I didn't know how much money the farmer was willing to spend and thought 'what if this farmer is both rich and curious'? I was informed that the budget was $20 000. Nowhere near enough for what I had 'quoted', but actually a reasonable amount of money – what I would call real money to answer real questions.

For interest I spoke with the consultant some more about what he was going to propose to the farmer, and he said that they were probably going to run a relatively standard set of pumping tests based on a new bore to estimate the usual hydraulic parameters for the aquifer (transmissivity, hydraulic conductivity, etc.). He would then (I assume) extrapolate those results to the rest of the property. I think that both he and the farmer would have preferred a study that would provide information about the entire property – like the geophysics that was originally envisioned, but that was pretty well out of the budget.

So, what is the punchline of all of this? When I started writing this piece I wasn't sure what it would be, but as I wrote and thought it through it became clearer. I think that it is in the national interest to give farmers the sort of information that this sensible farmer wants to have about water movement through his land – and is willing to pay a reasonable amount to obtain.

Ultimately, if farmers have this information they will be able to farm

smarter and more efficiently. Australia is not an easy country to farm, and more information is better than less (stating the obvious perhaps, but…). Giving farmers the information that our farmer wants would improve the longevity of farming operations for most farmers in our part of the world – which would ultimately improve prosperity for all of us.

I think that there are at least two challenges here. Firstly I think that there is a challenge for us (the geophysical community) to work on improving the various technologies available for this kind of work so that the price of surveys is reduced and the quality of information improves as well. It's time to bring on improvements in collecting IP data from EM/AEM surveys; time to figure out airborne NMR (hmm, now that's a challenge); time for faster cheaper surveys based on drone platforms; and, more than anything, it's time to figure out how to make some of the standard surveys that we do cheaper and easier for 'normal' people to access and understand. Secondly (fifthly?), I wonder if it is time for the Australian governments (state? federal?) to cover most farming country with high quality AEM. This base data set would go a long way towards understanding where the water is coming from and is going, and give clues as to how deep the various aquifers are; it would then be up to individual farmers to do infill surveys or add well-sited bores to flesh out the information that they need to effectively farm their holdings.

I would be interested in your views and in any suggestions you might have about alternatives to the approach I have suggested to obtaining baseline information about water movement through the Australian agricultural landscape. Please write to me and maybe we can put your ideas into a future column.

Australia needs this!

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Minerals geophysics

Terry Harvey
Associate Editor for Minerals geophysics
terry.v.harvey@glencore.com.au

Championing old data

With continuing advances in geophysical exploration technology, and the ability we now have to collect and store a wealth of data, geophysical survey results from the past can be overlooked. I feel motivated to champion old data. My introduction to exploration geophysics was an ABEM vertical component torsion magnetometer survey at Nobles Nob mine near Tennant Creek over 50 years ago - although I'm not necessarily advocating that we go back that far. Our industry has undergone significant structural changes over the past 50 years, and there was arguably a longer term outlook in the past. Some of the larger mining companies had in-house crews, and embarked on some very extensive and systematic ground geophysical surveys. These old data could be valuable assets.

Often the first reaction to older geophysical data is 'Oh, that's old, it can't possibly be any good'. Granted, some of the data may be pretty basic, were collected with less sophisticated instruments and may not be in the most convenient, digital format. However, it is free (or relatively cheap), and it is readily available. In Australia there are legislative requirements that exploration results be reported to the responsible government body, usually to what used to be the State Mines Departments. These departments have been diligent in collecting and then releasing results in Open File form. If you are fortunate the original geophysical survey data will also have been collected and released. If not, you may be able to track it down in company or contractor files. In some instances commercial organisations have re-packaged the data for resale.

Early data were often slow and laborious to collect and, as a consequence, greatly valued. Results were read off dials and recorded by hand, and the instruments could be temperamental. Operators were, by necessity, intimately involved in the survey and their equipment - there was no simple pressing of a button and it's done. On the negative side, there was more chance of a mis-reading, fewer parameters could be measured, and the measurements were less accurate. Early gravity surveys levelled with a barometer are a case in point; clearly some data can't be pushed too far. With the advent of storage systems, data, whether analogue or digital, could at least be recorded and re-accessed later. Whether the storage media has survived and the data can still be retrieved is, of course, relevant.

Also to be considered is the previous treatment of these data. Presentation, processing and interpretation were often quite simplistic, limited by lack of computing power and CAD facilities. Results were presented as hand drawn profiles and contours, processing was done with a small calculator (or even a slide rule), and interpretation limited to model matching; there were no inversion routines. Think what modern processing and inversion techniques might extract from these data. True, it may require considerable effort to get the data into the necessary format, older data may have to be digitised and perhaps physical locations recovered, but it's worth at least looking at.

And, even if the data are inadequate – not enough power to see through the cover, not accurate enough to discriminate the subtle signals, not measuring the right parameter – there's still information to be had on the physical environment that may be pertinent to future surveys. Are there surficial conditions (silcrete, maghaemite) that need to be taken into account, is there conductive cover (deep weathering, younger sediments) to be penetrated, will the country rock cause problems (conductive, IP anomalous carbonaceous pyritic shales for example)? Valuable geo-environmental information may be gleaned from old survey data, even without re-processing.

Finally, as a special case, consider geophysical data collected pre-mining. It's irreplaceable. Once mining has begun, and infrastructure is established, the opportunity to develop a better understanding of the geophysical character of a deposit is lost. Before and after aeromagnetic surveys of the Ernest Henry deposit illustrate the point. The pre-mining 1970s survey (Figure 1) has 200 m line spacing and 60 m terrain clearance (here downward continued for comparison purposes) – the modern during-mining survey (Figure 2) has 50 m line spacing at 30 m terrain clearance. No matter how sophisticated the processing regime it is not possible to recover the magnetic signature of the Ernest Henry deposit from the post-mining survey.

So, the next time you're confronted with old survey data, give it a second look. There might be some effort involved, but it could deliver targets or at least provide information to help design a new survey. And it's already been collected!

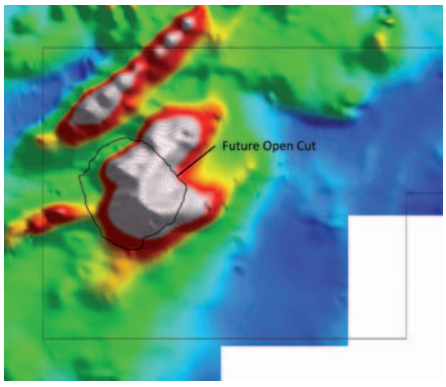


Figure 1. *Ernest Henry deposit pre-mining (RTP image of magnetic survey data).*

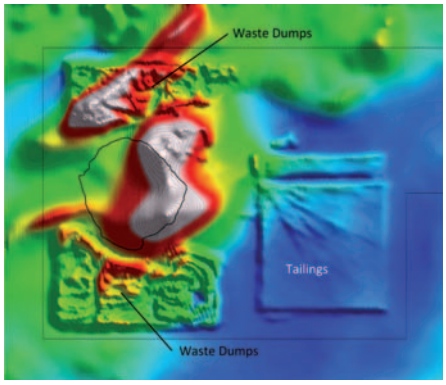


Figure 2. *Ernest Henry deposit during mining (RTP image of magnetic survey data).*

Seismic window

Michael Micenko
Associate Editor for Petroleum
micenko@bigpond.com

Pricing, gas, oil and governments

Why have gas prices risen on the east coast?

Without simplifying a complex situation too much, here are some reasons for the current situation.

- competition between LNG exporters,
- limited volumes of developed gas resources,
- a moratorium on onshore exploration
- bans on reservoir stimulation

No one is solely responsible for the current situation, but all interested parties have contributed to create a gas shortage.

As I write this article the Australian Government has announced that it will act to ensure access to cheap gas for domestic users. This is not a new idea. It was done fifty years ago when crude oil prices were manipulated to ensure the population had access to cheap petroleum products - as described below.

Most of this account relates to events that happened before I became involved in oil exploration, so I have used Australian Year Books as my principal source of information on the history of oil pricing in this country (summarised in Table 1).

In 1957, to encourage exploration, the 'Petroleum Search Subsidy Act 1957' was introduced and gave explorers a 50% subsidy on the cost of stratigraphic drilling. This was amended in 1959 to include all types of geophysical surveys and off structure drilling. Various amendments were made to alter the subsidy rate and types of applicable operations from 1968 to 1972. Onshore drilling received a 30% subsidy of approved costs, and onshore geophysical surveys received 50%. Offshore operations were subsidised at a rate dependent on the Australian financial contribution with a maximum rate of 30% for 100% financed Australian companies. In May 1973 it was announced that the subsidy scheme would terminate on 30 June 1974 and operations after this date would not be eligible for subsidy. It appears the subsidy scheme had done its job.

Early in 1965, following the discovery of oil at Moonie (1961) and Barrow Island (1964), the Tariff Board conducted a public enquiry to determine an appropriate price for Australian crude oil. There were conflicting aims for the Government at the time – they needed to encourage the search for oil and to provide an incentive, but were anxious to minimise cost increases on petroleum products supplied to Australian consumers and to ensure refineries using Australian crude were not detrimentally affected. The Tariff Board recommended that Moonie crude should be valued at $2.69/barrel, which included a variable quality differential and a 22.4c incentive. The Government agreed but raised the incentive to 67c/barrel. They also imposed import duties of 0.8c/gallon (28c/barrel) on crude and 2.4c/gallon (84c/barrel) on petrol to be paid by companies that did not take their fair share of local crude (based on the amount of imported crude they used). As a result the cost of Moonie oil delivered in Brisbane was $3.14, and Barrow Island oil was $3.24/barrel when delivered to Kwinana (started in April 1967). This pricing was to remain until 1970.

The discovery of large oil reserves in the Gippsland Basin revealed that under this pricing structure the Australian consumer could be paying more for indigenous petroleum products than for similar products refined from overseas crude oil. To rectify this the Commonwealth Government held discussions with the Gippsland producers who agreed to forgo the 67c/barrel incentive. They also agreed to forgo a further 5c/barrel. So, on the commencement of production in October 1969, Gippsland crude was priced at $1.80. (I wonder if the oil producers really 'agreed').

From September 1970 the price of all Australian crude oil has been 'based on import parity' pricing, which was fine until the oil price shock of 1973 when international prices quadrupled to $12/barrel.

From September 1975 the Government policy changed by differentiating between oil produced from future discoveries (new oil) and oil produced from already discovered fields (old oil). Under this policy, new oil would attract a price at the nearest refinery equivalent to the landed cost of imported crude. At the time this meant a return of about $6.90/barrel. Prices for already discovered oil were set at $2.33 for all Gippsland production after 18 September 1975, while Barrow Island oil prices increased yearly starting at $2.73 in 1975 up to $3.17 in September 1977. Similarly Moonie crude oil prices increased each

Table 1. Brief outline of events affecting Australian crude oil pricing 1960–1980

Year	Event
1957	Subsidies introduced on stratigraphic drilling
1959	Subsidies amended to include geophysical surveys
1961	Moonie oil discovery
1964	Barrow Island oil discovery
1965	Public enquiry to determine appropriate price for domestic crude oil
1969	Gippsland production commences
1968–72	Various amendments to subsidy scheme
1970	Move to import parity based pricing
1973	Announcement that the subsidy scheme would end in 1974
1975	'Old oil' vs 'new oil' concept introduced
1978	Full import parity pricing introduced (providing a windfall for government)

September from $3 in 1975 to $4.35 in 1976 and $5.25 in 1977.

The Government had our interests in mind and this policy aimed to provide 'maximum practical incentive' for exploration for new fields while looking after producers of known oil fields by giving them a fair return on their investment so that all economically recoverable oil could be produced.

The policy changed again in August 1978 in response to another sharp rise in the international oil price and it was decided to raise the price of domestically produced oil to full import parity. This was complemented by an extension to the excise arrangements that provided for 'appropriate sharing of the import parity price' between producers and Government. This was implemented by the addition of a crude oil levy on local production from fields discovered before August 1976. New oil fields were not subject to any levy and received full import parity price. It seems the Gippsland producers were being ripped off in this 'framework within which conservation, new fuel substitution, exploration and development as well as research into alternative fuels could flourish'.

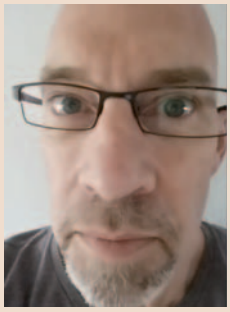
Can you spot the trend in this brief history of crude oil pricing? Firstly, the Government encourages an industry with subsidies and then, over time, reduces the subsidies and increases taxes while fixing prices to protect the consumer and finally, the industry pays 'its fair share' and the general public gets used to paying the world parity price.

The current gas situation is not quite the same but price management by the Government is again being used to ensure the domestic consumer is not paying too much for gas (for now).

Sources

Most of the information in this article was obtained from the Australian Bureau of Statistics Year Book Australia (various issues between 1960 and 1980).

Webwaves



Dave Annetts
ASEG Webmaster
david.annetts@csiro.au

Continuing work on the ASEG website

Much of the work on the website over the past two months has been administrative and evolutionary. Two of the state branches have asked for more detail to be added to the appropriate pages. Currently Members who are travelling interstate can check general details of upcoming Branch meetings in NSW and Western Australia. WA's current Branch page offers a guide to other branches interested in acknowledging sponsors or committee members.

One issue that continues to cause concern is access to *Exploration Geophysics*. Currently, this is provided to Members from a page that can only be accessed after they have logged in. In rare circumstances Member's details have not been passed on to CSIRO Publishing, where the journal is hosted, and the result is that legitimate Members are charged to access articles. Adding to the confusion, some Members have tried to log in to CSIRO Publishing's website. The intermittent issue appears to be unrelated to browser or platform. The Web Committee has found that rightful access can be restored through the following steps:

- log off aseg.org.au (click on 'Logout' at the top right of the screen or through the hamburger on a mobile device)
- clear your browser's cache
- clear cookies related to ASEG and CSIROP
- login to aseg.org.au

Needless to say, methods of accessing *Exploration Geophysics* that maintain security and are easier than current methods are under active investigation by the Web Committee, and we expect to be able to implement these in the next few months.

One addition to the website in the past month has been details of collected papers (http://www.aseg.org.au/collected-papers). This page is an initiative of the History Committee (and Kim Frankcombe) and is designed to put interested parties in touch with those who have agreed to as act the custodians of the libraries of notable non-practising or deceased Members. The History Committee will be responsible for determining whether a collection is notable, therefore Members seeking to make their libraries available to the wider community are urged to contact the History Committee at history@aseg.org.au.

Following the publication of this column in the April issue of *Preview* (PV 187), and the reference therein to making conference workshops and seminars available online, some Members contacted the Webmaster (webmaster@aseg.org.au) with more material. Currently, material from two workshops is available to interested parties.

Other web-related developments over the next few months are the provision of various documents to appropriate parties. Currently, these documents are stored on an FTP server graciously provided by Kim Frankcombe. One factor contributing to the design of the new website was making these documents more easily available.

Data trends

Guy Holmes
guy.holmes@katalystdm.com.au

My new digital classroom

Last week I presented a 20 minute talk at the PPDM luncheon in Perth on technologies that stand to change the future of the geophysical and data management industry. I covered Blockchain, IoT (Internet of things), Hadoop and Watson (IBM's cognitive computing offering).

I am no expert on these areas, but I have done some casual reading and have taken a general interest in the unfolding of new technologies including things not even remotely related to geophysics, like Uber and Instagram.

Someone in the audience at this PPDM talk asked me how I keep up to date on these technologies – some of which they had never heard of. The answer was podcasts. Podcasts have become a significant part of my daily routine. I don't just listen to podcasts on technology either – I also partake of several social/entertainment podcasts and a mix of podcasts that blur the line between entertainment and technology. If you don't know what a podcast is here is the Wikipedia definition: 'A podcast is an episodic series of digital audio files which a user can subscribe to so that new episodes are automatically downloaded via web syndication to the user's own local computer, mobile application, or portable media player'. The name came from the combination of the words IPod and broadcast.

I was introduced to podcasts by my wife Amanda, who was listening to a podcast called 'Sex Death and Money' (from WNYC Studios) one day when she was doing laundry. I came home from work early and opened the front door and heard a man talking about the best way to kill a husband. I stood just inside the front door of my house for 5 minutes, with the door part way open just in case I needed to make a quick getaway, before I realised that it was a podcast and not some hit man that my wife had hired. Needless to say it piqued my curiosity.

There are hundreds of thousands of podcasts you can choose from depending on your interests. Some are single episodes on a particular subject that changes every week, and others are serial (each new episode follows on from the last like a series of different chapters from the same book). My wife chose a podcast on how to murder me, and many of you may wish to subscribe to that one as well, but for others with less determination and broader interests you can choose subjects that are less detrimental to my health.

The Society of Exploration Geophysics has a podcast called Seismic Soundoff, which is a series of in depth conversations in applied geophysics. If you are interested in geology there is the Geology Flannelcast made by three grad students who purportedly 'discuss geology topics that no one else dares to touch'. It just so happens that the podcast is one that I don't dare to touch. But if you like soil analysis and Milankovitch cycles, this one may be for you.

My personal favourites vary widely. 'How I Built This' hosted by Gay Raz from NPR radio is focussed on innovators and entrepreneurs and 'Start Up' from Gimlet media is a series about what it's really like to start a business. Those two are two on the top of my favourites list.

On the technology front, I listen to the 'Ted Radio Hour', which is a choice TED talk mixed with in depth interviews from the speakers who gave the talk, as well as the AWS podcast (Amazon Web Services), which details all of the new developments in cloud based computing, storage, etc. on the Amazon platform.

I highly recommend subscribing to a few podcasts and giving them a try. Anyone who has a commute to the office of more than 15 minutes can use that time to learn about a new topic in an entertaining and well written format that takes no effort at all to consume.

Now – back to looking for a podcast about how not to get murdered.

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Conductivities of Broken Hill style lead ores

Don Emerson
systemsnsw@gmail.com

Introduction

In terms of volume, the main conducting mineral in the Broken Hill (New South Wales) style of lead-zinc mineralisation is medium to coarse grained (~1 mm +/-) galena, PbS. The zinc mineral is an iron-rich sphalerite: marmatite (Zn, Fe)S. Sphalerite is a semiconductor with a wide band gap rendering it non-conductive (Shuey, 1975). To assess exploration in this important region, it is useful to have some information on the conductivity behaviour of these ores. Accordingly a suite of sixteen samples was examined – nine from lead mineralisation, and seven from zinc mineralisation. The results are referenced to the conductivities of three 'ideal', very high grade (collector grade), virtually pure, very coarse grained (>1 mm) galena from Rapid Bay (South Australia), Sweetwater Missouri (USA), and Dalnegorsk (far eastern Russia). The samples were sourced from dealers, the writer's collection, and some material from the AMIRA Project 369A (Emerson and Yang, 1994). The basic mineralogy is given in the notes to Table 1. Representative materials from some of the test samples are shown in Figure 1.

Besides the AMIRA results, some data on lead-zinc sulphide conductivities and resistivities have been published by Emerson (1997) and Bishop and Emerson (1999). The data presented herein supplements the previous work, but the emphasis is on galena; previously it was on the sphalerite.

'Broken Hill type' deposits comprise stratified lead, zinc and silver mineralisation in quartz-gahnite, garnet-quartz horizons (Stevens et al., 1990). Johnson and Klingner (1975) give a good outline of the Broken Hill mineralisation styles where lead and zinc lodes occur in a Proterozoic metasedimentary sequence subjected to granulite grade metamorphism.

In hand specimen, or under 20x binocular, galena is easily recognised by its lead-grey colour and streak, metallic lustre, perfect cubic cleavage, and softness (Moh's hardness 2 ½). Marmatite is harder, and readily identified by its dark grey blackish colour, subdued lustre, perfect [011] cleavage, and red-brown streak. Other sulphides (Table 1) were not regarded as being important, except for the yellowish sulphides, pyrrhotite and chalcopyrite. Galvanic microprobing permitted assessment of galena intra- and inter-grain electrical conductivity, and this was facilitated by the coarse grain sizes.

Foliation is discounted as a variable as none was obvious at core scale. The materials are regarded as quasi-random, coarse grained, aggregates of mainly galena and marmatite set in a silica/silicate variably grained host in which fine loops and threads of pyrrhotite and chalcopyrite can also occur. Given the high metamorphism to which the Broken Hill rocks were subject, it was not surprising to see that ductile, soft galena, apparently mobilised along grain boundaries, thus contributing to a more effective electrical framework. The galena grains in contact with one another appear to be well sutured.

For reference, nominal values of conductivity, magnetic susceptibility, and density have been ascribed, in Table 1 and Figure 3, to the minerals mentioned in this article. These values are based on data published by: Shuey (1975); Olhoeft (1981); Clark and Emerson (1991); Deer et al., (1992); Clark (1997); and Emerson et al., (2001).

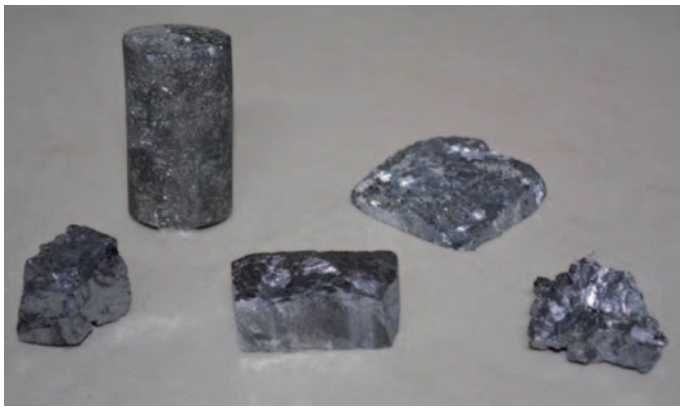

Figure 1. *This photograph shows subsamples representative of some of the cored galena materials. The first prism, on the left, is from Sweetwater, Missouri; it has 10 mm +/- grainsize and an EM conductivity of 7812 S/m. The second prism, in the middle, is from Rapid Bay South Australia; it has 5 mm +/- grainsize and conductivity of 6364 S/m. These two prisms are virtually pure galena continua. The third subsample of irregular outline on the right is from Dalnegorsk in Russia; it has 5 mm +/- grainsize but it contains some gangue, voids, and other discontinuities so its lower conductivity of 3010 S/m is not unexpected. The slab is from the parent lead lode material from which L10 was cored (see Table 1), it contains about 60% by volume of distributed galena with grainsize 2 mm +/-; L10's conductivity is 587 S/m. The 45 mm diameter core is Z3 from the zinc lode suite with 70% marmatite, 15% galena, and small percentages of pyrrhotite/ chalcopyrite that have contributed to Z3's conductivity of 87 S/m. In the photo the galena, or at least some of it, can be identified by the metallic reflections, but the wispy pyrrhotite and chalcopyrite in Z3 cannot be seen at this scale.*

Measurements

Laboratory mesoscale measurements were carried out on cored, air-dried, low porosity samples for electrical conductivity and magnetic susceptibility, to 1% accuracy. Induction coils (Figure 2) were used and energised to 1 MHz for induced electromagnetic conductivity and 400 Hz for magnetic susceptibility. Changes in the resistance (R) and inductance (L), when cores were inserted, were measured by an impedance bridge. Following the Yang and Emerson (1997) procedures, conductivity was determined from ΔR, and susceptibility from ΔL. Volumes for the densities were measured by mensuration or by Archimedes' immersion.

Figure 2. *This photograph shows an induction coil of the type used in the measurements. It is 95 mm long x 50 mm internal diameter; the cylindrical housing is 120 mm long. At a particular frequency (below the onset of the skin effect) the change in resistance (ΔR) and in inductance (ΔL) are measured on an impedance bridge when a core is inserted. From these quantities, conductivity (ΔR) and magnetic susceptibility (ΔL) are calculated (see Yang and Emerson, 1997).*

Although the writer has carried out many galvanic measurements on samples from the Broken Hill Block, EM conductivity was the preferred technique in this exercise. The EM measurement is not responsive to insulating minerals, it just 'sees' conductors and induces eddy currents in them; also it is quicker to do. Lab EM favours conductive features normal to the core axis; galvanics, parallel to the core axis. The differences, which do exist for Broken Hill mineralisation, are related to texture and will not be dealt with here (see AMIRA Report P369A).

Galvanic microprobing of sulphides was undertaken by measuring DC ohmic resistance using two electrode needle probes. This gave a qualitative and relative indication of sulphide conductivities. In four electrode measurements, described by Harvey (1928), a Wenner micro-array was set on polished mineragraphic blocks to give quantitative grain resistivity/conductivity values. Such measurements were beyond the scope of this article.

Results

The data cited in Table 1 are categorised into five groups for which conductivities have been plotted against density in

Table 1. Physical properties of some coarse grained semi-massive to massive galena ores

Sample	Plot code	Bulk density (g/cc)	% gal	% sph [marm.]	% s	% gangue	EM cond (S/m)	mag k (SI × 10^{-5})
Very high grade galena								
C1 [RB]	▲	7.56	100	→0	→0	→0	6364	All
C2 [SM]		7.45	99	→0	→0	1	7812	diamagnetic
C3 [RUS]		7.07	90	→0	→0	10	3010	(negative)
Broken Hill lead lode galena with networked pyrrhotite (po) and chalcopyrite (cpy)								
L1 [US79]	◆	4.93	40	→0	5	55	3750	241
Broken Hill lead lode, relatively poor intra and intergrain elec. conductivity, low sph, no po/cpy								
L2 [B Pr]	■	5.40	55	5	→0	40	167	25
L3 [A Pr]		6.43	75	5	→0	20	500	38
Broken Hill lead lode, good intra and intergrain elec. conductivity, low sph, no po/cpy								
L4 [B1]	●	4.61	35	5	→0	60	347	36
L5 [B2b]		4.49	30	5	→0	65	269	43
L6 [B2f]		3.97	20	5	→0	75	135	40
L7 [B3]		6.08	66	2	→0	32	680	37
L8 [B9]		6.21	70	2	→0	28	778	38
L9 [B8]		6.65	80	2	→0	18	842	40
L10 [B7]		5.67	58	2	→0	40	587	41
Broken Hill zinc lode sph and gal, with networked po, cpy								
Z1 [AM10]	+	4.94	35	35	2	28	1700	210
Z2 [AM9]		4.76	25	65	2	8	780	276
Z3 [AM7]		4.37	15	70	≥1	≤14	87	228
Z4 [AM8]		4.18	10	75	≥1	≤14	5	232
Z5 [AM1]		3.87	0	90	≥1	≤9	1	244

Notes:
1. Mineralogy estimated visually under binocular microscope, volume percentages regard as approximate, s = po, cpy.
2. Broken Hill sulphide minerals include: economic targets galena, PbS, 7.5 - 7.6 g/cc, diamag.; 'black jack' sphalerite [marmatite (Zn, Fe)S ≥ 10% Fe content], 4.00 g/cc (varies with Fe), pure sphal is an insulator & diamag. but marmatite is a paramagnetic with mag k ~ 100 x 10^{-5} (varies with Fe). Also accessories: pyrrhotite, Fe_7S_8, 4.6 g/cc which may be both monoclinic, mag k ~ 40 000 x 10^{-5} SI, and hexagonal, mag k ~ 150x10^{-5} SI; and others in trace amounts, such as loellingite, $FeAs_2$, arsenopyrite, FeAsS; tetrahedrite, complex silver sulphide.
3. Broken Hill gangue minerals include: Mn garnet, spessartine, 4.18 g/cc, 680 x 10^{-5} SI, mag k; Mn silicate, rhodonite, 3.69 g/cc, 415 x 10^{-5} SI; quartz 2.65 g/cc, diamagnetic (negative mag k); calcite, 2.72 g/cc, diamag; Zn aluminate, gahnite, 4.55 g/cc, diamag; and others.

Figure 3, to view features and trends in perspective. Magnetic susceptibilities have not been used in a plot as the pyrrhotite is a mix of monoclinic and hexagonal types, and the magnetic susceptibilities of marmatitic sphalerite and some of the gangue minerals, e.g. garnet and rhodonite, are not trivial. Sulphide electrical grain-quality values are given in Table 2: the lower the ohmic resistance, the better the grain quality, singly and in aggregate.

The reference group C of very high grade, very coarse grained, very dense, diamagnetic galenas, have excellent conductivities, ranging from 3010 to 7812 S/m. The conductivities increase with density towards the nominal galena value of 10 000 S/m.

The galena ore L1, with pyrrhotite and chalcopyrite, has a markedly lower density (it has less than half the galena content of group C), but has a conductivity that is comparable with group C.

Samples L2 and L3 were galvanically microprobed to ascertain why the conductivities of those galena-rich samples were only fair, 167 and 500 S/m. The inter- and intra-grain electrical continuities, while extant, were found to be inferior to those of the next group, samples L4 to L9, and so plot beneath them in Figure 3.

In Figure 3, group L4-L9 has a moderate rise in conductivity (135 to 842 S/m) over a wide range of density (3.97 to 6.65 g/cc) as the galena conductivity framework increases in volume. In the writer's experience, these good, but not excellent, conductivities are typical of granular galena in a metamorphic setting. Extrapolated to galena's density it seems that about 1000 S/m could be the limiting conductivity for very massive galena of this type. Galvanic microprobing indicated that electrical continuity of the galena was inferior to group C.

The zinc mineralisation group, Z1 to Z5, with ancillary galena and pyrrhotite, manifests an extraordinary increase in conductivity, 1 to 1700 S/m, over a narrow density range, 3.87 to 4.94 g/cc. This is a consequence of the pyrrhotite and chalcopyrite operating an independent filamentary network through the galena, sphalerite, and gangue grains. While galena without doubt contributes to the conductivity (except for Z5 where it is absent) the conductivity character is dominated by the yellow sulphides, pyrrhotite and chalcopyrite. Galvanic microprobing indicates that their continuity is better than all the others, despite the fine, thready nature of these two sulphides.

Table 2. Sulphide grain relative electrical continuity

Category	Intra-grain (ohms)	Inter-grain (ohms)
C1–C3		
Collector grade galena		
Very coarse grain size	10	15
L1		
Lead lode + yellow sulphide		
Galena	50	200
po/cpy	<1	1
L2, L3		
Lead lode		
Galena	100	300
L4–L10		
Lead lode		
Galena	30	50
Z1–Z5		
Lead lode		
Galena	40	80
po/cpy	2	20

Note: Ohms measured by two electrode needle probes connected to a DC voltage source; intra-grain electrode spacing 1 mm, inter-grain spacing several mm to cm; measurements included contact resistance between probe and sulphide so regard data as qualitative and relative indications of electrical grain quality, only; typical values cited.

Discussion

Galena's conductivity is quite variable. Studies of crystals have shown both *n*-type and *p*-type semi-conduction and conductivities ranging from 1 to 100 000 S/m with *p*-type more resistive than the *n*-type by an order of magnitude (Shuey, 1975, see his histogram fig. 13-1). Considering the available data in the literature, a range of around 1000 to 10 000 S/m for galena crystals seems reasonable.

Aggregates of crystals are a different matter. The cubic crystals' grain boundary characteristics (thin films of other mineral phases, voids, microcracks, cleavage) usually result in aggregated galena

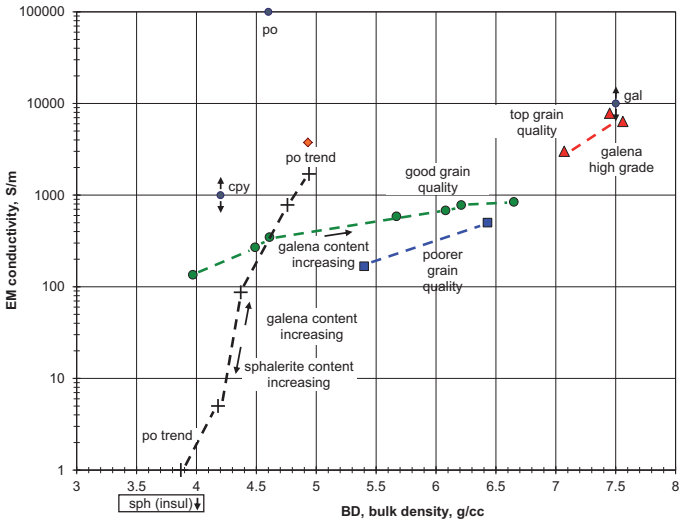

Figure 3. *A plot of electromagnetic (induced) conductivity against density, in the air-dried state, for three types of coarse grained (1 mm +/-) galena ores. Four trends are shown: the very high grade, very dense, very coarse grained samples plot near galena's nominal conductivity value and have excellent conductivity; the galena-dominant lead lode values show fair (at lower density) to good (at higher density) conductivity tending to, by extrapolation, a value of about 1000 S/m at galena's density. Two samples show subdued conductivity as a consequence of poorer galena grain electrical quality and grain continuity. The pyrrhotite trend for the Pb-Zn ore shows very good conductivity as density increases and this is ascribed to pyrrhotite, and perhaps chalcopyrite, electrically pervasive minerals even at low concentrations, significantly boosting any galena framework conductivity or providing a sparse but effective filamentary conduction when galena is low or absent. A high conductivity interpreted from a geophysical survey, in the absence of other data (e.g. gravity), cannot be inferred to indicate high grade galena in Broken Hill type lead-zinc provinces if there is pyhrrhotite about. Reference mineral conductivities plotted on this graph (as blue dots) are approximate.*

having a conductivity diminished by an order of magnitude, or more, below the single crystal values (Parkhomenko, 1967; Shuey, 1975). However, in exceptional conditions, when tectonic stress imparts better suturing of grain contacts, and strain effects cause plastic deformation flowage of galena, the results are good grain linkages and the formation of an effective electrical framework throughout the ore as is the case here for galena volume contents of 20% and above. The 'percolation' threshold for galena in the Broken Hill styles of mineralisation could be of the order of 15%, but this aspect is not pursued here.

In contrast to cubic galena with its blocky habit, monoclinic / hexagonal pyrrhotite and tetragonal chalcopyrite tend to be dendritic and interconnected (Shuey, 1975) forming loops, linears or networks, thus boosting conductivity even in small amounts, as in L1.The very high-grade reference group C galena, with fewer discontinuities, has very good grain conductivity. The grains are very large (5 mm +) and well linked, so these massive materials function, more or less, as electrical continua with excellent mesoscale conductivity tending towards a notional galena value of 10 000 S/m.

The lead mineralisation group, L4 to L9, has galena grains with internally developed cleavage planes but still manifests good grain conductivity and good grain linkages. Conductivity gradually increases with density and could, by extrapolation, peak at around 1000 S/m for 100% galena.

The lead mineralisation group, L2 and L3, has galena grains that are of a quality inferior to the previous group and so these two samples plot below the main galena trend.

The pyrrhotitic lead ore L1 with a galena content of 40%, has a high conductivity of 3750 S/m as a consequence of its excellent network of yellow sulphides. This sample could be compared with L4: 35% galena, no pyrrhotite, 347 S/m.

The zinc mineralisation group (Z1 to Z5) has subordinate or vanishing galena content which does contribute to conduction, but this is minor compared to the contribution from the contained yellow sulphide network. This boosts conductivities from low but finite levels (1 S/m for 90% sphalerite, Z5) through to the very good conductivity at the highest density 4.94 g/cc (1700 S/m, Z1, 35% galena, 35% sphalerite), approaching L1.

It is noted that pyrrhotitic L1 and Z1 to Z5 have magnetic susceptibilities higher (~240 x 10^{-5} SI) than the galena groups L2 to L9 (~40 x 10^{-5} SI) but no analysis has been attempted in the absence of better mineralogical information.

Conclusions

These limited test results for Broken Hill style semi-massive to massive lead mineralisation suggest that, after enduring granulite metamorphism, high grade galena ores, with densities exceeding 6.6 g/cc, can exhibit good conductivities, ≤1000 S/m, as a result of the galena's grain quality factors including grain conductivity, grain suturing, and grain linkages. However, these conductivities can be exceeded in lower grade galena and even sphalerite ore when a small, but electrically very effective, pyrrhotite and chalcopyrite content is networked through the rock.

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Don Emerson is a geophysical consultant specialising in hard rock petrophysics.

How Bernie Milton helped Hugh Rutter with the discovery of Olympic Dam

David Isles
disles@redgatevista.com.au

Introduction

The discovery of Olympic Dam in 1975 was a landmark event for mineral exploration worldwide. The WMC team that made it happen remains on an important pedestal in the annals of economic geology. Douglas Haynes' 2006 recollection of the events, and the various contributions of team members, are probably the most appropriate reading for those who were not in the exploration game at the time. Most of us who were in the game have our own personal 'twists' on the story. I was a very green postgraduate student at Adelaide University when the news broke. It felt like magic.

This note is not an attempt to re-write history. It seeks to reiterate the late Hugh Rutter's astute insights into the government data that lead to the discovery, and to highlight the role played by the South Australian Government – unquestionably through the efforts of the late Bernie Milton (Figure 1).

The importance of imagination

In recent trawling of the (soon to be scrapped) map cabinets at the Southern Geoscience Consultants office, I discovered a hand coloured, 'Andamooka' 1:250 000 scale TMI contour map, and it triggered a recollection of some Hugh Rutter wisdom. Soon after

Figure 1. *Bernie Milton on the road with the South Australian Geological Survey seismic field crew in the 1970s.*

Hugh invited me to join his team of geophysicists at BHP (early 1980) we were discussing issues around contouring of 'under-sampled' data and Hugh offered the example of the Andamooka gravity data. Figure 2 shows the 1971 published gravity map superimposed on that hand-coloured TMI contour map (published in 1965). These were the maps available at the time of WMC's interest in the Stuart Shelf – printed paper maps that cost a few dollars, uncoloured of course (young geophysicists spent Friday afternoons digesting their data by colouring it with their 'Derwents'). The red arrow came with the recently retrieved, archived copy of the gravity map. I think it points to the location of the discovery hole- a later, but important embellishment to the map!

Some critical observations on Figure 2 are that:

- Of the two extreme magnetic highs to the NE and SW of the 'Olympic Dam Anomaly', only the latter has an associated gravity high (this would later be defined as the 'Acropolis' mineralised system).
- The Olympic Dam magnetic anomaly is lower amplitude but appears more discrete. The gravity high associated with it appears as a more extensive linear feature and, based on the existing maps, it would be hard to argue for 'coincidence'.

Hugh Rutter's analysis of both magnetic and gravity 'line compilations' is well described in Haynes (2006). What is not described in Haynes' article is the 'focussed' or perhaps 'biased' way that Hugh re-contoured the gravity data. In Figure 3, I have highlighted and annotated the gravity station locations. Note the single, locally very anomalous station that is essentially coincident with the source of the aeromagnetic anomaly. The vagaries of barometric levelling coupled with the large station spacing, yielded the published map, contoured at 2 milligals and contoured in a firmly objective way (by the late Robin Gerdes). Hugh saw the single, highly anomalous gravity station as a likely indication of coincidence of sources and (as he described to me, verbally I hasten to add) proceeded to re-contour the gravity to give a 'circular' closure over the magnetic anomaly. Hugh's subjective but incisive re-contouring of the ~6 km grid of gravity stations highlighted the coincidence of gravity and magnetic anomalies at Olympic Dam. Without the re-contouring, the area looks decidedly less appealing, especially when compared to the larger area of very strong gravity and magnetic response to the SW. This then, I surmise, was the basis of Hugh's modelling leading to the statement: 'the anomaly at Olympic Dam possibly representing a fossil volcanic centre'.

Hugh also calculated a depth to the gravity source using a profile interpolated from his 'careful re-contouring' of the 6 km gravity stations. The preferred depth was 1150 m, with an alternative model shape at 850 m (Rutter and Esdale, 1985) and a recognition that the coarse station spacing would likely yield overestimates of the depth. The courage and intuition in Hugh's interpretation should not be underestimated, and it was totally in keeping with the courage of the WMC exploration team in vigorously pursuing conceptual targets at (even by today's standards) intimidating depths and 100s of kms from the nearest relevant bedrock exposures.

I have 're-enacted' Hugh's re-contouring of the SA Government gravity using the station locations from the original map and

Bouguer values interpolated from the most recent 'GADDS' data (using the original stations with their barometric heights was a bridge 'far too far'). Figures 4 and 5 show the near circular closure to which Hugh had alluded, and its 'coincidence' with the aeromagnetic anomaly. Note also the judiciously 'non-linear' colour schemes, another trick that 'us oldies' used when coloured pencils reigned and image processors were people in darkrooms with smelly chemicals!

I think these figures speak for themselves. The Olympic Dam anomaly stands out as 'coincident' in gravity and mag, quite localised and likely shallower than neighbouring features, hence its top priority for drilling. Readers are encouraged to source Haynes' account of the overall discovery story and the Rutter and Esdale paper for some further, key geophysical insights.

Perhaps the more important twist to the story relates to the SA Government's decision to cover the state with a ~6 km × 6 km gravity grid rather than the ~10 km × 10 km grid that was initiated by the BMR G&G (the Federal 'Bureau of Mineral Resources, Geology and Geophysics; precursor to AGSO and Geoscience Australia). I have not been successful in tracking down the origins of this decision, but my recollection is that the BMR had a funded program to cover the continent with approximately 10 km × 10 km stations. South Australia would have had to partially, if not wholly, fund the preferred tighter station spacing. The cost impost would have been substantial; 2.5–3 times more gravity stations. Figure 6 shows the 1976 gravity station distribution for Australia. The SA border is largely defined by the denser station coverage!

How did the decision to spend more on tighter gravity coverage affect the Olympic Dam discovery?

If SA had opted for the 'free' BMR coverage then Figure 7 shows that Hugh Rutter would have had very little to work with. I have created this image by forming a 0.1 minute (approx. 10 km) grid and interpolating Bouguer values from the same grid used for the 'Rutter re-enactment'. The Olympic Dam gravity anomaly is gone! The 0.1 minute grid is, I believe, very close to what the BMR crew would have planned for this area – there has been no need to 'tweak' the station positions to de-emphasise the Olympic Dam high. When viewed against the aeromagnetics, it is clear that not even Hugh could have made a case for drilling at OD!

I strongly submit that the SA Government's consistent and determined policy to gather 'its own' geophysical data coverage was an absolutely crucial factor in the discovery.

To whom should we attribute the credit? Clearly management was not only supportive of its geophysical department but was able to successfully draw funds from Treasury for this 'new-fangled' data gathering. My communications with 'old' SA Mines Department operatives, in particular Reg Nelson, Keith Johns and Chris Anderson, leave little doubt that Bernie Milton, who was the most senior geophysicist at the time, drove the decisions to gather higher quality data in locations that suited the State rather than going with the BMR's schedule. Bernie's management team, which included Keith Johns and Lee Parkin, also deserve credit for the State's push to promote exploration by gathering

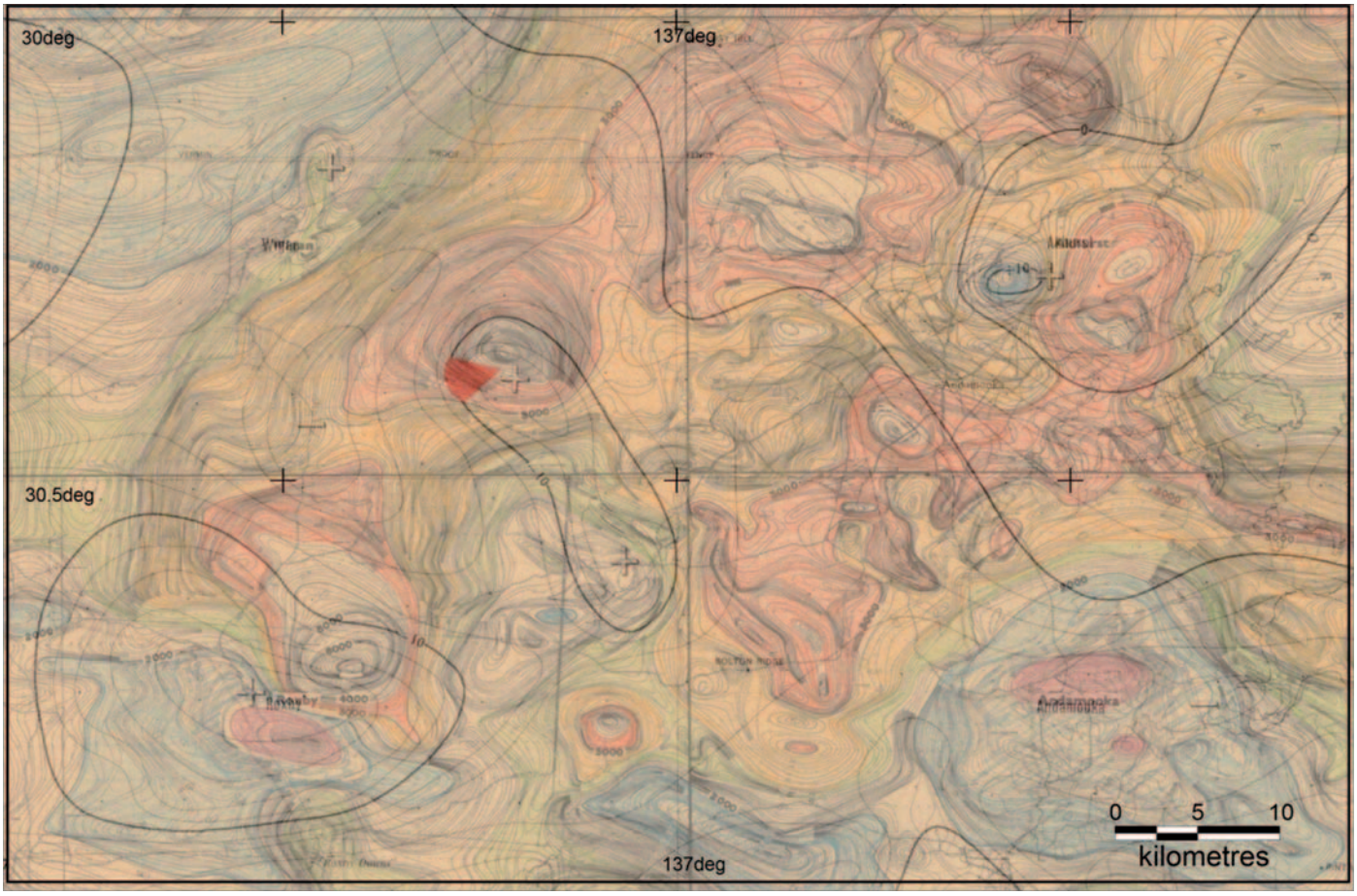


Figure 2. *1971 'Andamooka' SADME Bouguer gravity map superimposed on hand-coloured 1965 BMR/SADME aeromagnetic (TMI) contour map.*

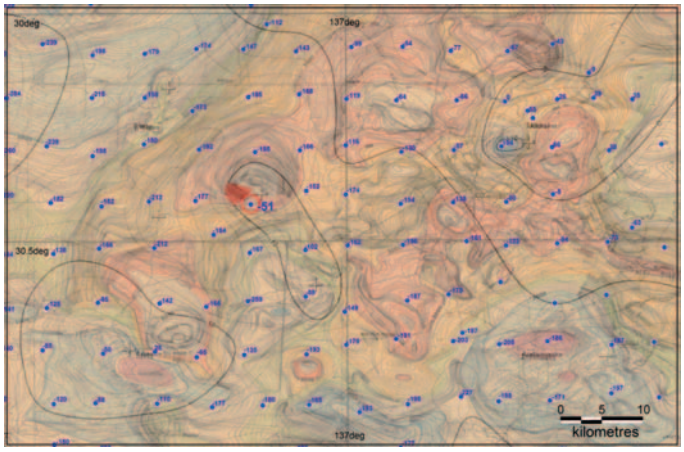


Figure 3. *Figure 2 with the addition of the original gravity station locations and 'modern' Bouguer gravity values.*

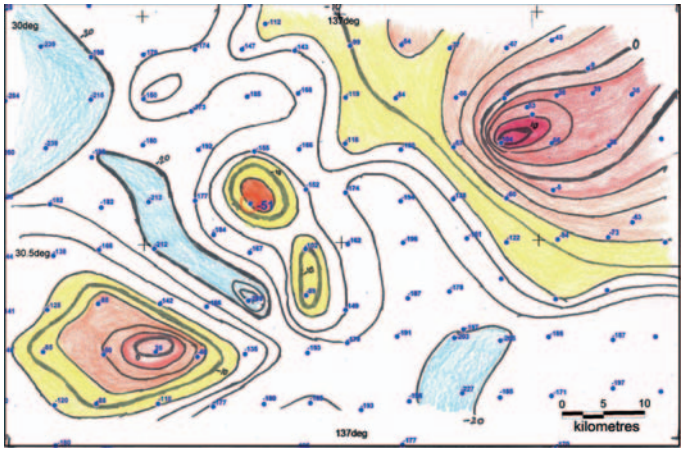


Figure 4. *Bouguer gravity values at the 1971 station location re-contoured by Dave Isles, guided by the aeromagnetic features using the 'Rutter method'.*

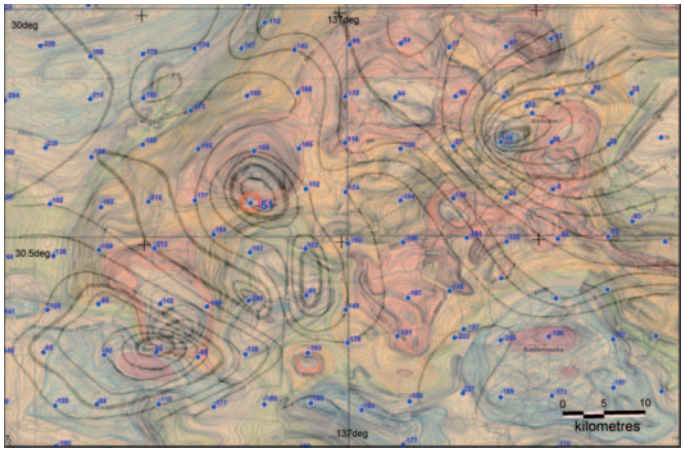


Figure 5. *Re-contoured Bouguer gravity superimposed on the aeromagnetics. Note the 'coincidence' of the Olympic Dam gravity and magnetic anomalies.*

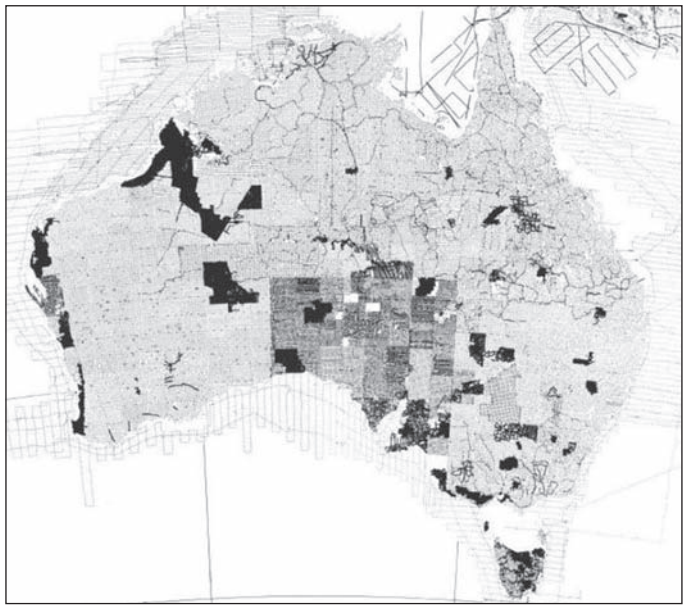
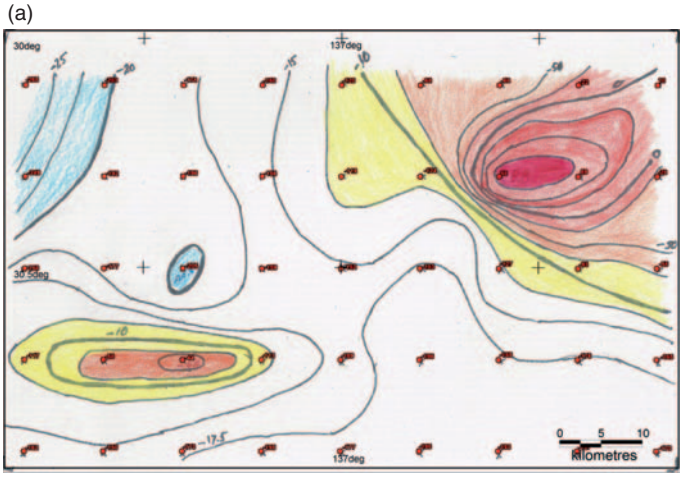


Figure 6. *1976 Australian (BMR) gravity station locations (taken from the first 'complete' Bouguer gravity map of Australia, Anfiloff et al., 1976).*

(a)



(b)

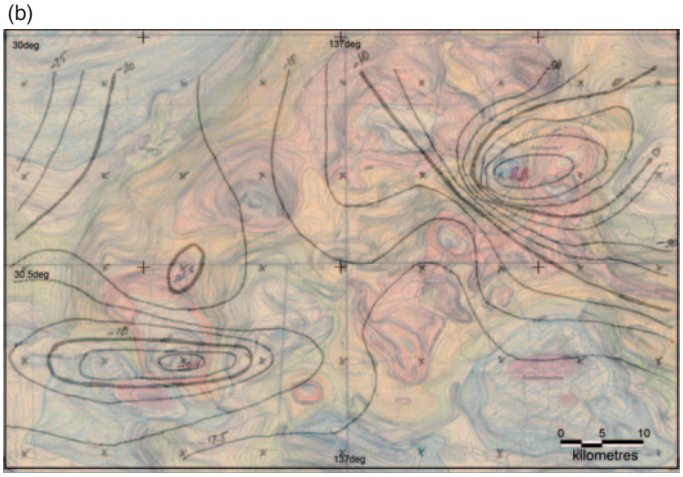


Figure 7. *(a) Simulation of 0.1 minute (~10 km) grid Bouguer gravity map. (b) 0.1 minute (~10 km) based Bouguer gravity map superimposed on a TMI contour map.*

pre-competitive geoscientific data and we should not overlook the forward thinking of Government and Treasury – the then Minister for Development and Mines was the Honourable Don Dunstan!

The book *Above and Below* (O'Neill, 1996) articulates the arm-wrestles between the BMR and the SA Geological Survey for 'mapping rights', highlighting the State Government's support in the 'Playford – Dickinson era' for pre-competitive data acquisition. Not only was Olympic Dam a consequence of this support, but also the oil and gas discoveries in the Cooper Basin. Bernie Milton also played a key role in those discoveries.

Conclusions

The Olympic Dam discovery was made possible by the availability of government gravity and magnetic data. South Australia's pro-active and independent approach to pre-competitive geophysical data collection was a significant drain on Treasury that rapidly reaped almost unimaginable reward, thanks of course, to the talent, determination and strong risk-taking culture of WMC – perhaps a lesson for the risk averse explorers and business analysts who dominate the exploration landscape today.

The easy option for SA would have been to go with BMR's program of ~10 km gravity grid. Bernie Milton, with the support of people like Keith Johns, had the 'fire in the belly', the vision and perhaps the impatience to go it alone and do it their way. The 6 km gravity grid and the fast tracking of aeromagnetic coverage on the Stuart Shelf resulted.

Hugh Rutter's analysis of the gravity should not be understated. If a pessimistic or totally objective or even lazy geophysicist had analysed the SA Government data, the Olympic Dam gravity and magnetic anomalies would have been much lower priority – and possibly never drilled.

The leading role of the Geological Survey of SA in the realm of acquiring and distributing precompetitive geoscientific data, now lauded around the 1990s South Australian Exploration Initiative and the decision to freely distribute data, actually had its beginnings in the 50s and 60s with stunning success. Today, despite the oscillations of the exploration cycle and mood-swings of Government support for Geological Surveys, we see that a visionary and perhaps risk-taking culture continues in South Australia. The SA Department of State Development recently announced the largest detailed airborne mag/rad survey ever flown in Australia – 1.8 million line km – designed to bring forward new world class copper discoveries.

From my personal perspective, a huge vote of thanks to both Hugh and Bernie for those early career lessons!

Acknowledgements

Phil Heath along with current and former SA Geological Survey colleagues; Peter Waring, David Love and Graham Pilkington, did the spade work to dig up the original 1971 SADME gravity map and provided insights into personnel involved with the 1960s/70s gravity program. Chris Anderson, who was hired by Bernie Milton soon after the discovery of OD to tie company gravity surveys on the Stuart Shelf into the National Gravity Network and has successfully continued his association with gravity in the region until very recently, contributed his perspective on that era. Reg Nelson, who worked under Bernie, contributed to the 'pre-OD' gravity and mapping programs and accompanied Bernie on seismic surveys at OD pre and post discovery, provided many insights into SA Geological Survey's exploration-driven culture which resulted in himself, as Chief Geophysicist and then Director of Mineral Development, being one of the main architects of the 1990s 'SAEI' and the subsequent 'PACE' initiatives. Finally and most importantly, thanks to Keith Johns who, as a regional mapping geologist on the Andamooka and Torrens '4 mile' sheets was on board BMR's DC-3 VH-MIN on 28 March 1962 when the aeromag survey tie-lines were flown, then as Bernie's 'boss' supported the independent approach to pre-competitive geophysical data gathering and later, as Director-General of Mines presided over Reg Nelson's successful endeavours to form the model for the SAEI. Keith has also written a book covering broad aspects of the discovery and development of Olympic Dam (Johns, 2010) and provided invaluable input to this article.

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Biography

Dave Isles's first job in geophysics (1971) was hand compiling airborne magnetic and radiometric data from the Narbalek region for Noranda Australia. He is a graduate of Melbourne (1975) and Adelaide (1983) Universities and has worked with BHP Minerals (1980–1987), World Geoscience (1987–1993) and a handful of junior explorer-miners (1993–2016). His involvement with aeromagnetics and gravity has been somewhat obsessive in that time – he has co-presented courses on these methods since 1978 and is co-author of the ASEG e-book on aeromagnetic interpretation. He is currently one of the 'senior' exploration consultants at Southern Geoscience and continues to provide short courses on aeromagnetics and gravity.

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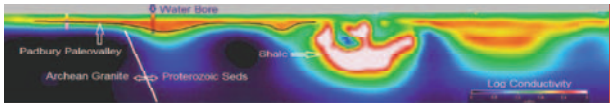

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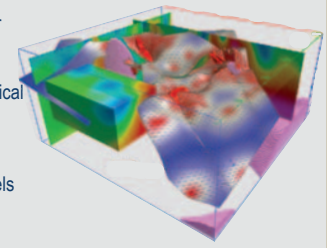

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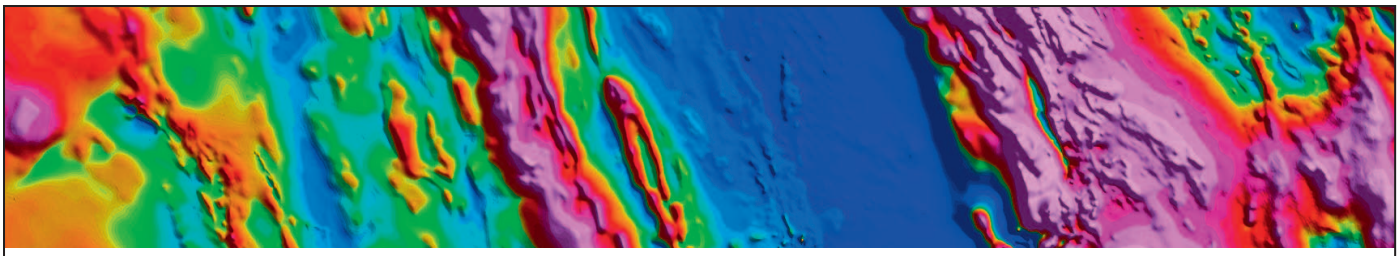

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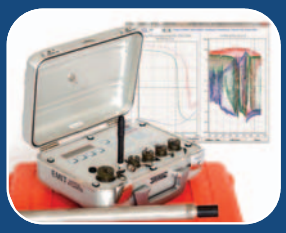

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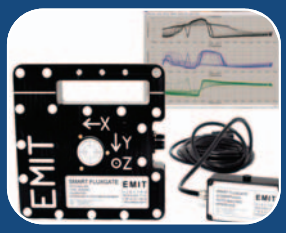

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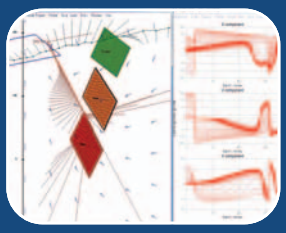

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