Australian Society of
Exploration Geophysicists

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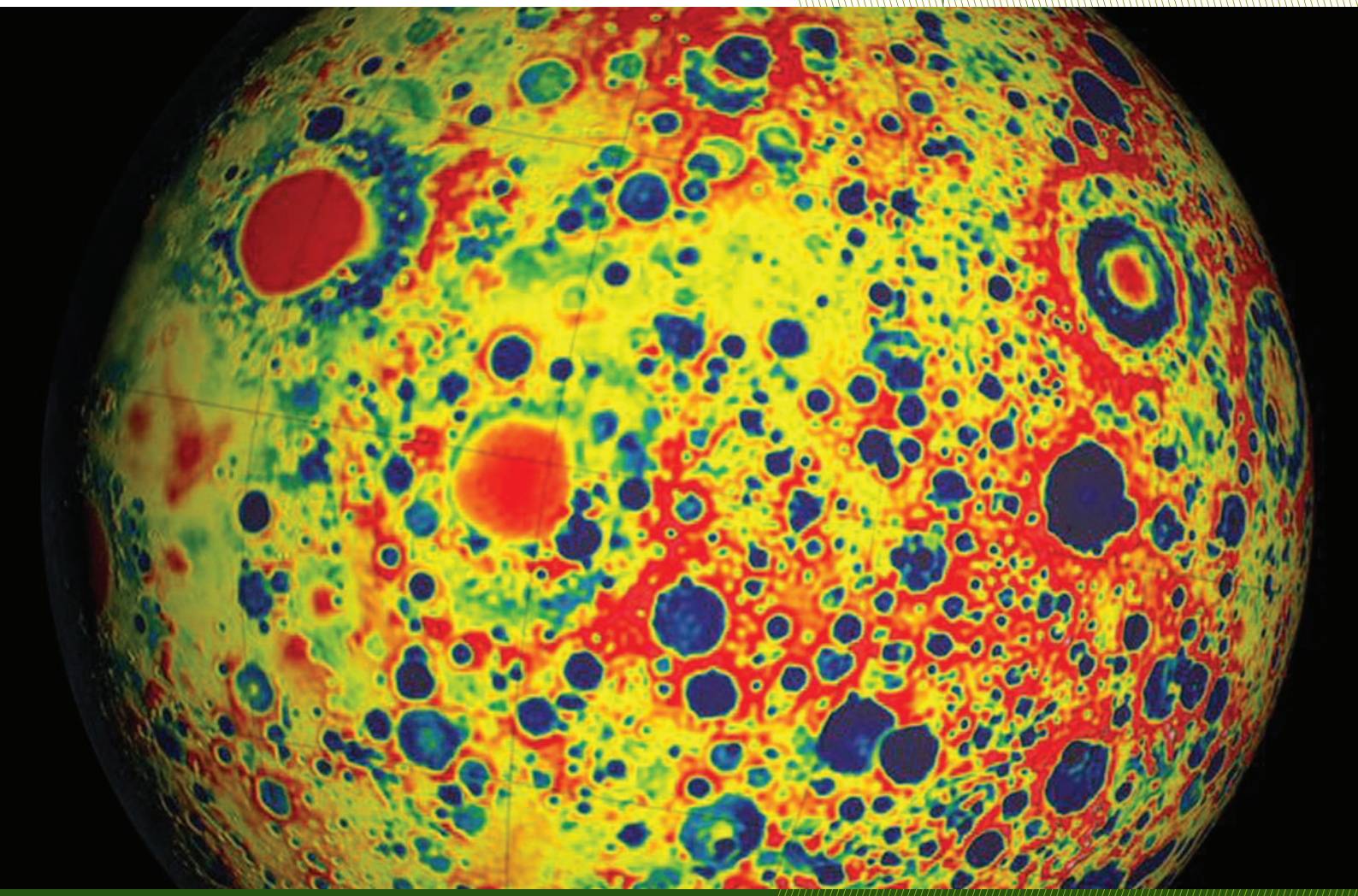
PREVIEW



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FRONT COVER

Gravity globe of the Moon, projected from data collected by the GRAIL mission. Source: NASA.

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Lisa Worrall

This issue of *Preview* features the first order results of the ASEG Members' Questionnaire. The *Preview* team was particularly encouraged by responses to Question One, which indicate that ASEG Members place a high value on access to *Preview*. Over the next couple of months the Federal Executive will consider, and consequently respond, to these results. I look forward to publishing the outcome of their deliberations in *Preview*. This issue also features an article by Jon Clarke on the use of geophysics to explore the solar system. Jon gave a talk on this topic to the ACT ASEG Branch meeting in July and they enjoyed it so much that they suggested he convert the talk into a piece for *Preview*. I was sold when I saw the gravity image of the moon – which is on the front cover.

The issue is also rich with news and commentary. Ken Witherly and John Hart summarise the presentations made to an ASEG PESA 2015 post conference workshop 'Geophysical Signatures of Mineral Systems; More than Bumps' and David Denham summarises the presentations made to an UNCOVER forum at Geoscience Australia. David also gives us the latest news from Canberra, including the latest news on investment in exploration and R&D. The new ASEG Webmaster introduces himself (a thankless task for a 'volunteer' if there ever was one) and explains that he intends to expand the website content, particularly along the lines suggested by Members in their responses to Members' Questionnaire. He is also considering establishing a Members' forum.

The next issue of *Preview* will be a bumper Christmas issue with our annual treat – an article by Don Emerson. Don will be taking a close look at Lapis Lazuli – the most beautiful rock in the world. As a bonus, Roger Henderson has promised an article on a gravity meter built in Sydney in the 1890s which, he is convinced, was the first gravity meter in the world – that should be an interesting read. The Christmas issue will also feature summaries of research carried out by students in geophysics in Australia in 2015. If you are a research student then make sure that a summary of your research, a short bio and photo is submitted to Michael Asten, our Associate Editor Education, by 13 November 2015. The best student photo (you carrying out your research) will be selected for the front cover.

You may need to fortify yourself for the holiday season so take a look at the 2015 ASEG wine offer. Details can be found in this issue of *Preview* or on the ASEG website. Salud!

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

ASEG innovation, deep exploration and the results of the recent Member questionnaire

Last Thursday night (9 September) I had the pleasure of attending WA's Branch Meeting, which was addressed by Tim Hopper from NMR Services. Tim talked about borehole logging and what he had to say was relevant for oil and gas as well as for minerals. I could not hope to summarise Tim's talk here, but I never cease to be amazed at the innovation of ASEG Members. I still hope to make it to at least one meeting of each Branch during my term as ASEG President.

Australia's high profile in mineral discovery is one of the reasons the EAGE (European Association of Geoscientists and Engineers) is keen to involve the ASEG in its meetings. Strategic thinkers in the EAGE have concluded that 'the reliable and secure supply of non-energy raw materials is of growing concern within not only Europe but also worldwide. It is fundamental for our economic growth, improved living style and to develop green technologies. The primary production of raw materials must increase to sustain the increasing demand for several strategic minerals throughout the whole value chain.' The EAGE will be holding a one-day workshop on 'Deep mineral exploration: chasing both land *and sea deposits*' in Münster in Germany on Friday 18 March 2016 (my italics). See: http://www.eage.org/event/?eventid=1398&section=1

The EAGE deliberations reminded me of Ken Witherly's article in the last issue of *Preview* (PV 177) where he draws attention to programmes such as the DETCRC (Deep Exploration Technologies Cooperative Research Centre), the UNCOVER Initiative in Australia and the CMIC (Canada Mining Innovation Council) Footprints in Canada, which are major efforts attempting to deal with the transition to deep exploration. As Ken points out, 'While mining companies don't have to grow, they do, by definition, have to replenish what they mine or they will cease to exist.' The problem we have in Australia is that the DETCRC is strongly focussed on drilling technology at the expense of geophysics and geochemistry and the UNCOVER Initiative has so far failed to generate enough government interest for significant federal funding. I suspect that it will not be long before other geophysical societies also prioritise deep mineral discovery, both on-shore and off-shore. Intersociety collaboration on deep exploration should be encouraged, but it is far from clear who will pay for these research initiatives.

The responses to the recent ASEG Member Questionnaire, which was overseen by Tania Dhu (Chair of State Branches), have been analysed and will be reported and discussed in *Preview* over the next few issues. We had 340 responses from approximately 1000 Members, which means that the findings represent the views of a fair cross-section of our membership. The response to the question about what OzStep courses Members would attend demonstrates how successful this initiative has been. Without pre-empting the reports, and as Kim Frankcombe points out, some of the responses to the open ended question about 'what the Society could do to improve things for you' indicate that some Members are unaware of the services we already offer. Clearly we are failing to communicate with the membership at large. Some examples of these responses include: suggestions for Emeritus membership (we already have the equivalent in 'retired membership'), conference concessions for the unemployed (never refused to my knowledge) and the removal of charges for colour pages in *Exploration Geophysics* (we have always had such for authors of papers from ASEG conferences and workshops and two years ago extended free colour to all authors as we transition to online delivery of *EG*). There also seems to be some misapprehension about the ASEG as a professional organisation vs a learned society. As Kim points out 'we cannot by our Charter represent the professional interests of our Members. To do so would see us fail the test for an organisation promoting science for which we gain tax exempt status. We need to state that case clearly and encourage people to also join the AIG or AusIMM as well as the ASEG for those benefits'. Kim found several other (somewhat surprising/alarming) examples of misunderstanding and/or ASEG's failure to communicate, which I will leave for the report(s) in *Preview*.

On a recent trip to the Kimberley I felt obliged to find a dinosaur footprint near Broome (see photo), being interested in things 'palaeo-'. Because of a series of thefts some years ago the authorities do not encourage visitors to seek them out. Signage emphasises that they are only visible at very low tide and climbing down the jumbled rock mass to the beach is fraught with danger and, anyway, the imitation ones in concrete at the top are just as good (they're not, the ones set in concrete look like the foot was webbed, like some giant duck). Needless to say, right on low tide hordes of visitors appear and clamber over the rocks to the exposed shelf where the foot prints may be found. The signage also states that although the genus of dinosaur is unknown, it could be that of a Late Jurassic North American creature. I assumed they meant similar to, rather than actually coming from, North America.

Photo taken by Greg Baker.

Phil Schmidt
ASEG President
president@aseg.org.au

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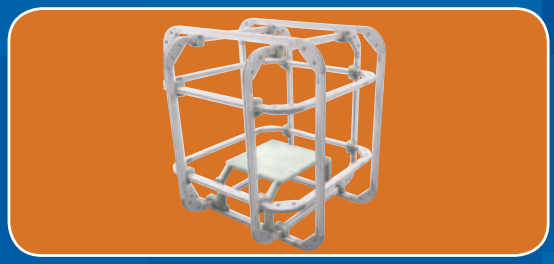

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Welcome to new Members

The ASEG extends a warm welcome to 28 new Members approved by the Federal Executive at its August and September meetings (see table).

First name	Last name	Organisation	State	Country	Membership type
Erick	Adam	Wolf Geophysics Pty Ltd	Quebec	Canada	Active O/S
Julie	Buchanan	Macquarie University	NSW	Australia	Student
Giada	Bufarale	Curtin University	WA	Australia	Student
Anders	Christiansen	Aarhus University		Denmark	Active O/S
James	Cleverly	REFLEX Geochemistry	WA	Australia	Active
Jesse	Cotterill	University of Adelaide	SA	Australia	Student
Raphael	Doutre	University of Western Australia	WA	Australia	Student
Thomas	Dubos		NSW	Australia	Associate
Max	Fry	University of Adelaide	SA	Australia	Student
Tsige	Gebremriam	Axum University		Ethiopia	Student
Tm	Horrocks	University of Western Australia	WA	Australia	Student
Piva	Jonathan	James Cook University	QLD	Australia	Student
Seogi	Kang	University of British Columbia	Vancouver	Canada	Student
William	Kovach	Macquarie University	NSW	Australia	Student
Paul	Larkin		VIC	Australia	Active
Andrew	Lovell	Heathgate Resources	SA	Australia	Associate
Samuel	Macdonald	Golder Associates	ACT	Australia	Active
Michael	McMillan	University of British Columbia	Vancouver	Canada	Student
Hassan	Mohamed	Kyushu University		Japan	Student
Muriel	Naguit	Research School of Earth Sciences	ACT	Australia	Student
Parkash Kumar	Rajasekaran	University of New South Wales	NSW	Australia	Student
David	Ross	Macquarie University	NSW	Australia	Student
Janelle	Simpson	University of Adelaide	QLD	Australia	Student
Leo	Snowman		Texas	USA	Active
Jarrad	Trunfull	Southern Geoscience Consultants	WA	Australia	Active
Patrick	Tutty	Earth Signal Processing Ltd	Alberta	Canada	Active
Kevin	Ung	Curtin University	WA	Australia	Student
Gavin	Ward	Subsurface Team Lead	WA	Australia	Active

The South Australian branches of **AIG**, **ASEG**, **AusIMM**, **GSA**, **SACOME** *and principal supporters* **Department of State Development** *and* **Paydirt** *invite you to the:*

12th SA Exploration and Mining Conference

Friday 11 December 2015

20 PRESENTATIONS
• New companies • Exploration projects
• Feasibility studies • Mining operations

KEYNOTE ADDRESSES
• Opening address (TBA) • DSD Review

WRAP UP
• Q&A session, chaired by Derek Carter

NETWORKING
• Four hours of networking in five sessions

WORKSHOPS
• AIG Roger Taylor – 2-day ***Breccia Workshop, 9–10 Dec***
• Geological Survey of SA – Half-day ***Seismic & MT Workshop, 10 Dec***
• AusIMM/AIG – 1-day ***Monograph 30 Roadshow – Resource and Reserve Estimation, 10 Dec***
• AIG – 1-day ***McLaren Vale Wine Tour, 12 Dec***

ADELAIDE CONVENTION CENTRE
North Tce, Adelaide

• Sessions in Hall L
• Catering breaks and displays in Halls M and N

• Registration 7.30 to 8.30 am
• Conference 8.30 am to 5.00 pm
• Drinks to follow 5.00 to 7.00 pm

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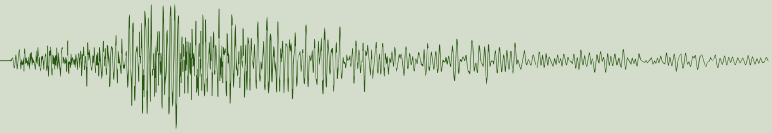
Registration and more information available via website:

www.saexplorers.com.au



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The ASEG Federal Executive signs off on new By Law

The ASEG Federal Executive approved a new By Law to establish Conference Organising Committees at its meeting on 16 July 2015.

By Laws are used frequently by the Federal Executive. They are an interface between the rather more general words in the Constitution and the more detailed administrative arrangements needed to operate a society with over a 1000 members scattered across Australia and around the world. Changes to the Constitution have to be approved by Members of the Society. By Laws can be approved by the Federal Executive but Members can vote to have a By Law overturned. Therefore all Members have to be notified of any new By Laws or changes to existing By Laws, this is done by publication in *Preview*.

The Society's Conferences and Exhibitions are significant events in our calendar. They are a mechanism to bring new science to our Members, provide networking experiences especially through the technical exhibition and social functions, and the conference surpluses give a major boost to the Society's finances. The planning and conduct of each conference and exhibition are oversighted by a Conference Organising Committee (COC) that acts independently (but is overseen by) the Federal Executive and another committee – the Conference Advisory Committee - that is made up of Members with experience in running previous conferences. Our conferences and exhibitions have very large budgets that are managed by the COC. But, a review of our practices revealed that although the delegation of financial powers to each COC was implied in various unofficial documents, financial powers were not explicitly delegated under the terms of our Society's Constitution. The new By Law addresses this issue.

The new By Law is published below for the information of Members. Anyone wishing to challenge this By Law should contact the Honorary Secretary through the ASEG Secretariat, PO Box 576, Crows Nest, NSW 1585. Tel: (02) 9431 8622, Fax: (02) 9431 8677 or directly by email: fedsec@aseg.org.au.

Barry Drummond
Honorary Secretary
fedsec@aseg.org.au

A By Law to establish and disband a Conference Organising Committee (COC)

This By Law is established under the terms and conditions of Clause 8 [FEDERAL EXECUTIVE], Clause 11 [COMMITTEES], Clause 13.3 [BANKING] and Clause 15 [By Laws] of the Constitution of the Australian Society of Exploration Geophysicists (ASEG).

1. Purpose of this By Law

   i. To define how a COC will be established to plan, host and operate all aspects of each International Conference and Exhibition (Conference) of the Society, including how financial powers are delegated from the Federal Executive of the ASEG to the COC.

   ii. Recognising that the ASEG also organises other conferences, workshops and seminars either solely or jointly with other societies, the principles and practices set out in this By Law will also apply to those other events when

      a. the ASEG holds the primary financial accountability for the event, and

      b. a Member of the ASEG is to hold the financial delegation; except that the Federal Executive shall have the discretion of appointing one Chair rather than two Joint-Chairs as set out below in Clause 3.

2. Background

   i. The ASEG conducts an International Conference and Exhibition ('Conference') approximately every 18 months.

   ii. These Conferences are often co-hosted by one or more other professional societies, with the ASEG taking the role as lead host.

   iii. The ASEG will provide written advice to the COC through the provision of a committee charter and a conference handbook which are based on the cumulative knowledge of the ASEG acquired through having organised past meetings, and oral advice from a Conference Advisory Committee (CAC) that the Federal Executive has established or will establish, comprised of members who have been involved in the planning and running of previous Conferences.

3. Appointment of Committee Members

   i. The Federal Executive of the Society will appoint two Joint-Chairs of the COC.

   ii. In the event that the Conference is to be conducted jointly by another society or societies, the ASEG will give consideration to the appointment of Joint-Chairs who represent fairly the interests of all host societies.

   iii. The Joint-Chairs will then appoint the other members of the COC, subject to the right of veto of any appointment by the Federal Executive if the Federal Executive is of the opinion that a member of the COC is or becomes unsuitable and this is not dealt with appropriately by the Joint-Chairs.

4. Make up of a COC

   i. The Joint-Chairs of a COC may appoint members to perform any tasks they think appropriate.

   ii. Notwithstanding the discretion allowed to the Joint-Chairs by 4(i), the Joint-Chairs will appoint a Treasurer for Conference to the COC.

   iii. The COC may establish sub-committees to assist in the planning and conduct of the Conference.

   iv. The COC may engage the services of a Professional Conference Organiser (PCO) to assist it with the planning and conduct of the Conference.

5. Financial Arrangements:

   i. The Federal Executive of the ASEG will provide a Charter Letter of the form set out in Attachment A to this By Law to the Joint-Chairs of the COC delegating financial powers to the Joint-Chairs and the Treasurer[1] under the terms and conditions allowed by the Constitution of the ASEG.

   ii. Under Clause 8.12 of the ASEG Constitution no member of the COC including the Joint-Chairs and the Treasurer has the power to further delegate their financial powers to any other person.

      a. Where the Joint-Chairs or Treasurer require financial powers delegated to another person, that delegation must be done directly by a Director of the ASEG.

      b. The delegation of financial powers to a PCO will be done through specific clauses included in a contract signed by a Director of the ASEG and the PCO.

   iii. The Treasurer of the COC will prepare a budget for the Conference and the COC will monitor the performance of the planning and conduct of the Conference against that budget.

   iv. After the Conference, the Federal Executive will appoint independent auditors to review the accounts for the Conference.

   v. After all financial matters have been dealt with by the COC, including any raised by the independent auditors,

      a. if the conference has returned a surplus, any surplus funds will be transferred to the accounts of the ASEG and other societies which are co-hosts for the Conference in the proportions

[1] Note: Each Joint Chairs will receive and be named in a Charter Letter. In contrast the delegation to the Treasurer is to the position of Treasurer. The Treasurer is appointed by the Joint-Chairs, who obviously cannot make the appointment until they themselves are appointed through their Charter Letters. The Federal Executive in effect has a veto over the appointment of someone as Treasurer to whom the Federal Executive does not wish to delegate financial powers [Clause 3(iii)].

agreed at the beginning of conference planning, or

b. if the conference has made a loss, then the COC will negotiate with the Federal Executive and representatives of the other societies which are co-hosts for the Conference to determine how the loss will be apportioned to each of the hosting societies.

vi. All conference accounts will then be closed.

6. Winding up the COC

i. The Federal Executive will consider the COC to have been wound up when

a. the conference has been held, and

b. all accounts for the Conference have been settled and audited, and

c. any surplus funds transferred to the ASEG and co-host societies or losses funded, and

d. the COC has delivered a final conference report to the Federal Executive, and

e. the contract with the PCO has been terminated, at which time its financial delegations will be withdrawn.

ii. The financial delegations to the COC will cease when the activities at 6(i) (a-e) have been completed.

This By Law was approved by the Federal Executive on 16 July 2015

ATTACHMENT A

ON ASEG Letter Head Paper

Legal Address of the Society

To Go Here

Dear [Name of Joint-Chair]

Charter Letter to Appoint Joint-Chair of the Conference Organising Committee

For [Name of Conference]

Through this Charter Letter and with the endorsement of the Federal Executive of the Australian Society of Exploration Geophysicists I am pleased to appoint you as Joint-Chair of the Conference Organising Committee (COC) for the [NAME OF CONFERENCE] ('Conference').

A similar letter will be sent to your other Joint-Chair, [Name of Other Joint Chair].

I now ask you and [Name of Other Joint Chair] to formally appoint the rest of your Conference Organising Committee, including a Treasurer to manage the financial matters of the Conference.

Under the Terms of Clause 8 of the ASEG's Constitution, the Federal Executive delegates its financial powers to you and to [Name of Other Joint Chair]. These financial powers are also delegated to the position of Treasurer of the COC. Because of the financial responsibilities of the position of Treasurer, his or her appointment will require endorsement by the Federal Executive.

You do not have the authority to delegate those financial powers further to any other person whether a member of the COC or not, or to a Professional Conference Organiser. Should you wish other people to have a financial delegation you must ask the Federal Executive to provide that delegation directly to them.

This letter is sent to you under the terms set out in the ASEG's By Law governing the establishment of Conference Organising Committees. You must use that By Law and the ASEG's Constitution as the governing documents for your Conference Organising Committee.

Your appointment as Joint-Chair, the financial delegation and the existence of the Conference Organising Committee will cease when the terms set out in Clause 6 of the By Law have been met.

Let me take this opportunity to thank you for taking on this role.

Yours sincerely,

[Name of President or Delegate]

ASEG President

Date

First call for nominations for the 2016 ASEG Honours and Awards

To be presented at:

ASEG-PESA 2016: 25th Geophysical Conference & Exhibition, 21–24 August 2016 – Adelaide, South Australia.

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

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

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

For further information and submission of nominations, please contact:

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

ASEG Branch News

Australian Capital Territory

August saw great minds unite at the Spanish Club for the annual Geo-Society Quiz Night. ASEG members fielded two tables – 'The Dirty Ores' and 'Magnetic Storm'. Magnetic Storm struggled to find their flare but showed consistency, trailing in last place after every round. The Dirty Ores, on the other hand, struck gold early and continued to expand their lead, taking out first place. The questions were a great balance of the interesting and scientific with a favourite round being 'Geoscientist or Mass Murderer?' (some images are attached for you to try). The ACT Branch would like to thank the team that put the night together. The team, which was led by **Millicent Crowe** (ASEG), included **Sarah Marshall** (IAH rep), **Col McInnes** (AusIMM rep), **Claire Orlov** (PESA rep), **Phil Main**, **Neil Symington**, **Sarah Buckerfield** and our MC's for the night, Dr **Chris Folkes** and **Adam Bailey**. We look forward to seeing more people at the event next year.

Images from the ACT Geo-Societies Quiz-night for the Round 'Geoscientist or Mass Murderer?'.

Answers

1. Alice Wilson – Geoscientist
2. Dr Harold Shipman – Mass Murderer
3. Rosemary West – Mass Murderer
4. Douglas Mawson – Geoscientist

Geoscience Australia (GA) celebrated National Science Week by welcoming the community to its annual Open Day on Sunday 23 August 2015. The ASEG has around 40 Members who work at or have been associated with GA and many volunteered at this event. Interactive and innovative geoscience displays kept visitors busily engaged with Geoscience Australia's work across the six Strategic Priorities. Visitors found out how earthquakes are detected, chatted with geoscientists, learnt how a dancing robot can help make Australia's GPS system more accurate, discovered a dazzling array of mineral specimens and explored a wide variety of geoscience career options. We appreciated the opportunity to engage with the community and young scientists as well as to catch up with ASEG Members who travelled from other states for this event.

Open Day at Geoscience Australia: Exploring undercover.

Open Day at Geoscience Australia: Mineral identification.

Dr **Josef Holzschuh** repeated his Near Surface SEG talk, which he presented in Hawaii in September, for ASEG ACT Branch Members. The talk was titled 'Extracting near surface information from complex regional seismic data with thick limestone and sand dunes at the near surface'. Josef talked about how near surface information can be obtained from regional seismic data highlighting the weathering and layering properties, as well as dipping bedrock structures. In his case study he showed how hard limestone layers overlying soft sediments in the near surface make complex refracted arrivals and refraction statics which are

difficult to define. Josef also spoke about very large surface sand dunes (over 10 m high) causing significant time delays for reflected data. He commented that refraction statics were essential prior to further reflection processing. You will all know Josef from the front cover of the last edition of *Preview* – climbing out of a lava tube! He also featured in the Hula Dancing photo – practicing his seismic moves.

Dr Josef Holzschuh presenting his Hawaiian Near Surface SEG talk at Geoscience Australia.

Phillip Wynne presented a talk on the Australian Fundamental Gravity Network (AFGN) to the ACT Branch. The AFGN is a set of permanently marked and documented stations providing the datum for gravity surveys conducted throughout Australia. Geoscience Australia is the custodian of this network and collaborates with the states and territories to maintain it. Phil spoke about the most recent field campaign, which checked existing stations, replaced old stations, and established some new stations in locations readily accessible to users of gravity data. Phil has been with Geoscience Australia and working with gravity for over 20 years.

By the time this edition of *Preview* hits the streets we will have also run two OzStep courses, the **David Lumley** reservoir monitoring OZSTEP course on 12 October at Geoscience Australia and the **Bob Musgrave** potential fields OZSTEP course on 19 of October, also at Geoscience Australia. We are also gearing up for visiting lecturers towards the end of the year with **Alessandro Ferretti** presenting on 'Satellite InSAR data: reservoir monitoring from space' on 25 November and **Hansruedi Maurer** presenting on 'The curse of dimensionality in exploring the subsurface' on the 9 December, both lectures will be held at Geoscience Australia.

AFGN 2015 A-10 recording at Mt Nelson.

AFGN 2015 trip.

Keep the date free – 20 November - for the ACT Branch Christmas Event with our very own **Ted Lilley** talking about MT and the history of geophysics!

For more information about any of these events please email **Marina Costelloe** at actpresident@aseg.org.au or see the ASEG website.

Marina Costelloe
(ACT Branch President)

New South Wales

In July, we held our annual dinner. Once again, it was held in a steakhouse; we ate lots of steak, drank lots of red, and discussed lots of geophysical and non-geophysical topics. We had a good turnout and a great time was had by all.

In August, **John Triantafilis** from the University of NSW gave a presentation entitled 'Digital mapping to measure, monitor and map soil and hydrological properties in 2D and 3D'. John spoke about how he uses EM techniques to study the spatial variation of soil properties. John discussed generating 2D and 3D models of the calculated electrical conductivity at any given depth. John looked at examples of his research from an irrigated agricultural field in an extensive Quaternary alluvial clay plain northwest of Moree in NSW, to a pivot-irrigated field growing Lucerne in San Jacinto, USA.

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

Mark Lackie
(NSW Branch President)

Queensland

The Queensland ASEG/PESA Branches' Annual Trivia night held in August was a great success with the alcoholic spirits identification round being the most popular among our Branch Members! **Emma Brand's** talk 'From UQ to the US and back: a story of one UQ grad's international adventures' also held in August was equally a great success. The meeting had over 40 attendees, this year's biggest attendance at a local Branch meeting.

Emma Brand being thanked for her presentation to the QLD Branch.

September brings **Noll Moriarty** presenting his talk 'Predicting timing of commodity prices booms & busts: a scientific approach'. This talk is sure to bring a crowd of interest given the current climate in the industry.

Queensland will also host three OzSTEP courses in the following months. The first is **David Lumley**'s course on 14 October which will focus on reservoir monitoring and 4D seismic. **Bob Musgrave** will host a course on potential fields on 30 October and **Brian Russell** will give his course on concepts in AVO and inversion on 4 November. Local Branch meetings will also be attended by OzSTEP presenters while they are in Brisbane. Queensland has kept Member's prices for these OzSTEP courses low in an attempt to encourage attendance. Non-members can sign up for full 2016 ASEG membership and receive the Member's rate on all workshops.

Megan Nightingale
(QLD Branch Secretary)

South Australia & Northern Territory

In early August the South Australia and Northern Territory Branch of the ASEG hosted **Duncan Cogswell** from Borehole Wireline for our monthly technical evening at the Coopers Alehouse. Duncan's talk 'Geophysical logging – understanding the measurement' was a fantastic overview of the versatility of geophysical logging (adopted primarily from wireline logging in the oil and gas industry) when used in the mining, groundwater, geotechnical and environmental fields. Duncan also discussed the various measurement types, specific applications and interpretation of the results. The event had a great turnout and was well received by all in attendance.

The annual wine tasting was held in late August at the Public Schools Club. As always it was a great hit with all who attended. Two worthy winners were chosen after much tough deliberation, a testament to the strength, diversity and quality of South Australia's not so well-known wineries. Details of the winning wines, as well as the order forms, are available in this issue of *Preview*. If you are interested in attending the wine tasting there are three easy ways to get an invitation – join the SA/NT committee, sponsor our local state branch or give a presentation at one of our technical evenings!

Our next technical evening will be our annual Industry Night, 22 September starting at 5:30 pm at the Coopers Alehouse, which will include presentations from some of our sponsors from 6:15 pm. Other events include the upcoming OzSTEP courses, with '4D reservoir monitoring' presented by Prof **David Lumley** on 16 October and 'Potential Fields: a (re)introduction for geophysicists and geologists' presented by **Bob Musgrave** on 28 October. Both courses will be held in the Balcony Room at the Hotel Richmond, more information and bookings under the events tab @ https://aseg.org.au/. We will also be hosting the SEG Near Surface honorary lecturer Dr **Hansruedi Maurer** on 19 November.

As ever, without the generous support from our sponsors we would not be able to hold so many great technical events. This year thanks go to Beach Energy, the Department of State Development, Geokinetics, Minotaur Exploration, Petrosys, Santos, Schlumberger, Borehole Wireline and Zonge.

Finally, new Members and other interested persons are always welcome to local events and we are always on the lookout for people interested in giving a technical presentation for the local Branch membership. For further details on events or if you wish to present, please contact Josh at Joshua.Sage@beachenergy.com.au or Michael at mdello@hotmail.com.

Josh Sage
(SA/NT Branch President)

Tasmania

The Tasmania Branch is hosting **Bob Musgrave**'s OzSTEP course 'Potential fields: a (re)introduction for geophysicists and geologists' on 15 October in the CODES Conference Room at the University of Tasmania, Sandy Bay. Details of this one-day course, covering physical properties, data presentation, filtering and inversion can found in this edition of *Preview*.

Tasmania will be squeezing Bob pretty dry as later that same evening (15 October) he has kindly agreed to back up to address a joint meeting of the ASEG and Geological Society of Australia on 'What can geophysics tell us about the mobile phase of the Lachlan Orogen?' This will get under way from 6 pm in the UTas School of Earth Sciences lecture theatre, preceded by drinks and nibbles at 5:30 pm.

30 November will see the Tasmania branch hosting the SEG 2015 Near Surface Honorary Lecturer, Dr **Hansruedi Maurer** of ETH Zurich, on 'The curse of dimensionality in exploring the subsurface, illustrated by several examples from near-surface geophysics including 3D tomographic inversions.' This lecture will be held at noon in the CODES conference room.

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. Contact Mark Duffett taspresident@aseg.org.au for further details.

Mark Duffett
(Tasmanian Branch President)

Victoria

It was a busy winter in Melbourne.

On 22 July the well-attended technical luncheon at the Kelvin Club with **Jon Keall**, Chief Geoscientist at FAR Ltd, was a great success. Jon presented 'The world's largest oil discovery for 2014: What does it look like and how did we get there?' outlining the recent discoveries by FAR in offshore Senegal. It is always interesting to hear a success story! On Wednesday 12 August it was again time to network with the local geoscience and exploration community at the joint PESA-ASEG-SPE Mid-Winter Social at the Duke of Wellington Hotel. Finally, on Thursday 3 September, the ASEG Victoria Branch hosted a technical meeting at the Kelvin Club with **Andrew Button**, Caistor Geoscience, presenting

on 'Empirical geologic-geophysical search model for bulk mineable platinum-palladium-base metal deposits of the Platreef type'.

This spring promises to be even busier.

On Wednesday 7 October the ASEG Victoria Branch will host a technical evening meeting at the Kelvin Club with **Bill Lodwick**, Fletchwick International, recently returned from Malaysia. The title of Bill's talk is 'Geophysicists, petrophysicists, seismic data and well logs'. The meeting will be starting at 6 pm (drinks and nibbles) for a 6:30 pm presentation.

On Friday 9 October we will be hosting the all-day OzSTEP course on '4D reservoir monitoring' presented by **David Lumley** from the University of Western Australia. Registrations are open via the ASEG Events web-page.

On Tuesday 13 October we will be hosting the all-day OzSTEP course on 'Potential fields: a (re)introduction for geophysicists and geologists' presented by **Bob Musgrave** from the Geological Survey of New South Wales.

On Thursday 29 October it is time for the ASEG Victoria Branch 'Annual Student Night', where honours and graduate students from Melbourne's top geoscience education institutions will present their research results and compete for generous prizes. The meeting will be held at the Kelvin Club, starting at 6 pm (drinks and nibbles) for a 6:30 pm presentation.

Let me remind you all of the second annual 'Victorian Geoscience R&D Forum' to be held on 4 November at the KPMG offices in 147 Collins Street in Melbourne's CBD. The event is organised by the Victoria PESA branch, which extends an invitation to all interested ASEG Members. The event is generously sponsored by KPMG and will be free for all attendees.

On Friday 6 November we will be hosting the all-day OzSTEP course in 'AVO and inversion methods in exploration seismology' by **Brian Russell**, Hampson-Russell/CGG.

Make a big mark in your calendars for the Annual Joint PESA-ASEG-SPE Christmas Luncheon on Wednesday 9 December – as always, there will be an interesting talk from one of the remote coal faces of exploration (TBA), along with games, quizzes, excellent food and drink and even better company!

On Thursday 10 December the ASEG Victoria Branch will host a technical meeting with Dr **Hansruedi Maurer**, ETH Zürich and SEG Honorary Lecturer, presenting 'The curse of dimensionality in exploring the subsurface'. The meeting will be held at the Kelvin Club, starting at 6 pm (drinks and nibbles) for a 6:30 pm presentation.

Pre-meeting registration for any of the upcoming events is mandatory, and can be made via the ASEG Events web-page. We look forward to seeing many ASEG Victoria Branch members at the meetings in the coming months.

Asbjorn Norlund Christensen
(Victorian Branch President)

Western Australia

The WA Branch held two technical sessions in July and August. **Andrew Long** (Petroleum Geo-Services) presented on 'Imaging and characterizing the earth using seismic multiples' in July and **Barry Bourne** (Terra Resources) presented on 'The geophysical response of intrusion related gold with an example from Okvau, Cambodia' in August.

The WA Branch Committee also successfully experimented with phone conferencing at its August monthly meeting.

Three OzStep courses will be held in October and November in WA. These are: 'Potential fields: a (re)introduction for geophysicists and geologists' **Bob Musgrave** (26 October), '4D Reservoir Monitoring' **David Lumley** (30 October) and 'AVO and inversion methods in exploration seismology' **Brian Russell** (2 November). Registration opened in August, with ASEG Members pricing from $220 for the one day courses and reduced rates available for student members.

Geophysics students from the University of Western Australia and Curtin University have been invited to apply for ASEG Student Awards. The applications closed at the end of September and the awards will be presented at the October Technical Meeting.

Prue Leeming
(WA Branch Preview *correspondent)*

ASEG calendar: technical meetings, courses and events

Date	Branch	Event	Presenter	Time	Venue
2015					
7 Oct	VIC	Technical night: Geophysicists, petrophysicists, seismic data and well logs	Bill Lodwick	1800–2000	The Kelvin Club, 14–30 Melbourne Place (off Russell Street), Melbourne
7 Oct	NSW	OzSTEP: 4D reservoir monitoring	Prof David Lumley, UWA	0900–1700	Rugby Club, off 31 Pitt Street Sydney
9 Oct	VIC	OzSTEP: 4D reservoir monitoring	Prof David Lumley, UWA	0900–1700	5 on 505, Level 5, 505 Little Collins Street, Melbourne
12 Oct	ACT	OzSTEP: 4D reservoir monitoring	Prof David Lumley, UWA	0900–1700	Geoscience Australia, Symonston
13 Oct	VIC	OzSTEP: Potential fields: a (re)introduction for geophysicists and geologists	Bob Musgrave	0900–1700	5 on 505, Level 5, 505 Little Collins Street, Melbourne
14 Oct	QLD	OzSTEP: 4D reservoir monitoring	Prof David Lumley, UWA	0900–1700	TBA
14 Oct	WA	Technical Night	TBA	1730–1900	City West, Function Centre, Perth
15 Oct	TAS	OzSTEP: Potential fields: a (re)introduction for geophysicists and geologists	Bob Musgrave	0900–1700	CODES Conference Room, University of Tasmania, Sandy Bay
15 Oct	TAS	Joint ASEG/GSA meeting: What can geophysics tell us about the mobile phase of the Lachlan Orogen?	Bob Musgrave	1730–1900	School of Earth Sciences, University of Tasmania, Sandy Bay
16 Oct	SA/NT	OzSTEP: 4D reservoir monitoring	Prof David Lumley, UWA	0900–1700	Balcony Room, Hotel Richmond
19 Oct	ACT	OzSTEP: Potential fields: a (re)introduction for geophysicists and geologists	Bob Musgrave	0900–1700	Geoscience Australia, Symonston
21 Oct	NSW	OzSTEP: Potential fields: a (re)introduction for geophysicists and geologists	Bob Musgrave	0900–1700	Rugby Club, off 31 Pitt Street Sydney
26 Oct	WA	OzSTEP: Potential fields: a (re)introduction for geophysicists and geologists	Bob Musgrave	0900–1700	TBA
28 Oct	SA/NT	OzSTEP: Potential fields: a (re)introduction for geophysicists and geologists	Bob Musgrave	0900–1700	Balcony Room, Hotel Richmond
29 Oct	VIC	Annual Student Night	Honours and Graduate students	1800–2000	The Kelvin Club 14–30 Melbourne Place (off Russell Street), Melbourne
30 Oct	QLD	OzSTEP: Potential fields: a (re)introduction for geophysicists and geologists	Bob Musgrave	0900–1700	TBA
30 Oct	WA	OzSTEP: 4D reservoir monitoring	Prof David Lumley, UWA	0900–1700	TBA
2 Nov	WA	OzSTEP: AVO and inversion methods in exploration seismology	Brian Russell	0900–1700	TBA
4 Nov	QLD	OzSTEP: AVO and inversion methods in exploration seismology	Brian Russell	0900–1700	TBA
4 Nov	VIC	Victorian Geoscience R&D Forum	Various	1300–1700	KPMG offices, 147 Collins Street, Melbourne
6 Nov	VIC	OzSTEP: AVO and inversion methods in exploration seismology	Brian Russell	0900–1700	5 on 505, Level 5, 505 Little Collins Street, Melbourne
6 Nov	WA	ASEG-PESA Golf Day	ASEG/PESA	TBA	Joondalup Golf Course
11 Nov	WA	Technical Night	Student presentations	1730–1930	City West, Function Centre, Perth
18 Nov	WA	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	City West, Function Centre, Perth
19 Nov	SA/NT	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	TBA
20 Nov	WA	EAGE (EET9) workshop: satellite InSAR data: reservoir monitoring from space	Alessandro Ferretti	0900–1700	CSIRO, Perth
20 Nov	ACT	Christmas Event: MT and the history of geophysics	Ted Lilley	TBA	TBA
23 Nov	QLD	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	TBA
24 Nov	WA	AGM and Christmas party		1730 till late	TBA
25 Nov	ACT	EAGE (EET9) workshop: satellite InSAR data: reservoir monitoring from space	Alessandro Ferretti	0900–1700	Geoscience Australia, Symonston
30 Nov	TAS	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	1200	CODES Conference Room, University of Tasmania, Sandy Bay
9 Dec	VIC	Annual joint PESA-ASEG-SPE Christmas luncheon	TBA	1200–1700	TBA
9 Dec	ACT	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	Geoscience Australia, Symonston
10 Dec	VIC	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	1800–2000	The Kelvin Club, 14–30 Melbourne Place (off Russell Street), Melbourne
11 Dec	SA	SA Exploration and Mining Conference	Various	0830–1700	Adelaide Convention Centre, North Terrace, Adelaide

TBA, to be advised (please contact your state branch secretary for more information).

Nominations open for EAGE Awards in 2016

The European Association of Geoscientists and Engineers is asking if you know an exceptional geoscientist or engineer.

The EAGE believes that an important and integral part of the role of a professional association is to recognize and honour the scientific advances and achievements made by its Members. Consequently, EAGE presents a number of awards each year for highly significant contributions to a particular scientific discipline, to the Association, or to both. Winners of these awards are nominated by their colleagues.

As the greatest achievements are not limited to those by EAGE Members, this year the nominations for the prestigious Desiderius Erasmus award, like the best paper awards, will be open to any geoscientist or engineer in recognition of his/her outstanding and lasting achievements in the field of resource exploration and development. The EAGE is hoping to attract nominations from around the world and, in particular, is hoping that someone in the Australian geoscience community will be nominated for the Erasmus, Honorary Membership, Schlumberger and Wegener or Van Weelden Award. If you have a colleague whom you would like to nominate for one of these Awards, these are the steps to follow:

From 1 July until 31 October 2015 you can find the nomination form on the EAGE website (http://www.eage.org/). After nominating someone you will be contacted to provide the following additional information to complete the nomination package:

- The nominee's CV and list of publications;
- An extended version of your citation that summarises the individual's achievements and details why this person deserves that EAGE Award. It is particularly important to describe how the candidate's work has made a significant difference to our society or science;
- At least one citation by technically qualified people who know the nominee and his/her work. In order to allow appropriate consideration for this year's awards the Awards Committee must receive completed nomination packages for the Vienna cycle by 31 October 2015. After this deadline, nominations will be considered for the following cycle but you don't need to wait for the deadline to make a nomination, so feel free to nominate at any time throughout the year.

More than bumps: ASEG-PESA 2015 post conference workshop summary

Ken Witherly, Condor Consulting, Inc.,
ken@condorconsult.com

John Hart, Rio Tinto,
John.Hart@riotinto.com

As part of ASEG-PESA's 24th International Geophysical Conference and Exhibition, a workshop on the geophysical signatures of mineral systems was organised for 19 February, the day immediately following the main convention. The title of the session was 'Geophysical signatures of mineral systems; more than bumps'. The purpose of the 'Bumps' workshop was to examine how prepared the industry is for the transition from searching for deposits generally outcropping or under shallow cover, to environments where the cover is more extensive and geologically complex. Traditionally, geophysics has been primarily used to define singular targets (aka bumps), which were thought to represent potential deposits. Such targets were often shallow, so drill testing was simple and inexpensive and, in addition, such targets could often be further qualified with either geological mapping or basic geochemical approaches. Going forward, recognisable responses directly associated with deposits are deemed far less likely and the expectation is that geophysics will be called upon to map some aspect of a deposit's overall mineral system and, once established, a variety of approaches will be required to then 'vector in' to the economic part of the deposit. The overall economic success of the effort will be much more dependent on how well integrated geophysical technology is with other technologies as well as the financial, commercial and even societal aspects of exploration process.

Back story: the mineral system

Once the theory of continental drift was in place mid-last century, economic geologists could begin to model the earth's crust over time and understand that, in many settings, ore deposits were continually being formed and consumed. This also allowed them to predict where the geological column was more likely to host deposits at depth and quite possibly show little or no surficial expression due to the thickness or nature of the cover material. To be able to search for deposits in such environments required new approaches and the concept of a mineral systems approach, first suggested 20 years ago by Wyborn et al. (1994), has emerged as a powerful means to build strategies and define the required capabilities going forward. Wyborn et al. (1994), after having examined targeting strategies for oil and gas, developed what could be considered a minerals analogue. Central to this approach in the search for oil and gas is the fairway; a pathway or corridor where there is a greater likelihood of accumulations of hydrocarbons. The following definition of a fairway is adapted from Schlumberger's website:

The trend along which a particular geological feature is likely, such as a sand fairway or a hydrocarbon fairway. Prediction of conceptual fairways helps explorationists develop prospects.

The idea of a conceptual fairway is a powerful one as it allows us to envisage the pathway down which mineralised fluids passed prior to potentially being trapped at a depo-site. This pathway has been altered physically and chemically, sometimes for distances of 10 kms or more and therefore can offer a far larger and widespread path to locate and follow towards a potential deposit (the presence of a fairway does not mean, however, a deposit has necessarily formed or been preserved). Not all deposit styles, of course, lend themselves to being scrutinised by a minerals system approach but many do, and this could mean industry preferentially seeks such deposits as compared to more enigmatic ones. An introduction to these ideas and an assessment of the 'state-of-play' from a geophysical perspective is provided in Witherly (2014).

Bumps workshop

The Bumps workshop examined the present state of understanding of geophysical signatures of mineral systems; current examples and the role some of the important supporting technologies such as geochemistry will play. Also, the economic framework in which this new style of work will be carried out was considered, since a much greater degree of 'skin-in-the-game' will be required for all parties involved. Below are summaries of the eleven speakers in the workshop. Note, co-authors have contributed in many cases to these presentations and they are acknowledged on the title pages of the speakers' presentations.

Allan Trench (Curtin University/CET): 'An economic perspective on deep and under cover exploration: what are we looking for and how do we get there?'

Trench and his co-authors showed that there is much still to be understood about the economics of deep deposits that need to be mined underground as compared to those deposits that can be mined by open pit. Issues that include grade, deposit shape and metallurgy are important but are well understood, and they can change over the life of a mine. They examined issues related to a number of common Australian deposit styles including orogenic gold and IOCG and compared these with similar deposits in other parts of the world. The analysis did not factor in either the relative cost or time to find mineable deposits, factors that would have to be considered by a company planning to be in the mining business.

Mike Dentith (University of Western Australia/CET): 'The implications of the mineral systems concept for geophysical exploration: a perspective'

Dentith started by defining the basic concepts of mineral systems and related this to what can be measured with geophysical techniques (Figure 1). He introduced the major geophysical techniques; gravity and magnetics, active and passive seismics and magnetotellurics. The loss of resolution at depth was cited; multiple techniques can possibly help to overcome this. Better understanding of the petrophysics of rocks at depth is important but this has been a particularly difficult challenge to advance for a number of reasons.

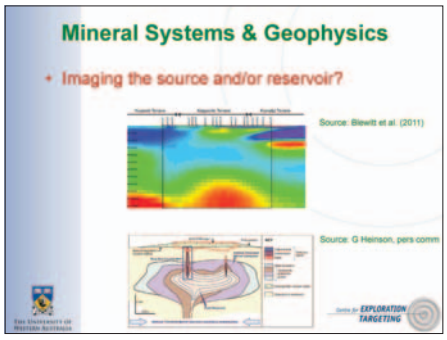

Figure 1. *Dentith PPT Slide: AMT section and hypothetical cross section of deposit forming magma chamber.*

Steve Beresford (First Quantum Minerals): 'Undercover exploration in 2030: an UNCOVER vision'

Beresford is Chair of Geoscience for the national UNCOVER initiative. He started the presentation looking at how most undercover exploration is carried out today, what the UNCOVER program was hoping to then achieve and laid out a vision for how exploration would look in 15-30 years. He then examined the changing role for geophysics in this vision; ie beyond bump finding. Steve emphasised that a new level of collaboration would be required, which is considered one of the major challenges as mining historically limits collaborative work to what is considered pre-competitive R&D (Figure 2). Other groups with similar 'big challenges' such as found in medical are cited as the style of collaborative work model required.

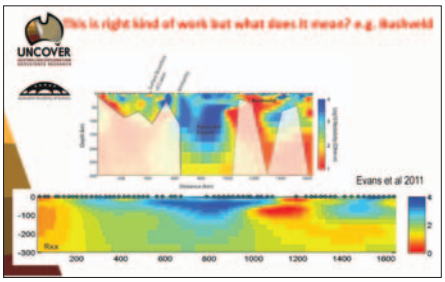

Figure 2. *Beresford PPT Slide: Geophysical imaging of Bushveld; some answers and some questions.*

Eric Anderson (USGS): 'Mineral systems approach to porphyry copper exploration – a magnetic perspective in southwest Alaska'

Anderson provided the first case history of the session and examined regional and detailed aeromagnetic data around the Pebble Cu-Au deposit Alaska. Pebble is one of the largest underdeveloped copper and gold deposits in the world and was the subject of an extensive geological, geochemical and geophysical assessment by the USGS (Kelley et al. 2013). Pebble itself lacks a strong direct magnetic signature but modelling shows that there is a very large magnetic high underlying the deposit area. As well, there are a number of other distinctive magnetic features in the vicinity of Pebble that collectively define a very anomalous terrain. When taken in a regional context Pebble appears to be part of a potential porphyry copper belt over 700 km in strike length that extends eastward into the Yukon (Figure 3).

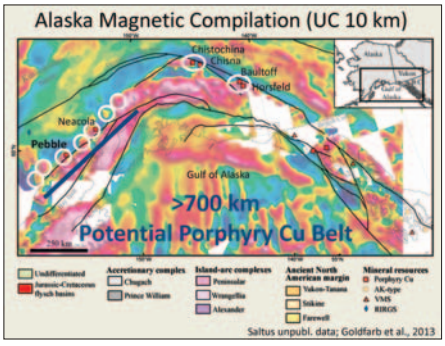

Figure 3. *Anderson PPT Slide: Image of upward continued aeromagnetic cover over southern Alaska-Yukon showing known or suspected porphyry systems over length of >700 km.*

Terry Hoschke (Consultant): 'Pathways to porphyries – mapping alteration and related mineralisation'

Hoschke began by highlighting the importance of subduction zones in the formation of porphyry deposits and how geophysics can map these important geological boundaries (Figure 4). With remainder of his talk, he focused on the geophysically mappable characteristics of porphyry systems. Unlike many other ore deposit styles, the porphyry copper deposit can have a very large primary alteration system, which can extend for several kilometres around the deposit. Even at considerable depths of burial the direct detection of a porphyry system is deemed a reasonable exploration proposition. The fact that the porphyry system is injected from below also means than the fairway for the individual deposit lies below the actual deposit itself.

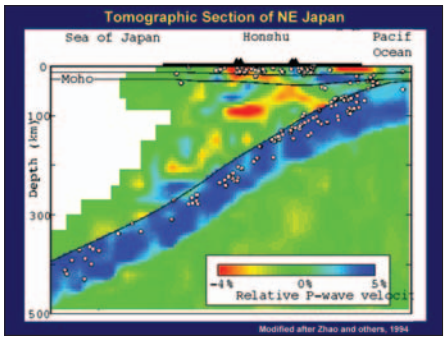

Figure 4. *Hoschke PPT Slide: Image of subduction zone NE Japan derived from seismic measurements.*

James Cleverly (REFLEX Geochemistry): 'Real time data and geologically meaningful bumps'

Cleverly outlined the revolution that is occurring in how geochemistry is being used to change the exploration process by making information on mineral chemistry available essentially in real time. Part of this is being driven by a major initiative within the DET-CRC to modify oil field tube drilling technology to minerals exploration. If successfully implemented, the tube drilling system will provide a stream of powder from the ground rather than traditional core or chips. Cleverly described an innovative technology called 'Lab-at-the-Rig' which would provide full analysis of the drill hole material at the drill site in a short time frame (Figure 5). As is often the case, Cleverley noted in his closing remarks that the success of this technology depends on there being a clear path forward as to how these exciting outcomes can be integrated with concurrently acquired geological and geophysical data to then effectively direct the exploration process in real time.

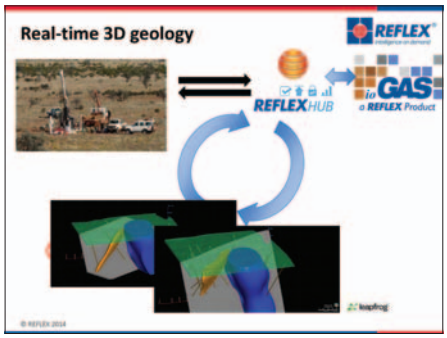

Figure 5. *Cleverly PPT Slide: Concept image showing recovery of detailed geochemistry and lithological information in real time at drill rig.*

Mark Jessell (University of Western Australia): 'From 3D geology to 3D geophysics, what next?'

The title of Jessell's talk could have been '3D geology; is it ready?' as the large part of the presentation dealt with the state of the art in 3D geological modelling and the impact that has on how this then links in with 3D geophysical modelling (Figure 6). Jessell showed that the world of geological modelling is moving beyond the single 'best guess' approach an individual might be expected to produce to schemes were multiple possible solutions are being automatically generated which in turn could be used as constraints for multiple geophysical inversion models.

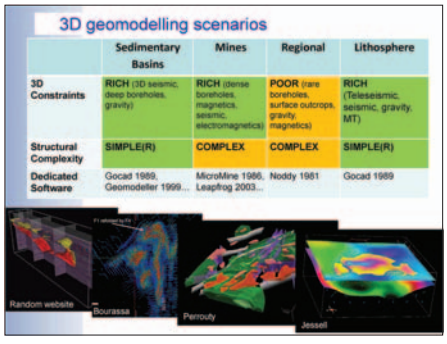

Figure 6. *Jessell PPT Slide: Outline of 3D geomodelling scenarios at various scales.*

Dave Clark (CSIRO): 'Petrophysical insights into targeting ore systems'

While the focus of Dave's talk was on the potential complexity of magnetic responses around deposits, much of the material covered district scale to more regional assessments and emphasised that, most times, interpreters are over-reliant on simple models for magnetic induction and ignore the effects of remanence, magnetite grain size and the often fickle nature of pyrrhotite (Figure 7). Numerous examples were shown where the 'one size fits all' approach to interpretation of magnetic data often fails to guide the user to the correct answer and can result in economically important targets being either misinterpreted or missed entirely. Remanence was pointed out to be a far more insidious factor in the assessment of magnetic data as it 'contaminates' likely 50% of all magnetic survey data, even if there are no 'telltale' strong negatives present in the data sets. This means that if this factor is left uncorrected inversion models will be geometrically distorted.

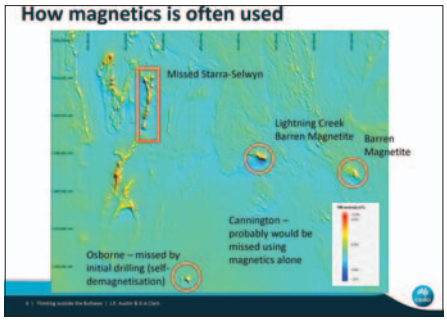

Figure 7. *Clark PPT Slide: Image of aeromagnetics from Queensland showing magnetic character of a number of deposits.*

Janne Kaukolinna (First Quantum Minerals): 'Finding the right bumps under glacial till in the Central Lapland Greenstone Belt'

Kaukolinna outlined the challenges of Ni exploration in northern Finland where the sought after target has strong geophysical characteristics (mag and EM, but so do many other features in the geological environment. Given the thin cover and a geophysically data-rich environment, a number of innovative processing techniques can be applied, which help narrow the search. A key component of this approach is a very large petrophysical data base acquired by the government.

Gavin Selfe (GRS Consulting): 'Following the mineral system and tracking it under cover – using every tool at our disposal'

Selfe presented four case studies from southern Africa that highlighted the need and value of combining a number of geophysical data layers and close integration with geology to develop effective exploration plays. The first example was from Mozambique and covered a large area, approximately 270 km by 220 km. Using a basic geological map, along with high quality aeromag and radiometrics data, Selfe was able to create a geo-interpretive map that was able to highlight areas prospective for mineralisation. The second project was in Botswana where the target was copper contained in conductive shales underneath a cover of Kalahari sediments. While the shales were easily mapped with EM, the challenge in this case was to define those parts of the stratigraphy close to the basement. This was achieved using a combination of careful analysis of the EM and air gravity data (Figure 8). The third example focused on a copper belt style play that straddles the Zambian-DRC border. Again, mag, EM and gravity were the key data sets but, in this case, the gravity provided a diagnostic response associated with the key breccia unit. The final example showed the work around a Ni deposit in north central Zambia. Here, careful ground geophysical work with modelling was used to define a complex ore zone in a graben structure.

Figure 8. *Selfe PPT Slide: Image of EM Tau Ternary image with structural interpretation added.*

Graham Ascough (Mithril Resources): 'Signatures of mineral systems; a perspective from the financially challenged'

Ascough indicated that the juniors made the majority of the mineral discoveries in the past decade but they have been 'unfriended' by investors in the past half-decade due to a perceived higher than acceptable risk. Historically low commodity prices and majors being distracted by their own issues has meant there has almost been a 'perfect storm' battering the juniors. It is not clear if a better geoscience story will do much to alleviate these concerns in the short term. Ascough then went on to show some examples where the junior sector was trying to be innovative in terms of both the commercial side and geoscience since, for the junior, these two factors must be in sync if they are to attract good investors and have the likelihood of producing satisfactory results. One example of this approach involved six companies pooling their properties in the prospective but remote Musgrave Block, in an area just east of the major Nebo Babel Ni-Cu deposit. They formed a new company and were able to do a $20M IPO which separately would have been impossible. Started in 2011, the project is now producing some spin-off plays with interesting and encouraging results.

The full set of talks is available on YouTube at:

https://www.youtube.com/playlist?list=PLUfG7j4LhdsdZ9CxKBPZh3qozAYXpLLPa

At the ASEG 2013 conference, a workshop with a similar theme was held and the proceedings were also recorded and are available on YouTube at:

https://www.youtube.com/playlist?list=PLUfG7j4Lhdscw0S3fgwhIewpV4KbYKcWN

The Decennial Minerals Exploration Conferences (www.dmec.ca) site also carries the links to these and other such topical workshop as well as a download point for the workshop handouts.

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ASEG-PESA-AIG 2016: news from the Conference Organising Committee

It's been a busy few months as dates for various aspects of the conference are being set in stone.

Expressions of interest forms to run a workshop are available now from the conference website (http://www.conference.aseg.org.au/cfp.html). These must be returned to the Conference Organising Committee by 1 December 2015 so that the Committee can tailor the workshop programme.

The Call for Abstracts will open on 1 November 2015 so, please start thinking about what you would like to present at the conference! As with previous conferences you'll be able to download the abstract template through the conference website. We're allowing longer extended abstracts for this conference; no longer will you be limited to four pages!

Earlybird registration will open in January 2016.

The programme subcommittees are working hard to identify keynote speakers for the conference. If you have any suggestions please do not hesitate to contact the committee.

The sponsorship and exhibition prospectus has been distributed to interested parties. If you would like a prospectus, please visit the conference webpage to download the pdf (http://www.conference.aseg.org.au/prospectus.html). Also available on the website is the floorplan for the conference. We've taken aboard feedback from previous conferences and are including more room for delegates to sit down during the day.

Many of our deadlines revolve around printing deadlines for the conference edition of *Preview*, so it is imperative that if you're thinking of sponsoring or exhibiting that you meet the deadlines outlined in the prospectus. Failure to do so will mean your company will not be included in the conference edition of *Preview*.

Planning for the dinner is also well underway. We're booked in at the newly renovated Adelaide Oval, and will see a return to a more traditional dinner format.

If you have any thoughts, questions or comments regarding the upcoming conference, you can contact us via email or by social media. We have a LinkedIn page, a Facebook page, and a Twitter feed. Links to these can be found on the website.

This conference – the 25th of its kind – is panning out to be a major event. We're delighted to have PESA return as co-host, and with AIG on board too we hope to reach many more geophysicists in Australia.

Philip Heath
Co-chair Minerals
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Luke Gardiner
Co-chair Petroleum
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ASEG-PESA-AIG 2016
25TH GEOPHYSICAL CONFERENCE & EXHIBITION

Interpreting the Past, Discovering the Future

August 21-24 Adelaide, South Australia

We would like to invite you to attend the 25th Geophysical Conference and Exhibition. This year the Australian Institute of Geoscientists (AIG) joins the Australian Society of Exploration Geophysicists (ASEG) and the Petroleum Exploration Society of Australia (PESA) to present a highly technical program. AIG is a professional institute representing geoscientists employed in all sectors of industry, education, research and government throughout Australia. The broad base of the AIG encourages transfer of technical expertise, experience and awareness of issues affecting all aspects of professional geoscience practice.

The ASEG-PESA-AIG 2016 Programme Committee will be working to attract abstracts in the three key areas of Petroleum, Minerals, and Near-Surface/Engineering geophysics. In each of these areas, super-themes will focus expertise into main avenues throughout the conference. We envision that many of the common technique-based themes seen at geophysical conferences will fit into these categories.

For further information on themes and subjects please visit http://www.conference.aseg.org.au/

CALL FOR ABSTRACTS OPEN 1 NOVEMBER 2015

PESA Petroleum Exploration Society of Australia

Australian Society of Exploration Geophysicists

AUSTRALIAN INSTITUTE OF GEOSCIENTISTS

UNCOVER: summary of presentations at a GA forum

David Denham AM
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As part of the 2015 Mines and Wines Conference held in Queanbeyan over 2–4 September 2015, Geoscience Australia hosted a forum on its contribution to the UNCOVER multi-agency program (http://www.uncoverminerals.org.au/). The aim of UNCOVER is to deliver major new mines by locating and unlocking future mineral wealth, primarily from areas that are covered by regolith. There were 13 speakers and their presentations are summarised below.

Richard Blewett: 'The Minerals programme at GA: an UNCOVER overview'

Australian annual exports from the minerals and energy sectors are more than $190 billion and yet in recent years the discovery of new resources has declined. New discoveries require new exploration, particularly in the areas where the basement rocks are covered. Four themes are addressed by the UNCOVER forum presenters namely:

Theme 1: Cover

Science problem: ~80% of the continent is covered by post mineralisation material, which poses a major exploration challenge and opportunity. What is the thickness and character of cover at each drill site?

Solutions: Harness legacy data, benchmark methods of cover-thickness estimation, develop new techniques of cover characterisation and produce new predictive maps.

Theme 2: 3D architecture

Science problem: World class mineral deposits result from efficient focussing of metal, fluid and energy through the lithosphere into the upper crust. What is the architectural record of these fluxes, especially under cover?

Solutions: Map the lithospheric architecture, define the crustal architecture and integrate towards national 3D model.

Theme 3: Geodynamics and mineral system evolution

Science problem: Most major ore deposits formed during specific time periods, linked to stages in supercontinent cycles. Australia is endowed with a >3.8 billion year rock record, but where are the favourably aged rocks hosting mineral deposits?

Solutions: New determinations of geological ages (stratigraphy, rocks, events, mineral deposits, etc.), translating theory into practical maps for exploration area selection and assessments of Australia's mineral potential, greenfields and under cover.

Theme 4: Distal footprints and toolkits

Science problem: Ore deposits are small, and are often under cover. How do we see the larger signals (footprints) of mineral systems to reduce risk in selected regions?

Solutions: Collect new data to map prospective fairways under cover (drilling), maximise the knowledge: develop new exploration toolkits at a range of scales and deliver products including data.

Theme 1: Cover

Marina Costello: 'Airborne electromagnetic (AEM) – cover thickness, cover character, advanced processing, interpretations and case study exemplars'

Nine government and industry funded AEM surveys have been completed in the last 15 years. They cover ~555 000 km² and include 194 000 line-km, as shown in Marina's slide (Figure 1). AEM data are ideally suited to exploration in the top ~300 m of the Earth's surface where explorable depths are within easy reach of current drilling technology. Regional AEM data are able to improve undercover geological mapping, reduce exploration risk and stimulate investment by industry.

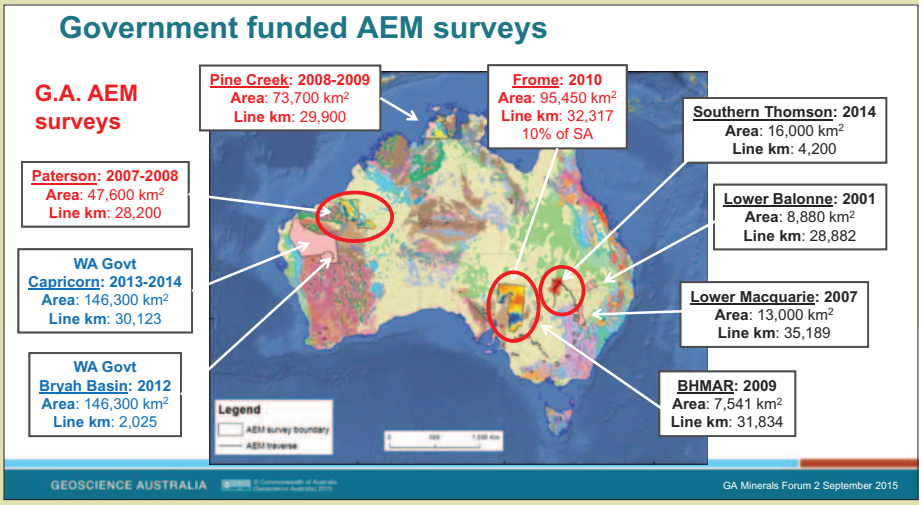


Figure 1. *Costelloe PPT Slide: Locations of recent AEM surveys, where the results are publicly available.*

Tony Meixner: 'Geophysics applied to variable cover: benchmarking multiple methods to known depths'

Depth to magnetic source methods can provide cover thickness estimation across most of Australia. Grid based methods of interpolation produce low reliability results – flight-line based methods produce higher reliability results, particularly where magnetic depth estimates can be geologically attributed. Passive seismic and refraction seismic can also be used to estimate basement depth. Tony showed an example from Stavely in Victoria where the magnetic depths are compared with the drilling results (Figure 2).

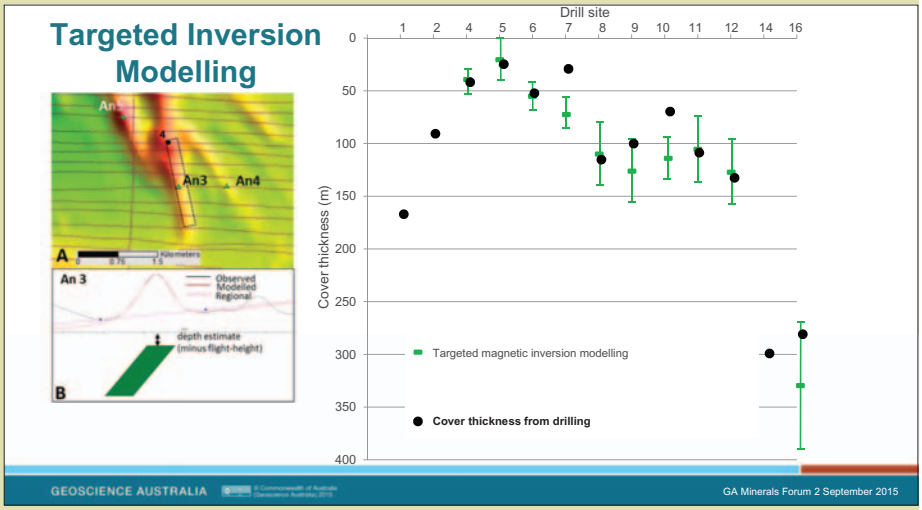


Figure 2. *Meixner PPT Slide: Inversion modelling from magnetics and drill hole results. Refraction seismic and passive seismic produce more accurate results, but are much more expensive to obtain.*

John Wilford: 'Towards a national cover thickness map using data mining: a model-based prediction of cover thickness'

Using 800 000 drill holes from the National Groundwater database, of which 350 000 have lithology available, together with the geophysical data bases and applying a cubist data mining technique the depth to the regolith has been estimated over the whole continent. As an example John showed the Cenozoic depth boundary for the Murray Basin with estimated uncertainties.

Theme 2: 3D architecture

Richard Chopping: 'The magnetotelluric method to map near surface to deep lithosphere: case studies and new developments'

Large-scale regional and national MT surveys to investigate crustal and lithospheric architectures in Australia have been carried out in the last few years. These include 16 regional surveys (more than 3000 sites) across potential mineral provinces and frontier sedimentary basins. In addition the Australian Lithospheric Architecture Magnetotelluric Project (ALAMP), a collaborative national survey for acquiring data at approximately 2800 sites with a ~50 km grid spacing, is being undertaken. Because the MT frequencies range from 10^{9} to 10^{-6} there is huge scope for investigating the Earth, however, the modelling resolution is quickly degraded as the depth increases. The deep seismic surveys are crucial to interpret crustal and mantle structures and their results compliment the MT analysis. A conductivity model for the crust beneath Roxby Downs was shown in one of Richard's slides (Figure 3). The first state ALAMP survey is in Victoria. There will be 7 months for data acquisition, 4 months for data processing and it is expected that the data will be released very soon.

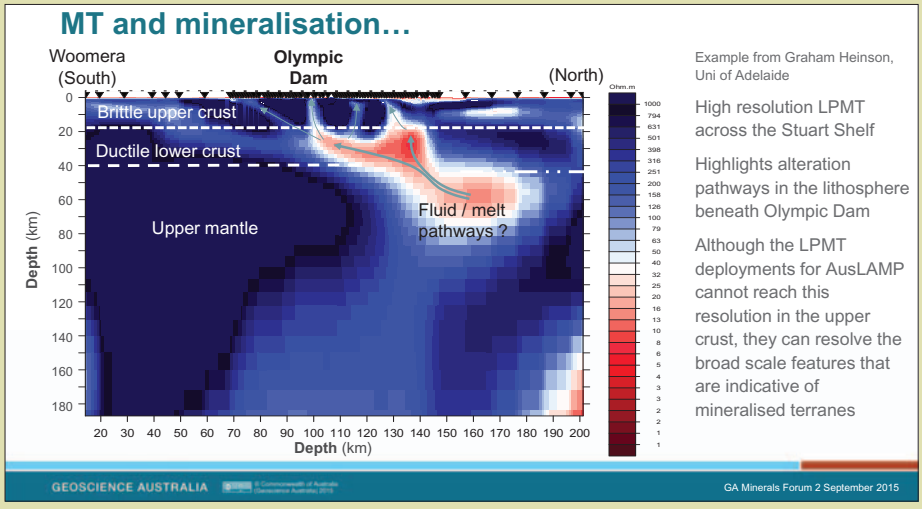


Figure 3. *Chopping PPT Slide: High resolution modelling across the Stuart Shelf highlights alteration pathways in the lithosphere beneath Olympic Dam obtained from MT data.*

Ross Costelloe: 'The seismic database of Australia: a continent in cross section'

Thousands of kilometers of deep crustal seismic data have been obtained in Australia since the 1950s (Figure 4). These data can be used to:

- *Image major crustal boundaries and faults*
- *Indicate potential fluid flow pathways, and*
- *Image under cover*

Processed data and images are available from GA website: http://www.ga.gov.au/about/what-we-do/projects/minerals/current/seismic

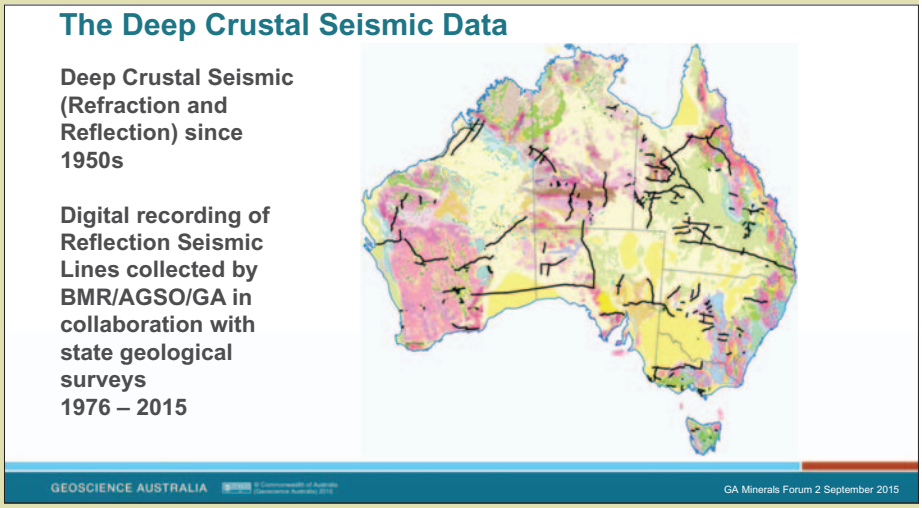


Figure 4. *Costelloe PPT Slide: Deep crustal recordings from 1950 to 2015. Explosives were used from 1976–1999, when Vibroseis took over.*

Karol Czarnota: 'Bringing it all together: the Australian Architecture Reference Model (AusARM)'

Using information from 7000 km of full crustal reflections a set of new comprehensive models of the crust and upper mantle beneath Australia have been produced. The results for the Moho were indicated on one of Karol's slides (Figure 5). Other models are available for different depth windows.

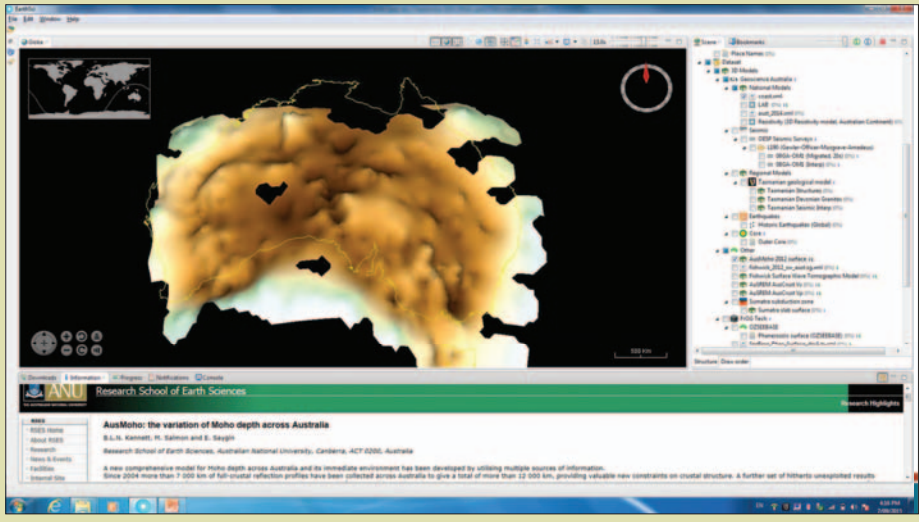


Figure 5. *Czarnota PPT Slide: Indicative variation of Moho depth across Australia.*

Theme 3: Geodynamics and mineral system evolution

Geoff Frazer: 'Australia through time: the U-Pb database of Australia, ASUD, GA's geochronology capability'

Dating specific geological events is crucial in developing models of mineralisation. Geoscience Australia has an in-house SHRIMP laboratory (~120 samples per year) and other in-house expertise (but not in-house analytical facilities) to use ID-TIMS U-Pb, Ar-Ar, K-Ar and Re-Os dating methods. More information can be obtained by contacting stratnames@ga.gov.au or geochronology@ga.gov.au.

Kathryn Waltenberg: 'Isotope geochemistry to map architecture and fertility: Sm-Nd, Pb and Hf'

The aim is to look 'through' the granite to date its source by timing when the crust was extracted from the mantle. The model ages approximate the bulk age of the crust. The technique is best used in relative terms and at regional scales. One of Kathryn's slides (Figure 6) showed an age map of the Australian continent, being built from the west to the east over about 3 billion years.

Lead isotopes can also be used in a similar way to the Sm-Nd method. It uses Pb-rich, U-free minerals (e.g. galena, feldspar) and is best used when the age of the system is independently known. Pb isotopes in feldspar can represent bulk-crust/mantle composition through time and Pb isotopes in galena provide direct information about crust/mantle input during mineralisation events. And finally, GA is using Lu-Hf and O isotopes and is maintaining a data base of samples and ages.

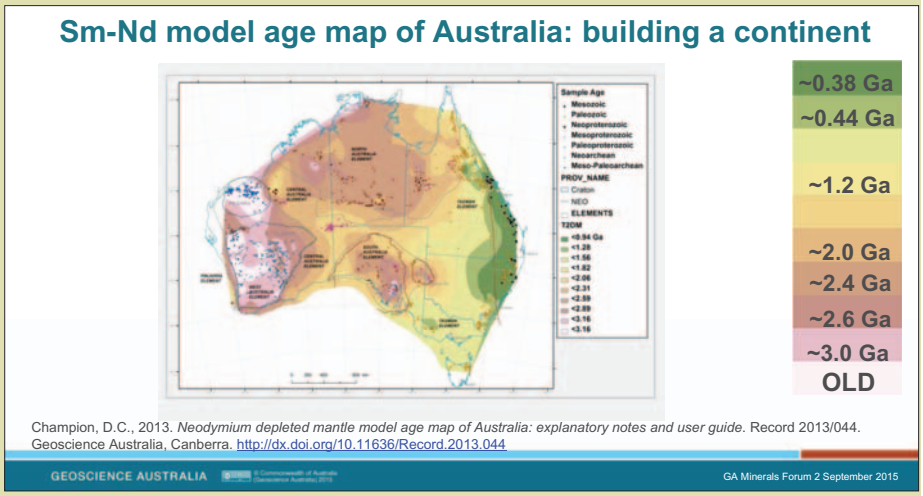


Figure 6. *Waltenberg PPT Slide: Sm-Nd age map of the Australian crust showing how accretion occurred from west to east over ~3 billion years.*

David Huston: 'Mineral systems as an area selection method at the national and regional scales: examples of magmatic Ni-PGE, IOCG and salt lakes'

The challenge is to develop dynamic models to describe the formation of mineral systems, so that geologists can search for analogues (Figure 7). I think that the models might be just a little too complex for geophysicists, but may as well be included for completeness. These methods appear to work in isolating more prospective areas.

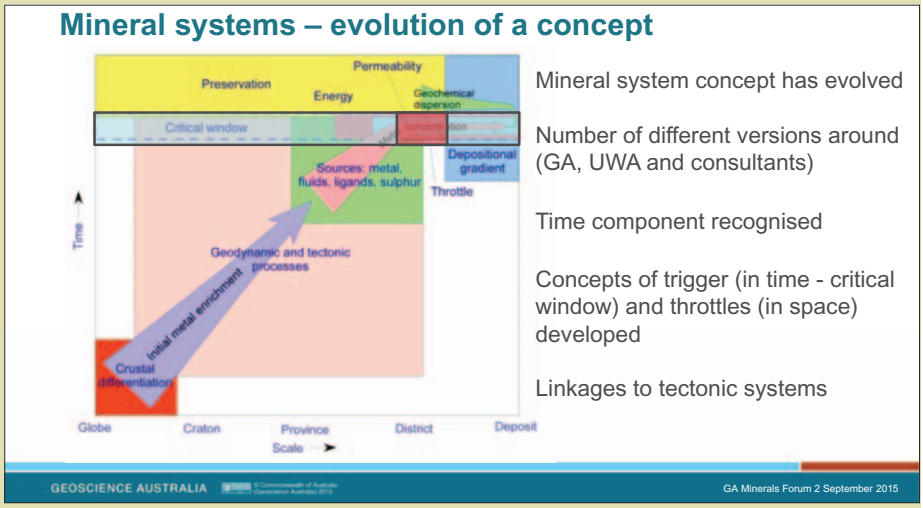


Figure 7. *HustonPPT Slide: Schematic of possible evolution of a mineral system.*

Theme 4: Distal footprints and toolkits

Anthony Schofield: 'Update on regional stratigraphic drilling projects: Stavely and Thomson'

In the end a borehole has to be drilled to test the modelling and 14 fully cored stratigraphic drill holes have been drilled at the Stavely Arc in Victoria (Figure 8). The drilling program included the deepest sonic hole drilled in Australia (212 m) and used a suite of logging techniques to detect lithological changes and distal signatures of mineral systems. These included: Lab-at-Rig® (geochemistry), AutoSonde™ (geophysics), Rock properties, HyLogger™ hyperspectral data and whole rock geochemistry.

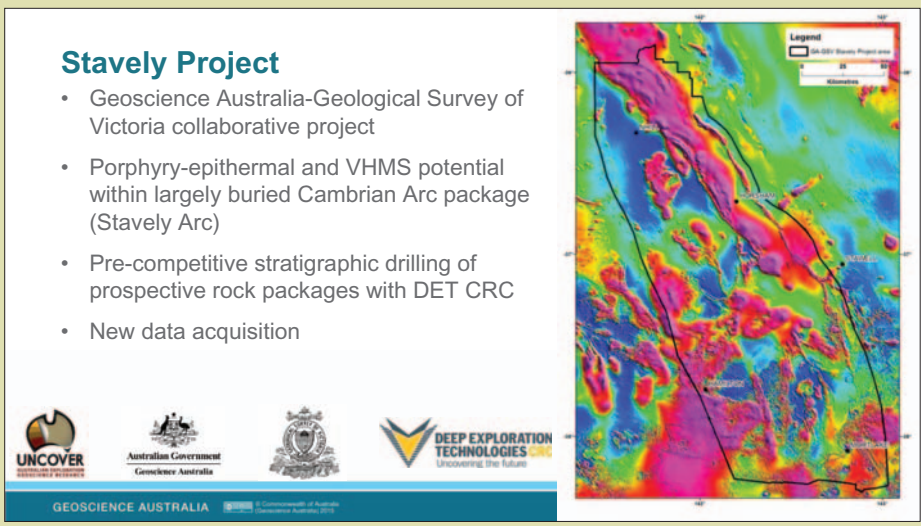


Figure 8. *Schofield PPT Slide: Location of Stavely project inside the black line on the image.*

James Goodwin: 'Lowering the entry level to big data and big compute: the Virtual Geophysical Laboratory and its future development'

There is an estimated 3 petabytes of publicly funded geoscience data in Australia, and most of these data are held by Geoscience Australia. In terms of geophysics this includes nationwide datasets of: gravity, magnetics, radiometrics, seismic, magnetotellurics, airborne electromagnetics (AEM) and satellite derived data. Big fast computers are needed to perform inversions on large data sets. GA uses RAIJIN, named after the Shinto God of thunder, lightning and storms; it is a Fujitsu high-performance, distributed-memory cluster, with: 57472 computer cores; >10 petabytes Research Data Storage Infrastructure; peak performance of 1.2 PFlops; ranked 38th most powerful computer system in the world (Figure 9).

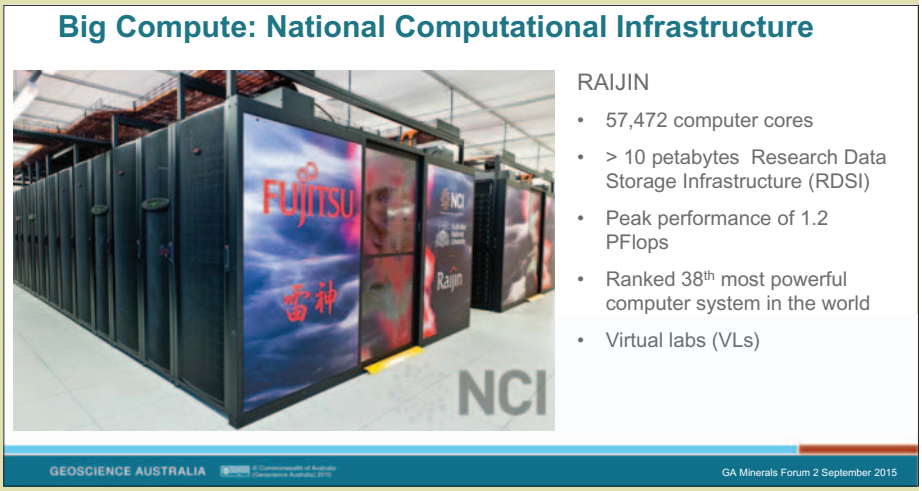


Figure 9. *Goodwin PPT Slide: Raijin, named after the Shinto God of thunder, lightning and storms.*

Ollie Raymond: 'Data delivery and discoverability: Rock Properties, Geoscience Portal, GADDS'

Finally there needs to be a way to easily access all that data.

GA is using OGC Web Services. This means that maps and data are broadcast over the internet, like streaming TV, using international standard protocols developed by the Open Geospatial Consortium (OGC). There are three main services:

- *WMS (Web Map Service): it delivers map data as an image, the data can be queried online, the data behind the WMS can be accessed if a link is provided in the WMS to a downloadable file, typically, symbolisation/legend is delivered with the WMS map and WMS maps are primarily used as query able backdrops in your GIS analysis.*
- *WFS (Web Feature Service): it streams data as XML, the live XML feed can be rendered, filtered, and queried by a mapping application, or, it can be consumed on-the-fly by analytical and modelling applications, or, it can be downloaded in various formats to your local PC (e.g. CSV, shapefile, gdb).*
- *WCS (Web Coverage Service): it delivers gridded (raster) data, the real data values, not just RGB pixel values, data can be queried and consumed for data processing online, data can be re-stretched by your mapping application, can be downloaded in various formats (e.g. NetCDF, geoTIFF).*

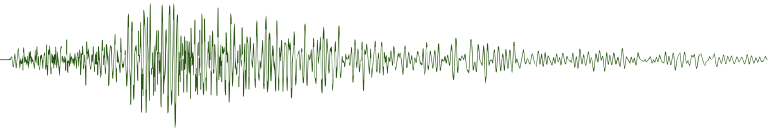
Geoscience Australia Web Services include:

- *Surface Geology of Australia (1:2.5M & 1:1M) – WMS*
- *Geological Provinces – WMS*
- *National Geophysical Grids – WMS*
- *Onshore Seismic Surveys – WMS*
- *Rock Properties – WMS & WFS*
- *Elevation and Bathymetry – WMS & WCS*
- *Topography and Infrastructure – WMS & WFS*

and over 100 more – just type 'web services' into the GA and use the website search tool.

So there you have it. All you need to know about the collection, analysis, storage and access to geoscience information at Geoscience Australia – a wonderful afternoon!

I would like to thank Geoscience Australia for providing copies of the PPT slides used in this article. For further information please contact the individual authors or Richard Blewett at Geoscience Australia.



Update on Geophysical Survey Progress from the Geological Surveys of Western Australia, South Australia, Northern Territory and Victoria (information current on 10 September 2015)

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
Coompana	GSSA	GA	GPX Surveys	7 Feb 2015	255 265	400 m 80 m E–W	85 910	64.3% complete at 10 Sep 2015	TBA	173: Dec 2014 p. 24	TBA
Delamere/ Spirit Hills	NTGS	GA	Thomson Aviation	20 Jul 2015	96 500 est.	400 m 80 m N–S	33 690	42.7% complete at 6 Sep 2015	TBA	176: Jun 2015 p. 22	TBA
Yalgoo	GSWA	GA	MAGSPEC Surveys	30 May 2015	110 516 est.	100/200 m 50 m E–W	11 200	73.5% complete at 6 Sep 2015	TBA	176: Jun 2015 p. 23	TBA

TBA, to be advised.

Table 2. Gravity surveys

Survey name	Client	Project management	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Gippsland	GSV	GA	Atlas	30 Jun 2014	1440	12 traverses at 500 m station spacing	8358	100% complete at 21 Jul 2015	Final data expected to be released via GADDS when permission to do so is received from GSV	170: Jun 2014 p. 25	To be released with the North Wiso data
North McArthur Basin	NTGS	GA	Atlas	16 Sep 2014	7175	4 km regular grid with areas of 2 km infill; 1 area of traverses spaced 4 km apart with a station spacing of 1 km	71 030	100% complete at 4 Nov 2014		171: Aug 2014 p. 39	Released on 30 Jul 2015
Ngururrpa	GSWA	GA	Atlas	10 May 2015	5000	2.5 km regular grid	30 700	100% complete at 13 Jun 2015		176: Jun 2015 p. 23	Released on 30 Jul 2015
Northern Wiso Basin	NTGS	GA	Atlas	18 Jun 2015	5020	4 km regular grid with areas of 2 km and 1 km infill	83 240	100% complete at 9 Aug 2015	Preliminary final data supplied to GA in Sep 2015	176: Jun 2015 p. 24	TBA
SW Yilgarn WA	GSWA	GA	Atlas	12 Jun 2015	28 678	2 km along public roads and tracks	175 000	36.5% complete at 7 Sep 2015	TBA	176: Jun 2015 p. 24	TBA
Victoria Basin	NTGS	GA	Atlas	14 Aug 2015	6300	4 km regular grid	99 170	62.3% complete at 6 Sep 2015	TBA	177: Aug 2015 p. 17	TBA
Stavely	GSV	GA	TBA	Survey Quotation Request in preparation	Approx. 8000 in 9 separate areas	500 m regular grid in 8 areas and 500 m station interval along one traverse	TBA	TBA	TBA	177: Aug 2015 p. 18	TBA

TBA, to be advised.

Table 3. AEM surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Musgrave Region	GSSA	GA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	The technical specifications of the survey are being planned between GA, GSSA and CSIRO	Since *Preview* 176 the National Collaboration Framework Agreement was executed between GA and GSSA on 2 Jul 2015
West Kimberley and Ord-Bonaparte	WA Government: Departments of Water, Agriculture and Food	GA	TBA	Late Sep 2015	7837	Various +/- traverses	TBA	TBA	TBA	Current issue (Figures 1 and 2)	The Quotation Request was released on 25 Aug 2015 and closed on 8 Sep 2015. The proposed West Kimberley survey covers the Derby, Lennard River, Mount Anderson and Noonkanbah Standard 1:250 k map sheets. The Ord-Bonaparte survey covers the Medusa Banks, Port Keats, Cambridge Gulf and Auvergne standard 1:250 k map sheets

TBA, to be advised.

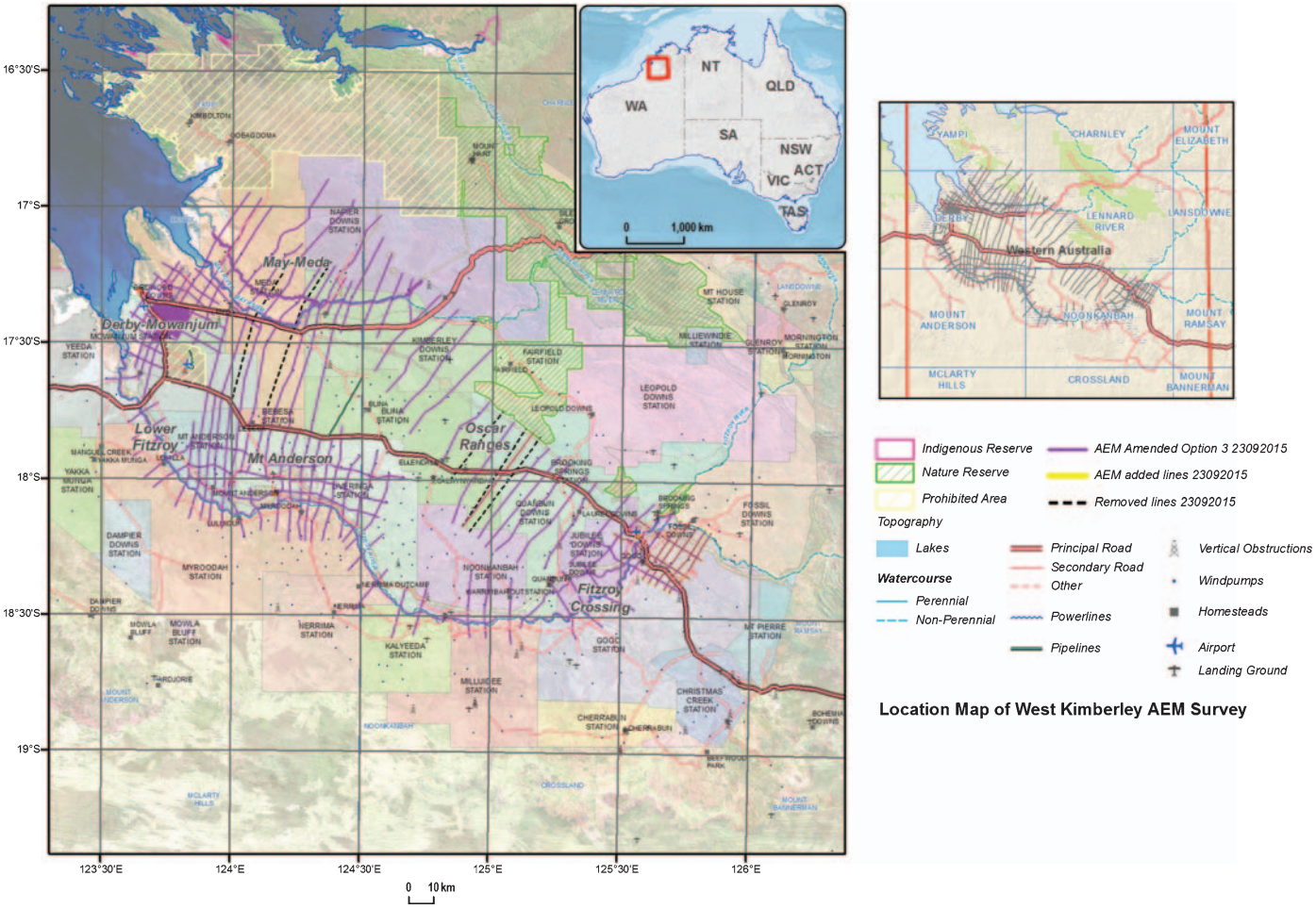


Figure 1. *Proposed West Kimberley AEM survey.*

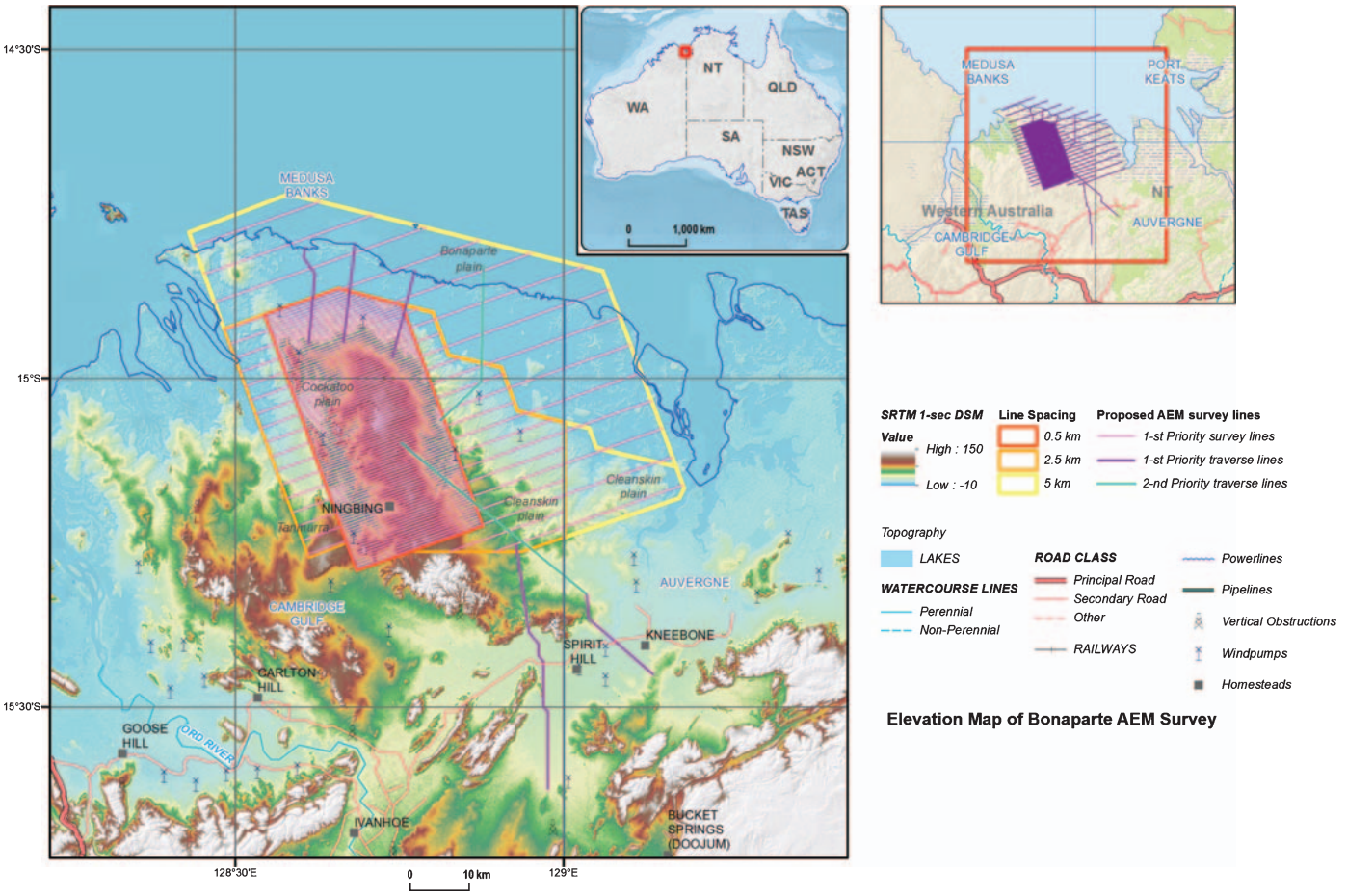


Figure 2. *Proposed Ord-Bonaparte AEM survey.*

New detailed magnetic image of SA

To aid a number of new projects the geophysicists at GSSA recently reprocessed and merged 287 magnetic surveys covering the WPA (Woomera Prohibited Area), EGP (Eastern Gawler Province) and SGRV (Southern Gawler Ranges Volcanics). The merge (Figure 1) will be used for exploration targeting with statistical cluster analysis, 3D inversions and mapping for the Mineral Systems Drilling Programme operating in the SGRV. The latter is a collaboration between the GSSA, DET CRC and industry to assess real time analysis of drilling data and construct regional vectors, including geophysics, for possible mineralisation vectors.

The merged grid will be available for download through http://minerals.statedevelopment.sa.gov.au/geoscience/geoscientific_data/new_releases and details of the drilling programme at http://minerals.statedevelopment.sa.gov.au/geoscience/geological_survey/gssa_projects/mineral_systems_drilling

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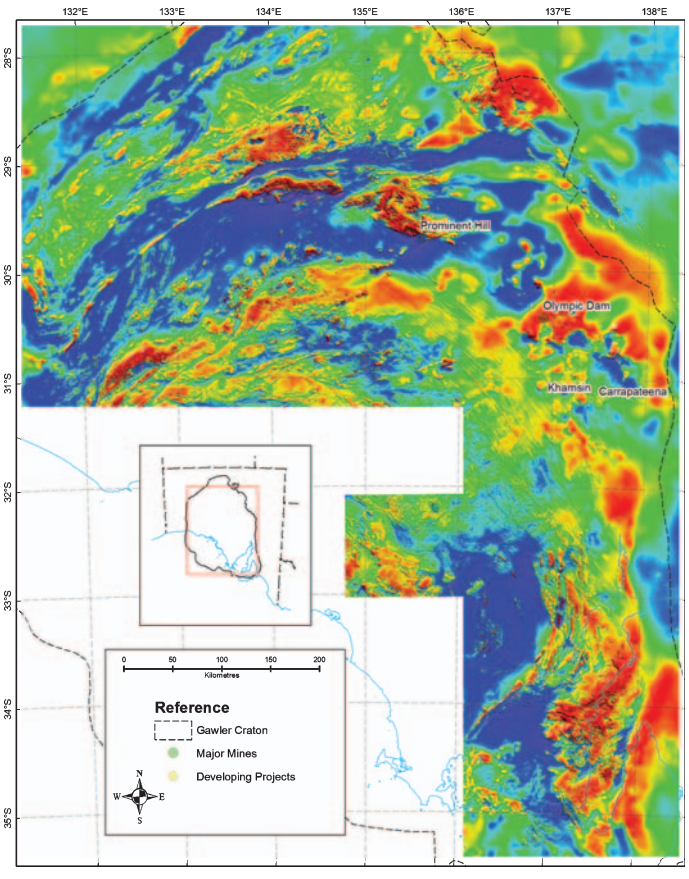

Figure 1. *New detailed magnetic image of South Australia.*

Canberra Observed

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Turnbull engineers clinical coup and a new Ministry is announced

The speed, efficiency and effectiveness of Turnbull's coup has to be admired because, although there had been disquiet in the Liberal Party for several months about Tony Abbott's performance, very few were prepared for what took place – particularly Mr Abbott himself. The challenge now is for Turnbull to maintain momentum before the unhappy troops re-group.

Tony Abbott was a paradox. He was a brilliant leader of the Opposition and after destroying Turnbull in 2009 he set about Rudd and Gillard in similar fashion. After being elected as Prime Minister he stopped the boats, eliminated the carbon tax and the mining tax as promised, then he appeared to grind to a halt. And that was the problem. There was no plan for the future. His attempts to reform health and education were unsuccessful, the budgetary deficit was going from bad to worse and traditional manufacturing industries were suffering the death of a thousand cuts. It will be interesting to see how effective Malcolm Turnbull is in the next few months because if he doesn't crash through with new directions and actions in that time he too will be vulnerable.

On 20 September 2015 Mr Turnbull announced his Ministry and in the table below (Table 1) I have shown what happened to those areas of government that are relevant to the ASEG and the geosciences.

Under Tony Abbott Ian Macfarlane was responsible for Industry and Science. It was a huge ministry and he appeared to manage it effectively. It was a logical grouping of portfolios. He has been dumped and there is now a Minister for Resources and Energy (Minister Frydenberg) and another for Industry and Science (Minister Pyne). We will have to wait and see how the old Ministry will be carved up because there is scope for duplication and turf wars. It should be noted, however, that Minister Pyne will be supported by an Assistant Minister for Science (Karen Andrews) and an Assistant Minister for Innovation (Wyatt Roy), but, at the time of writing, their responsibilities have not been specified.

Of concern is the fact that water policy and resources is now the responsibility of the Minister for Agriculture. Water resources are also of concern to the resource industries and those of us who live in urban environments. Once again we will have to wait and see how it works.

Finally, I am not sure why 'renewable energy technology development' has been moved to the Environment Ministry. I would have thought that this activity would have been better off in the 'Innovation and Science' area. However, it may have been done to save the Australian Renewable Energy Agency and the Clean Energy Finance Corporation from destruction. Time will tell.

Table 1. Changes in ministerial responsibilities for areas of government most relevant to the geosciences after Malcolm Turnbull became Prime Minister.

Tony Abbott		Malcolm Turnbull*	
Minister for Industry and Science	Ian Macfarlane	Minister for Resources, Energy and Northern Australia:	Josh Frydenberg
Minister for Education and Training	Christopher Pyne	Minister for Industry, Innovation and Science (–renewable energy technology development)	Christopher Pyne
		Minister for Education and Training:	Simon Birmingham
Minister for Agriculture	Barnaby Joyce	Minister for Agriculture and Water Resources (+water policy and resources)	Barnaby Joyce
Minister for the Environment	Greg Hunt	Minister for the Environment (+renewable energy technology development)	Greg Hunt

**The full list of the Turnbull Ministry can be found on: http://www.dpmc.gov.au/pmc/parliamentary-information.*

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Business expenditure on R&D increases slightly in 2013–14

During 2013–14 expenditure on R&D by Australian businesses was $18.8 billion, according to an Australian Bureau of Statistics release on 4 September 2015 (http://www.abs.gov.au/ausstats/abs@.nsf/mf/8104.0).

This represents an increase in 1% from 2011–12, when the numbers are adjusted for CPI increases. Incidentally, no report for 2012–13 was produced because of resourcing issues in the ABS.

Manufacturing remained the largest contributor to total Business Expenditure on R&D (BERD), contributing $4.84 billion (26%) in 2013–14. The next largest contributors were professional, scientific and technical services ($3.75 billion or 20%), financial and insurance services ($3.09 billion or 16%) and mining ($2.83 billion or 15%). Together, the four largest industries accounted for more than two thirds (77%) of total BERD in 2013–14 (see Figure 1). Unfortunately, mining recorded the largest dollar decrease in BERD from 2011–12, down $1.274 billion or 31%.

Essentially, Australia's BERD has remained constant since 2010–11, after healthy increases since 1992. The data are plotted in Figure 2 for the period 1992–2014. The total annual investment should reach $20 billion very soon, but the per capita value has remained almost constant since 2010 at about A$800.

The peak was in 2008–09, when it reached 1.34% of GDP (Figure 3). The ABS no longer publishes comparisons with other OECD countries, but the OECD average for 2013 was 2.36% of GDP. The highest levels were in Israel, with 4.21% and Sweden with 3.30%.

OECD estimates Germany at 2.85%, US at 2.73%, UK at 1.63% and Canada comes in at 1.62%.

The bottom line is that Australia has a lot of catching up to do and with the resources sector continuing to decline it's not clear how we can increase our research effort.

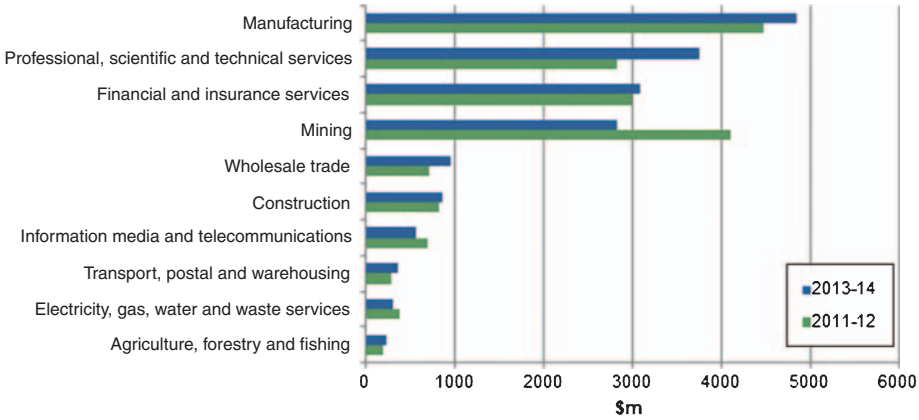

Figure 1. *Ranked Business Expenditure on R&D (BERD) for the top ten industries in 2011–12 and 2013–14. (Diagram taken from the September 2015 ABS release.)*

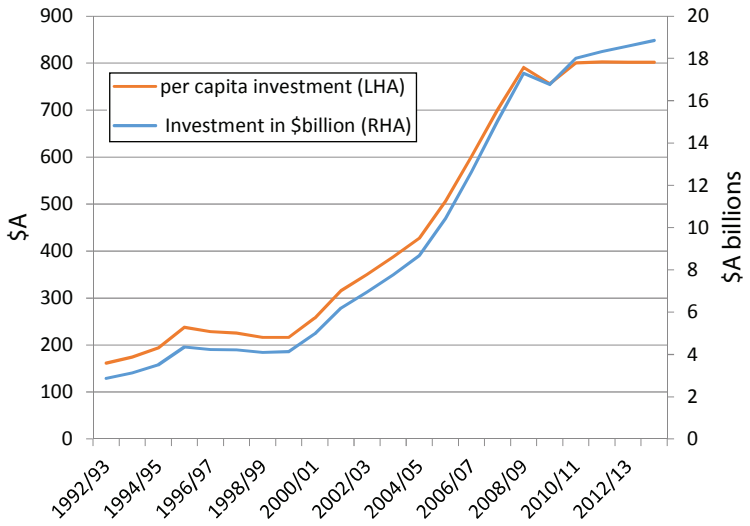

Figure 2. *Business expenditure on R&D from 1992–2014. The blue line represents the total annual investment in billions of $A. The red line represents the per capita amount in A$.*

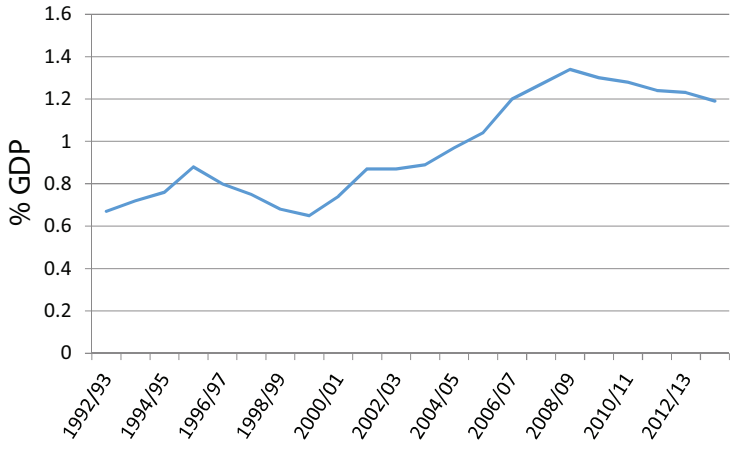

Figure 3. *BERD as a percentage of GDP.*

Mineral and petroleum exploration investment plummets

The exploration investment numbers for the June 2015 quarter, released by the Australian Bureau of Statistics on 31 August 2015 do not make good reading (http://www.abs.gov.au/ausstats/abs@.nsf/mf/8412.0?OpenDocument).

The trend estimate for total mineral exploration expenditure fell 10.9% (or ~$41.2m) to $336.2m. This is 28.0% lower than the June quarter 2014 estimate. The largest contributor to the fall was Western Australia (down 12.1% or ~$26.6m).

The trend estimate for the total petroleum exploration expenditure fell 12.7% (or ~$119.6m) to $821.3m in the same period. Exploration expenditure on production leases fell 21.2% (or ~$40.8m), while exploration expenditure on all other areas fell 9.2% (or ~$68.8m). Western Australia and South Australia took the brunt of the fall, down 11.1% or –$54.7m and down 52.1% or –$79.5m respectively.

The mineral and petroleum exploration investments are shown in Figure 1. Both sectors have suffered dramatic falls, as the oil price has halved from more than US$100 a barrel about a year ago to less than $US50 now and the main mineral commodities have also declined. Even the price of gold has fallen from about US$1800 an ounce in May 2012 to US$1100 in September 2015. The levels of exploration investment are now equivalent to what they were in June 2005 for minerals and June 2007 for petroleum.

One would have hoped that, in the mineral industry, the majors like BHP and Rio Tinto, would have maintained a higher level of exploration investment because in 15–20 years time several of the current mines will have reached the end of their economic life and new resources will have to be found. Unfortunately it doesn't seem to work like that.

The value of resource companies listed on the ASX has also declined over the past five years.

Figure 2 shows how the value of resource companies listed in the top 150 companies on the ASX has declined steadily over the last four years. In April 2011 their market capital was approximately $440 billion. In September 2015 their value has dropped to $170 billion.

Interestingly, the increase in real terms, adjusted for CPI increases, of the All Ordinaries Index is only slightly better than inflation over the 15-year period. One of the biggest losers is BHP, which has dropped from $155 billion in December 2010 to approximately $76 billion in September 2015. Perhaps of even more concern is that instead of being listed at the top of the table BHP is now below the big four banks. The Commonwealth Bank is at the top of the table with a listed value of $124 billion. And all that the banks make is money, which you can't eat, drink, travel in or live in – a bit of a worry.

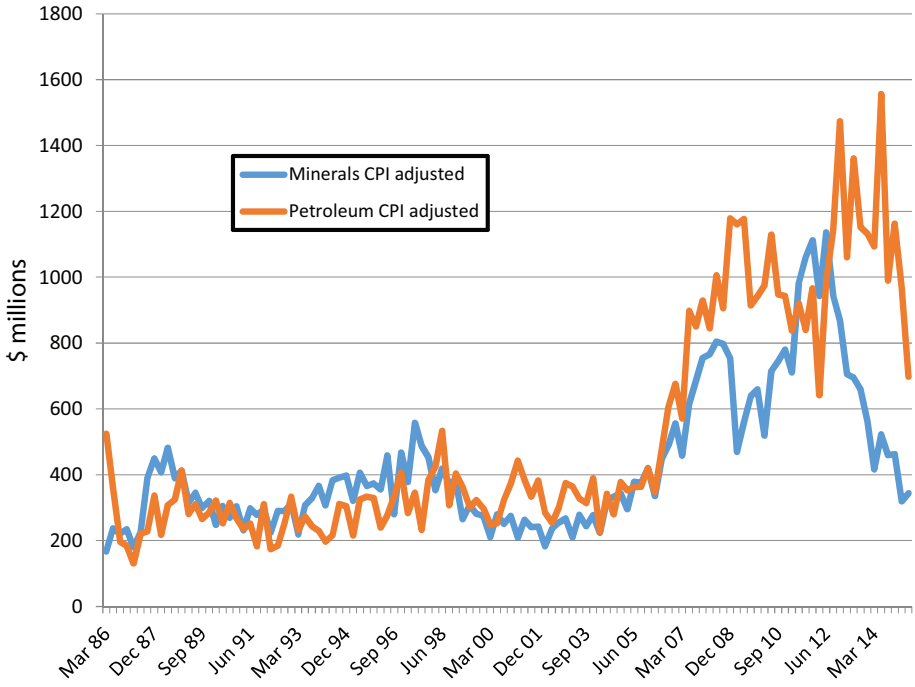

Figure 1. *Actual quarterly mineral and petroleum investment CPI adjusted to 2015 dollars, from March 1986 through June 2015.*

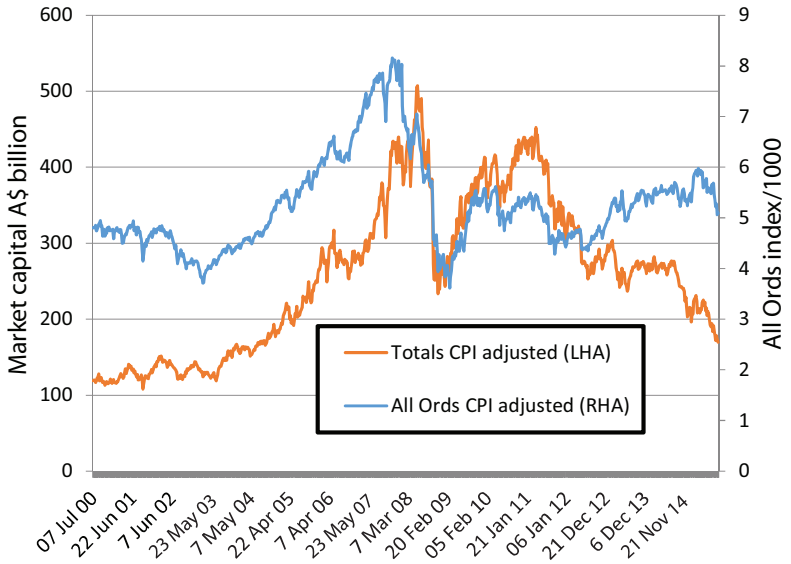

Figure 2. *Market capital of resource companies listed on the ASX from July 2000 through August 2015 (in red) and the All Ordinaries Index over the same period (in blue).*

Education Matters

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New travel grants announced for geoscience

The Australian Geoscience Council and the Australian Academy of Sciences have announced a generous Travel Grant Scheme for sponsorship of 'early career' geoscientists for conferences and study. In announcing the program AGC President Dr Bill Shaw said it is part of the Council's recently published strategic plan to raise the profile of geoscience in Australia.

Dr Bill Shaw, President of the Australian Geoscience Council.

The funding has become available following the highly successful 34th International Geological Congress (the quadrennial 'Olympiad' of the Earth Sciences), which was held in Brisbane in August 2012. The conference represented a huge organisational effort by geoscientists from universities, Geoscience Australia, state surveys and industry. Investment of the conference surplus is expected to fund the Travel Grant program for many decades.

Bill Shaw supplied *Preview* with some further details, indicating that these travel grants may be used to participate in professionally organised geoscientific conferences or conventions, undertake field work in appropriate areas, visit and work with appropriate international experts, or inspect appropriate mines or other geoscientific features such as type localities. There will be around five grants made available each year of between $2000 and $5000.

Further details and application forms are available online at www.agc.org.au. The inaugural round of applications for travel in 2016 closes on 31 October 2015.

The International Geological Congress (IGC) cycle allows us to establish the literary equivalent of a 'time capsule'. I remember that at the previous IGC held in Australia (Sydney, 1974), I and a few other of my senior colleagues were graduate students and members of a team of slaves populating an information desk. In 2012 I had somewhat more of a policy role as ASEG President. We will be watching our current student cohort for suitable organisers for another 'IGC Olympiad' in about 2050.

A challenge to geoscientists today: what are the predicted or hoped-for break-throughs in geosciences before that next IGC in Australia? Let me know, and I'll build a list. I'll start the ball rolling with an item: a quantitative understanding of natural cycles relative to anthropogenic forcings in climate-change modelling. Now it is your turn.

Advance notice – *Preview* summary of the geophysics theses of 2015

In keeping with practice from previous years, *Preview*'s December edition will run a sampling of project titles and abstracts of theses completed in the current year. Make sure you are included! I prefer that supervisors aggregate this information and forward it to me but, if in doubt, students should send me individual items. You never know when your abstract is going to catch the eye of an interested colleague or employer!

SEG and EAGE Distinguished Lecturer Presentations

As advertised in the June and August issues of *Preview*, the following presentations are scheduled in November. See the ASEG calendar in this issue or go to the ASEG website for further details.

18 November – Perth; 19 November – Adelaide; 23 November – Brisbane; 30 November – Hobart; 9–10 November – Canberra:

Hansreudi Maurer, Professor of ETH exploration and engineering geophysics at ETH Zürich, Switzerland, is the SEG's 2015 Near Surface Honorary Lecturer. His topic is 'The curse of dimensionality in exploring the subsurface, with particular application to tomographic inversions of 2D and 3D seismic data.'

http://www.seg.org/education/lectures-courses/honorary-lecturers/2015/maurer/abstract

20 November – Perth, and 25 November – Canberra:

Alessandro Ferretti, CEO of Tele-Rilevamento Europa, Milan, Italy, is the EAGE's visiting lecturer in its international continuing education and training program. His topic is 'Satellite InSAR data: reservoir monitoring from space'; a one-day seminar in radar interferometry (InSAR), which is becoming a standard tool for monitoring surface deformation phenomena. This EET course is intended as a guided tour of InSAR and its applications.

http://lg.eage.org/?evp=10266

Australian Society of Exploration Geophysicists

Australian Specialist's Travelling Education Programme (OzSTEP)

4D seismic reservoir monitoring

Date: October 2015

Who Should Attend: Managers and staff on development and production asset teams; geophysicists, geologists, and reservoir engineers; any others with a science or engineering background, including university students, who are interested in time-lapse techniques to monitor fluid flow in the earth.

Instructor: Prof David Lumley, UWA

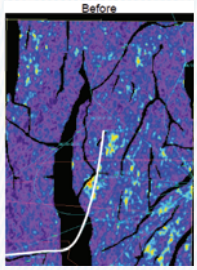
David Lumley is a Winthrop Professor and Chair in Geophysics, jointly appointed to the School of Physics, and School of Earth & Environment, at the University of Western Australia (UWA). He is also the founding Director of the UWA Centre for Energy Geoscience research. Prof. Lumley has published 150+ refereed journal papers and expanded abstracts, and is the lead or senior Chief Investigator for over $130 Million in competitive research grants. He is a physicist with a focus on geophysical energy and environment applications, with prior research and operations roles in industry (including Chevron Research), and academic institutions (including Stanford University, PhD '95, and the University of Southern California). David has significant business owner experience as the Founder and Chief Scientist of 4th Wave Imaging Corp., a 4D seismic technology company purchased by Fugro in 2007. Prof. Lumley actively participates with international scientific societies such as ASEG, SEG and AGU, where he has served as a chairman and organizer of various scientific committees and workshops, and was elected as First Vice President of the SEG (2009-10) representing 35,000 members worldwide. David has served as an international Distinguished Lecturer for the SEG, SPE and AAPG societies, and has received several scientific honors including the first SEG Karcher Award for his "pioneering work in developing time-lapse 4D seismology" to image subsurface fluid flow. Prof. Lumley serves as an expert adviser to industry and government organizations, including the Western Australia state government for regional exploration and development of hydrocarbons, geothermal energy and CO2 storage, and the US National Academy of Sciences.

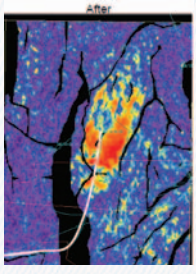
Course Outline:

This 1-day course is a practical overview of the most important theory, concepts and methods used in the modeling, design, acquisition, processing and quantitative interpretation of time-lapse 4D seismic data. Lecture topics include:

- 4D Rock and Fluid Physics, and various approaches to time-lapse 1D/2D/3D Seismic Modeling, to quantify how physical changes in the reservoir respond as changes in seismic data. This is useful for predicting the strength of the 4D signal, designing 4D seismic surveys and processing flows to enhance 4D signal and reduce 4D noise, and quantitatively interpreting 4D seismic data in order to estimate changes in reservoir properties such as fluid saturation and pore pressure.
- 4D Seismic Acquisition and 4D Processing techniques, to quantify non-repeatable 4D noise and suppress it, and to enhance real 4D seismic signal in the reservoir.
- 4D Quantitative Interpretation techniques to detect and analyze reservoir fluid flow anomalies, and to quantify them in terms of changes in pressure/saturation and other reservoir properties, using both qualitative and quantitative methods, including inversion.
- Monitoring aquifer drive and injected fluids such as water, gas, steam and CO2, locating bypassed hydrocarbons, identifying reservoir compartmentalization, and quantifying the hydraulic properties of faults (seals, leaks, baffles).
- Integration of 4D seismic information with geologic and engineering data to update the reservoir fluid flow model so that predictions of hydrocarbon recovery and fluid injection match the actual production data better ("4D seismic history matching").
- Time permitting… advanced 4D seismic topics including compaction, geomechanical stress, anisotropy, 4D FWI (full waveform inversion), passive and ambient noise seismology, 4D gravity.
- Many case study examples from around the world, both onshore and offshore, including primary depletion, water or gas injection, steam flood, and CO2 storage.

4D Seismic Pressure Anomaly





Australian Society of Exploration Geophysicists

Australian Specialist's Travelling Education Programme (OzSTEP)

Potential fields: a (re)introduction for geophysicists and geologists

Date: October 2015

Who Should Attend: geophysicists who wish to update/expand their appreciation of the use of potential field techniques; geologists who use gravity and/or magnetic data in mapping, exploration or interpretation (or who should do so!).

Instructor: Bob Musgrave, Geological Survey of New South Wales

Bob Musgrave is the Research Geophysicist with the Geological Survey of NSW. Bob graduated with a BSc (Hons) from the University of Sydney in 1981, majoring in geology and geophysics. Bob went on to complete a PhD (1987) at the University of Sydney in palaeomagnetism. Bob's interests in tectonics, palaeomagnetism and magnetic petrophysics led him through post-doctoral fellowships at Victoria University of Wellington (1987), the Australian National University (1988-89), and the University of Tasmania (1989-91). Bob went on to join the Ocean Drilling Program, based at Texas A&M University (1991-93), and to date has sailed on 5 ODP/IODP expeditions, the most recent in 2014. Returning to Australia, Bob was a Senior Lecturer in geophysics at La Trobe University until 2003. Bob was then a Senior Research Fellow at Macquarie University, before joining the Geological Survey of NSW in 2005. Bob is currently also a Conjoint Senior Lecturer at the University of Newcastle and an Honorary Associate of the University of Sydney. 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. His research has yielded more than 50 peer-reviewed publications.

Course Outline:

Prerequisites: basic geology. No prior geophysical training is necessary, and the maths will be kept "light", so the course should be accessible to all geoscientists – but there will be the opportunity for more sophisticated discussion for those with established skills in geophysics.

Session 1 - Basics:

- Course overview and scope
- Basic form of potential field anomalies
- Data acquisition
- Scalar, gradient and tensor data. Earth's gravity and magnetic fields

Session 2 - Physical properties :

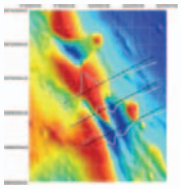
- Density and magnetic susceptibility
- Remanence
- Magnetic properties and mineralisation
- Microbes and magnetic diagenesis

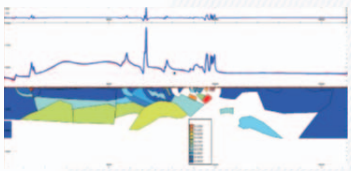
Session 3 - Data presentation and filtering :

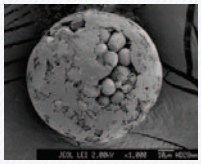
- Derivative filters; phase filters and the tilt filter.
- Edge analysis ("worming").
- Euler depths; spectral depths. Curie depth.
- Isostatic correction.
- Tensor and gradient data interpretation.

Session 4 - Potential field inversion :

- Source mapping; derivative maps; inferring lithology.
- Direct inversion, and its limitations.
- Geologically constrained inversion.
- Remanence and inversion.
- Case studies.







Australian Society of Exploration Geophysicists

Australian Specialist's Travelling Education Programme (OzSTEP)

AVO and inversion methods in exploration seismology

Dates: 2nd Nov (Perth), 4th Nov (Brisbane) and 6th Nov (Melbourne)

Who Should Attend: Geoscientists with a solid background in exploration seismology who wish to broaden their knowledge of AVO and inversion methods and their applications.

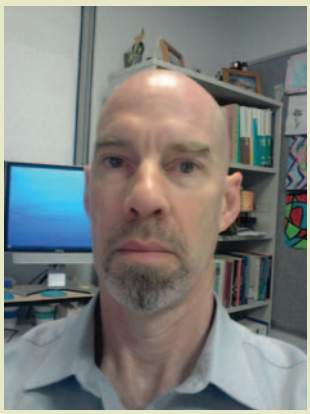
Instructor: Dr Brian Russell

Brian Russell graduated from the University of Saskatchewan (BSc) in 1973 with a major in physics, and received a BSc (Hons) (1975) at the same university, a MSc in geophysics from Durham University (1978), U.K., and a Ph.D. from the University of Calgary (2004), all in exploration geophysics. He joined Chevron as an exploration geophysicist in 1976 and subsequently worked for Teknica and Veritas before co-founding Hampson-Russell Software with Dan Hampson in 1987. Hampson-Russell is now a subsidiary of CGG, where Brian is Vice President, GeoSoftware and a CGG Fellow. Brian is involved in the development of new AVO, rock physics, inversion and seismic attribute techniques as well as presenting courses throughout the world. He is a past-President of both the SEG and Canadian SEG (CSEG) and has received Honorary Membership from both societies, the CSEG Medal and the Cecil Green Enterprise Award from SEG. He is currently Chairman of the Board of the Pacific Institute for the Mathematical Sciences (PIMS), an Adjunct Professor in the Department of Geoscience at the University of Calgary and at the School of Energy Resources at the University of Wyoming, and is registered as a Professional Geophysicist (P.Geoph.) in the Province of Alberta.

Course Outline:

- Part 1: The rock physics basis of AVO and inversion
- Part 2: Post-stack seismic inversion and wavelet analysis
- Part 3: Pre-stack inversion and AVO methods and case studies.
- Part 4: Azimuthal amplitude and velocity analysis for fracture determination.
- Part 5: Stochastic inversion methods.
- Part 6: Applications to unconventional plays.

Webwaves



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A new webmaster for the ASEG

In addition to some excellent talks and workshops, this year's ASEG-PESA conference in Perth saw much lobbying behind the scenes. Some of the results of that lobbying have already been seen in the form of new *Preview* columnists for Education (Mike Asten) and Environmental Geophysics (Mike Hatch), and there may be more to come. I was fingered for the job of webmaster but it was recognised, by virtue of the work undertaken by previous webmasters, that the load might perhaps be better spread over a committee than shouldered by an individual. So, although I have title of 'webmaster' and will write the Webwaves column for *Preview*, three others share the administration and will help to chart the direction of the ASEG's website. They are Karen Gillgallon (SGC), Ian James (Terraspect) and Chris Bishop (Geosoft). I will introduce myself this time around and no doubt they will introduce themselves at some stage in the future.

My current employer is CSIRO and I'm employed as a scientist researching applications of electromagnetic surveys in their various forms to problems ranging from CO_2 sequestration, to groundwater, to massive sulphide exploration. I'm an experimentalist and forward modeller by inclination, but find myself more concerned with inverse modelling, increasingly with a Bayesian perspective. I've been fortunate to have been able to intersperse study and research with the odd visit to the real world.

The so-called world-wide web is ubiquitous. From its initial restriction to academics and military personnel, it is now used by much of the planet on a daily basis. Part of that web, the ASEG's website, needs to operate in such a way that it fades into the background – however it is used. Despite the sterling efforts of previous webmasters it is fair to say that we have yet to reach that point. However, a site that does not impede visitors doing what they came to do is not an unreasonable goal.

In addition to the paramount task of handling membership renewals and wine orders, the website is designed to serve information. The committee has started to address how information that might be of interest to the ASEG's Members might be more accessible. We will also be adding to the website's content. Some of these additions have already been made and Members been notified through the news feed on the ASEG website's main page. Videos from Ken Witherly's 'More than bumps' seminar from the 23rd International Geophysical Conference and Exhibition held in Melbourne in 2013 have been added. Ken and John Hart have also made available, in video and hardcopy, the contents of their very successful 'Geophysical signatures of mineral systems: more than bumps' workshop held at this year's ASEG conference. This workshop is also summarised in this edition of *Preview*.

An addition, and of particular interest, is a session at the 24th International Geophysical Conference and Exhibition held in Perth earlier this year. The late Tuesday afternoon session was themed 'Atomic Dielectric Resonance'. In what we hope is a trend (challenge ...) for future ASEG conferences, both the technical presentations and the following Q&A session were videoed. These 90-minute videos were made available to the public on YouTube and, after one month, only one has not been viewed at least 10 times. These videos are available through the YouTube button at the base of each page on the ASEG website or from YouTube by searching for 'ASEG Videos'.

Other planned additions to the website include documentation of the historical aspect of our profession. Digital copies of manuals for some of the older instruments could potentially be a valuable resource. Although the electronics may be fried and the manufacturer has ceased to trade, the data collected using older instruments may remain viable, and it may be that the manuals are the key to unlocking useful information. The History Committee would welcome donations of manuals for old instruments. The manuals will be scanned and made available to all Members.

We also hope to resurrect the forums section of the website. With enough subscription such a forum could be a valuable resource for all of us.

Environmental Geophysics

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Welcome to *Preview* readers this month. In this column Dave Walsh, president of US-based Vista Clara Inc., introduces some new geophysical tools that Vista Clara (VC) have developed to measure water content in the very near surface. VC has been producing state-of-the-art geophysical tools that use nuclear magnetic resonance to detect water in the subsurface. The instruments that he is introducing here are unique in their ability to characterise the shallow unsaturated zone both for water content as well as for relative pore size, with minimal to no physical disturbance of the soils in the zone of investigation. This work was done in collaboration with Ken Hurst Williams from Lawrence Berkeley Laboratory (US DOE); their interest was to develop tools for monitoring carbon cycling in near surface soils.

Portable nuclear magnetic resonance tools for measuring and monitoring soil moisture

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Soil moisture content, and its distribution in space and how it changes in time, has a critical influence on processes in the natural world ranging from land surface evolution to ecosystem development, carbon cycling, climate variation, groundwater recharge and groundwater flow. There is a particular need for sensors that measure soil water content non-invasively. Invasive measurement techniques, like gravimetric measurement of soil samples, can cause significant disturbance of the sample under investigation and these disturbances can lead to significant errors when estimating volumetric water content. Other types of sensors that require electrical or physical contact with subsurface soil are also affected by other similar, difficult to quantify errors due, for example, to disturbance or displacement of soil during or after emplacement of the sensor. For example, when measuring soil moisture content within or beneath paved surfaces, invasive soil moisture measurement is either impractical, or causes unacceptable damage to the structure under investigation. Invasive sampling and/or measurement methods can also introduce artefacts, such as the creation of artificial paths for fluid migration, thereby confounding robust quantification of time-varying moisture dynamics. Non-invasive approaches avoid these effects entirely.

Nuclear magnetic resonance (NMR) is a non-invasive physical measurement that is widely used in medicine (Liang and Lauterbur 1999), oil and gas development (Kenyon et al. 1988), and more recently groundwater hydrology (Walsh 2008, Walsh et al. 2012, 2013). NMR measurements are based on the detection of the weak magnetic moment that is present in the hydrogen protons of each H_2O molecule. When placed in a static magnetic field B_0, the magnetic moments of individual hydrogen protons align weakly in the direction of the static field. This causes the water sample to exhibit a small magnetic moment. To detect the magnetic moment of the water, a perpendicular, alternating magnetic field B_1 is applied to the sample at a specific frequency, causing the individual proton magnetic moments to rotate in phase about the static field axis and tip away from the static field axis. When the alternating field B_1 is turned off, the magnetic moments from the hydrogen protons continue to rotate in phase about the static field axis, generating a circularly rotating magnetic moment that can be detected using a nearby induction coil. The detected NMR signal (or spin echo train) generally exhibits a multi-exponential decay in the time domain, and the signal magnitude and time constants derived from this signal are used to characterise water content in saturated and unsaturated soils. The initial signal amplitude is directly proportional to the total quantity of water – i.e. the total volumetric water content. The signal decay rate reflects the geometry of the pore environment, with fast-decaying NMR signals indicating water in small pores, and slow-decaying NMR signals indicating water in large pore sizes. As a practical matter, to accurately detect and measure water content in unsaturated soils, it is important that the NMR measurement is able to detect the fast decaying early time signals.

To meet the increasing demands for fast, accurate and high resolution measurement of soil moisture, we developed the modular Dart and Discus NMR soil moisture tools. This family of man-portable NMR instruments, shown in Figure 1, includes a battery powered NMR control unit, a small diameter in-situ NMR probe ('Dart'), and a non-invasive NMR sensor that sits on the ground ('Discus'). The NMR control unit includes a high speed data acquisition

Figure 1. *Portable nuclear magnetic resonance (NMR) soil moisture instruments. Left: 4.45cm diameter 'Dart' NMR soil moisture probe with control unit. Right: 'Discus' non-invasive NMR soil moisture profiling sensor.*

system and compact RF amplifier, and is powered by internally housed batteries. The Dart NMR probe is designed for measurements in small temporary soil core holes, up >30 m in depth (depending on cable length). The Dart probe has a diameter of 45 mm, and senses water content in two thin cylindrical shells at a distance of about 5 cm from the outer surface of the probe with a vertical resolution of 25 cm. The Discus sits on the ground, collecting data on water content at four distinct depth zones ranging from 5 cm to 20 cm. Both sensors collect NMR data with an echo spacing of less than 500 microseconds; fast enough to measure water content in almost all naturally occurring soil types. Typical measurement times for these tools range from 3 to 10 min per location. Figure 2 shows an example of data collected using the Dart, highlighting the raw data and some of the information available from the reading.

Since their commercial introduction in 2014, the Dart and Discus tools have been used by government and industry users for soil and shallow aquifer investigations in the US, Australia, Canada and Europe. A larger 1.0 m Discus sensor is presently under development, and will be capable of non-invasive soil moisture measurements to depths up to 0.5 m. A multi-coil Dart probe is also currently under development that is intended to be used for long-term, multi-level monitoring of soil moisture content.

Acknowledgements

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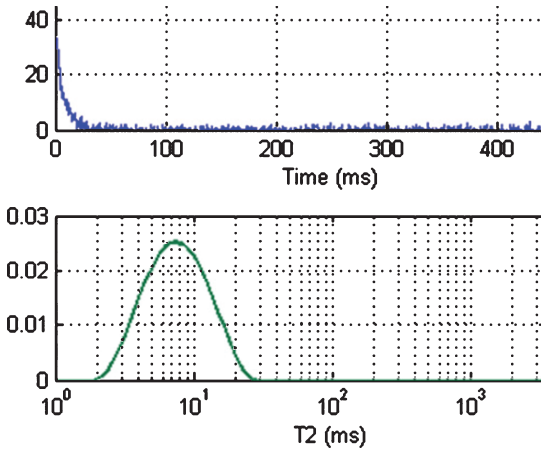

Figure 2. *Typical raw signal decay and multi-exponent fit for data collected in saturated fine grained sediments using the Dart system. Total water content is estimated at ~40%, while mobile water content is <0.1%.*

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Seismic Window

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Contours, maps and visualisation

Early in my career I learnt to hand contour maps. It was a skill that is still useful today. Contouring was a therapeutic pastime and was commonly done on a Friday afternoon after a long lunch at one of Adelaide's many watering holes (and often repeated on Monday mornings). Unfortunately, long lunches and hand contouring disappeared at about the same time – is there a link?

Contouring can be fun. My first job out of university was with Geoex in Adelaide. One project involved flying a large aeromagnetic survey out of Broken Hill. It covered a huge area and the data to be contoured was posted on large sheets that were spread over a good sized table. Around the table were a number of keen new graduates, including me. We spent several days contouring these sheets under the supervision of John Haigh. The challenge was to contour an animal or fish into the map sheet without anyone noticing. I'm not sure they all got through but it would be interesting to hear from anyone that has an aeromagnetic map with fishy contours.

I am led down this path by an email I received from Scott Tideman of Petrosys* following one of my articles last year. Scott says that 'an increasing number of senior managers are regularly seeing poorly-produced subsurface maps' so he set about working with clients to improve mapping standards. Test your skill with the example challenge at http://www.petrosys.com.au/improving-mapping-standards/.

Alternatively you can have a go at the simple example in Figure 1 (answers later).

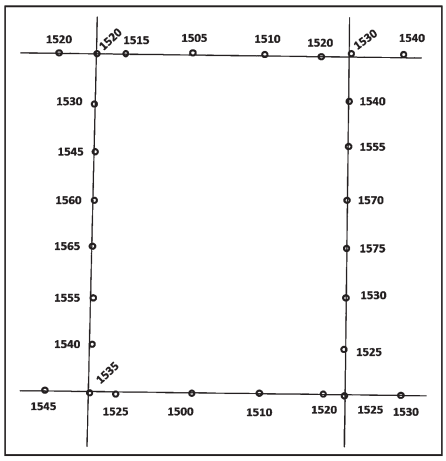

Figure 1. *Contouring exercise – hand draw some contours on this figure.*

I agree with Scott. I see a lot of maps and some are shockingly bad even today when almost all are computer generated. But it's not just about making maps. Maps are a tool to help evaluate an area's prospectivity but, as the VP of one large independent quoted by Scott says 'The prevalence of 3D seismic has left many geoscientists unable to conceptualise and portray geological structures in areas without 3D. An unskilled geoscientist simply makes grids and contours that portray the available data, and will regularly fail to recognise prospectivity'.

Perhaps the physical exercise of hand contouring our maps in the past allowed us time to think of the various options, formulate ideas and test them 'on the fly'. Certainly, all our work was checked by the team leader and chief geophysicist before being sent off for drafting. Unfortunately, these QC steps are often missing with the lean organisations of today.

But are contours relevant in today's exploration office? Maps are being replaced by 3D models from which colourful displays are extracted to give a better representation of the subsurface. The viewing angle of these displays can be varied to give the best possible representation of the structure or attribute. For example, the colour rendering of Figure 2 shows the possible distribution of sandy facies and the rendered surface gives the structural setting. In this case the structural surface is interpreted to be a deltaic prograde with fan sands (pink, orange) deposited in front of it after being transported down one of the incised feeder channels that can be seen snaking across the top sets (blue). It would be difficult to convey this information so easily on a contour map.

The latest technology can also be annoying. Often geos like to display surfaces from varying angles to keep us guessing the viewing direction. This is usually combined with a short display time so that the next picture is presented before the viewers can get their bearings. By convention north is at the top but Nintendo geos ignore this to confuse us (or provide the best angle). As my geography teacher once told me 'Every map needs four things otherwise it is just a picture: a title, a scale, a north indicator and a legend'. I must admit that most maps I make these days would not meet her approval. (At about the same time my English teacher also taught me a sentence has to have a verb – but that was last century.)

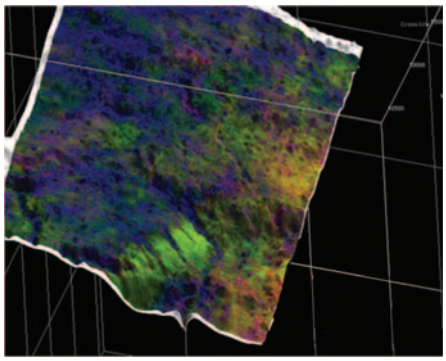

Figure 2. *3D rendering of a prograde surface and colour rendering highlighting possible sandy facies. (North indicator deliberately removed).*

Back to the exercise – if you contoured a syncline or low in the example of Figure 1 then your answer is correct. This example is from my time teaching at Curtin University and 80–90% of students contoured a low. Perhaps a more correct answer, definitely a more optimistic one, is a contour map showing an anticline.

Exploration is for optimists and 'Creating a quality map is about a lot more than just pushing buttons; having the right skills and tools is vital to the success of our business' says the Chief Geophysicist of a large exploration company.

*Disclosure: I have been using Petrosys mapping software for over 30 years – it's a great Australian product.

Data Trends

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Father's Day

In my column this month I will once again attempt to walk the thin grey line between what technical readers want to read and what I actually feel like writing about. Being non-technical by nature, I prefer to make fun of 'technical stuff' as a way of disguising my lack of intellect. Long integers and simultaneous equations are easy targets, so why not take advantage…right?

But this month I am not going to make fun of hapless numbers, instead I am going to talk about a complex matter sure to delight the technical few who read on. This article covers an area that I am more familiar with than most, and I feel no need to hide my lack of intellect or to make fun of the subject. I should add that the idea for this article came to me on Sunday 6 September – Father's Day.

To preface this – I am the father of five children, have been married for 25 years, and am 46 years old. Three of my children are boys and two are girls and their ages range from 4 to 15 years old. I work in the oil and gas industry, and I struggle every minute of every day with this subject. End of preface.

I am going to talk about the data trends we are seeing in 'work life balance' in the oil and gas sector. Like many things in life, it can take a hard knock to the head before you start to see the wood for the trees, especially when looking at a subject you have been immersed in for a long time. You think that after all your years of being a husband or wife and parent that you must know how the whole thing works – but when it comes to kids and marriage nothing is certain or predictable. I have received many hard knocks to the head in my life, and if you have ever had the displeasure of meeting me, you would have been confronted with the visual evidence of these as I approached.

My most recent smack to the cranium came in the form of a beautifully written Father's Day card sitting on my bedside table on Sunday morning. The card, written by my 14 year old daughter, detailed a story that she recalled about the two of us when she was 4 years old. She printed a photo of me holding her as a baby for the front cover and put glitter and sequins around the outside of it – the card clearly took some time to make and for that work, I was very grateful.

I sat in bed on Father's Day with my token cup of 'coffee in bed' looking at the photo for quite some time and wondered where all the time has gone? This drilling programme, that project, this new venture, and that conference I attended – all occupying the time that could have been spent on the loved ones – the ones that really matter when you reflect. I began to think that she chose to write about that single event because there was nothing else she could write about that we had done together in the last decade and, scariest of all, I had a sinking feeling that she might be right.

So many studies show that work life balance, particularly in the declining oil and gas sector, is not trending towards improved quality of life. In fact, the decreasing workforce in the oil and gas sector is seeing many of us working harder and longer to ensure we can survive the market conditions and budget cuts. We hope to be one of the lucky few that get to keep our jobs. Sadly, budget cuts in major oil and gas companies often don't take into account how hard anyone works. Further to this, in an article I wrote previously for *Preview*, I suggested that new entrants to the industry get very focussed on their role and find a niche to make themselves indispensable. Working smarter, not harder is the measure that many larger companies look for in the quality of their employees.

This great quote by Brian Dyson, former CEO of Coca Cola, is one that after 25 years in the industry I am only just starting to get: 'Imagine life as a game in which you are juggling some five balls in the air. You name them – work, family, health, friends and spirit – and you're keeping all of these in the air. You will soon understand that work is a rubber ball. If you drop it, it will bounce back. But the other four balls – family, health, friends and spirit – are made of glass. If you drop one of these, they will be irrevocably scuffed, marked, nicked, damaged or even shattered. They will never be the same. You must understand that and strive for balance in your life.' So further to this quote, he offers a quote that rounds out this article very nicely. Even in this industry of decline and uncertainty, one must 'work efficiently during office hours and leave on time. Give the required time to your family, friends, and have proper rest.'

If even one person who reads this goes home on time as a result, even if it is just for one day this week, I will be one happy chappy.

ASEG Members Questionnaire: results

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The response to the recent ASEG Membership Questionnaire was excellent, with 340 people participating. The first order results of the Questionnaire are shown in Figures 1–10 and Table 1. A number of highlights from the survey are summarised below.

Results from Question 1 of the survey show that Members highly value ASEG conferences, publications, and State Branch technical events (Figure 1). The most highly requested additional benefit is online access to material from ASEG events such as technical meetings, training courses, workshops and conferences. Other popular suggestions included mentoring and networking opportunities for early career geophysicists, improvements to the accessibility and useability of the website, increased continuing education opportunities and a range of employment support options (Table 1). A number of already existing benefits were also mentioned such as scholarships for students, these are currently awarded through the state branches on an annual basis, and removing charges for colour pages in *Exploration Geophysics*, which was addressed 2 years ago.

A number of questions were asked regarding attendance at State Branch technical events, time spent outside of Australian capital cities, and reasons for non-attendance at events. This data has been broken down on a state by state basis, over 50% of SA and ACT respondents attend more than half of the technical events with NSW not much further behind at 40%. The information on reasons for non-attendance will be used by the State Branches to help with the planning of future events.

Questions 9 (Figure 8) and 10 (Figure 9) regarding future and current careers revealed that over 60% of respondents are currently permanently employed and 57% of respondents are planning on continuing as practicing geophysicists. Finally feedback on future OzSTEP courses showed good interest in a wide range of topics, especially Potential Fields, and Electrical and Electromagnetic techniques (Figure 7).

The results from the survey provide key insights into the current ASEG membership and will be discussed in further detail at the Federal Executive strategic planning meeting in September. The ASEG would like to thank everyone who participated for taking the time to provide input.

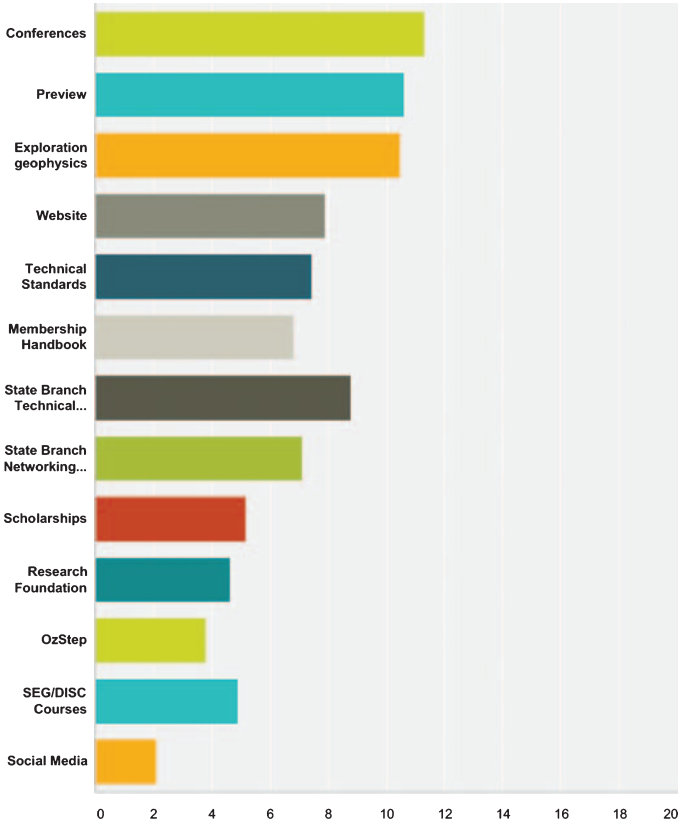


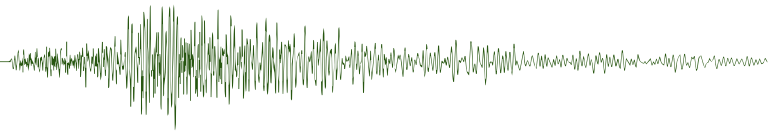
Figure 1. *The response to Question 1 'Please rank the following ASEG benefits in order of importance to you' (n = 340).*

Table 1. The response to Question 2 'List the benefits that you would like to see the ASEG introduce' (*n* = 340)

ASEG mobile app to access technical notes on the go
Record technical talks and post them online for members who cannot attend the meetings. More networking opportunities that encourage newer members to meet people in the industry
A blog to discuss and ask questions
A good web site, please!
A mentoring or buddy program might be good for students/early career Members to be mentored or buddied up with more experienced Members
A national geophysics lecture series that can be viewed on-line
A website that is current and contains information that one would expect from a society
Access to ASEG and SEG journals

Table 1. *Continued*

Access to more articles. Technical support group (for theory & software)
Access to on-line SEG publications
Access to other societies' publications
Affiliate membership fee discounts with other societies
Affiliation with EAGE
Am happy with what ASEG offers
An app for smartphones/tablets that allows you to access ASEG webpage features such as membership details and publications
Anything to encourage involvement from junior geophysicists
As I understand it, a portion of my dues goes to local Branch, but as an international member, I do not receive any benefit from this. How about reduced dues?
ASEG mobile app for easy access to journal articles, account details and registering for technical nights
ASEG provides quite a comprehensive service for its members
ASEG should continue to support AGC and be a member of STA so that we can provide input to science policy issues
Australian lecture tours
Better conference discounts
Better federal and state representation for the group as working professionals, support for small businesses and consultants
Better student development
Better talks
Book offers
Books
Career events
Career Prospects/advertising
Central support for technical meetings – for instance sponsoring say 2–3–4 travelling speakers each year
Centralised website for information regarding scholarships
Cheaper conference attendance of student/academics
Cheaper conferences – they have become expensive. All good if your employee pays but not so good for self-employed people. The cost of travel, accommodation and the conference is expensive. They used to be focused on the technical program
Cheaper conferences, but increase membership costs to offset
Cheaper courses
Childcare at conferences to make attendance possible
Conference
Conferences every 12 months
Courses in developing Pacific Island States and Territories
Current benefits are fine with me
Decent website and useable membership login facility
Digital database of publications
Discount arrangements on work equipment such as PPE etc.
Discounted print library à la SEG
Discounted sister society conference registrations
Discounted technical books/publications
Download/recording of Technical nights/events, for Members who live/work remotely
Drop/reduce colour charges for publications
Each Exploration Geophysics Volume in a Single PDF file
EAGE Access. Live stream of technical night talks
Emeritus
Emeritus membership
Employment board
Employment opportunities
Employment stats, salaries, charge out rates



Endorsement of accreditation through AIG rpgeo Scheme More combined symposia or workshops with sister societies

Fellowship

For ASEG to be more vocal about the threats to Member careers from misinformation in the public arena

Free t-shirt with subscription

Further co-events with other membership bodies such as Geological Society of Australia or PESA

Geophysical and related software or software maintenance discounts

Get the website working properly, PARTICULARLY THE MEMBER DATABASE

Graduate job board

Greater access to journals and abstracts

Greater flexibility to watch or get information on technical talks when not able to attend. Access to digital archives of previous workshops presentations etc.

Hands on experience for students

Happy with present, and I would like to get to the next screen

Have all workshops/training and meetings recorded and available for viewing on the internet (either live or after the fact)

History website

I have always found the collaborative social events with ASEG/PESA valuable for networking/keeping in touch

I think ASEG is doing just fine

I think it's pretty good as it is...

I would like to leave this blank but it won't let me

I would like to see more cross-discipline events – events where geology and geophysics are seen as an integrated whole

Improve the integration of ASEG publications into the SEG Cumulative Digital Index. Currently it doesn't seem to find any articles from *Exploration Geophysics*, and only finds very old ASEG conference abstract

Improved web site with easy access to technical material prepared for both members and the general public

In the down turn, there are likely to be several or even many geophysicists with time on their hands. Perhaps some sort of Geophysicists Without Borders program could be established?

Info on child friendly places at or near conferences and similar events

Insurance, courses

Internships

It is ridiculous that an answer to this question is mandatory

It would be interesting to see a section in Preview tailored to students, like: Handy Tips from Practicing Geophysicists etc.

It would help me if I could renew my membership for more than one year at a time

Job advertising section on the ASEG website? Opportunities within the industry for work or research?

Job notice board

Joint membership to partner societies (SEG/EAGE?)

Library access

Linking old fogies with youngies

Links to other organisations

Local SEG/DISC courses more than once a year

Lower fees $148 is lot for what I get, and more than SEG or AIG

Lunchtime technical and social local state events

Membership card in print form

More casual networking events

More early-career networking events

More focus on employment opportunities and training

More golf days

More half-day technical presentations within the Brisbane region

More in-depth information about different career pathways for students

More Intersociety collaboration

More media presence promoting the industry. Political campaigning to support industry

More online training courses

More petroleum focussed articles in Exploration Geophysics that are more interpretation based than acquisition and processing

Table 1. *Continued*

More social evenings
More sponsorship facilities for students
More things related to employment
More wine offers
Negotiated discounts on car hire and accommodation
Networking events during lunch hour
Networking events not involving golf
Networking functions
On campus talks
Online access to SEG material
Online or web-based short courses or webinars
Online webinars
Option of fee reduction if elect to get journals digitally rather than hardcopy
Papers on the geophysics new conference information
Perhaps an event such as: informal expo/demo rather than lecture combined with social event (food, drinks)
Perhaps group discount for technical software?
Polo shirt
Portraying ASEG as a scientific society (in addition to a technical and professional society) may be a good idea
Professional indemnity insurance discounts for Members
Professional qualification
Professional standards
Receive the SAGA newsletter, and the same from the Brazilian SEG (do they publish one?)
Record of talks given
Reduce book prices
Reduced cost for membership
Reduced membership fees for the unemployed
Reduced memberships for women on maternity leave. Childcare options for conferences. Child friendly Branch events
Reduced rates for under-employed
Regular meetings in Tasmania
Reintroduce free tickets to opening function for exhibitors
Research foundation
Retail discounts
Same affiliation into the EAEG journal as per SEG
Scholarships (on list but not actually in existence to my knowledge)
Single-day training courses, maybe associated with a Uni, but with recognised practitioners
Special events with more connection between academia and Industry would be great
Sponsor overseas students
Sponsored conference attendance under certain conditions (academic achievement, booth duty, ASEG volunteer record, etc.)
Sport (Active) social events, especially during the conferences. Also, good suggestion would be to have, maybe every first Thursday in the month some kind of active social gathering (cycling, golf...)
State Social days/networking opportunities
Student chapters and contests my (non-Australian) students could do
Student help
Student support/networking
Subsidised/part subsidized ASEG branded shirts/caps to wear representing the ASEG. Outreach to encourage young geophysicists - payment to conferences for exchange to help with ASEG work
Talks/Conferences within easy reach from my location e.g. visiting lectures
Tech nights be attend by web video
Technical specialist groups

Technical information

Training Courses

Training for Members on how to get value and use social media successfully

Unemployed active Member concessions at Conferences

Video link for conferences/presentations

Visiting lecturers

Web casts of events

Webcast video links to ASEG conferences and state technical meetings

Webinars/web-based training platform

Webinars from the technical meetings

Webinars. A library of recorded talks for download and listening to

Would be nice to see some Member only benefits or advance access to something for being a Member

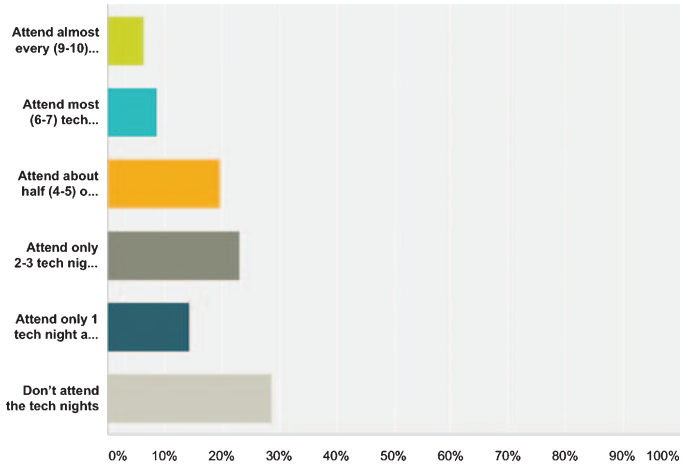


Figure 2. *The response to Question 3 'How often do you attend local State Branch Technical Events' (n = 340).*

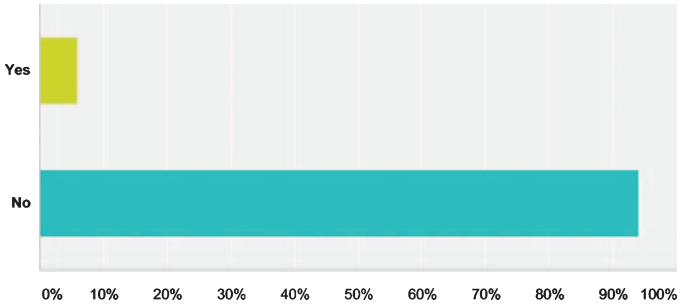


Figure 4. *The response to Question 5 'Would childcare facilities at conferences influence your ability to attend?' (n = 340).*

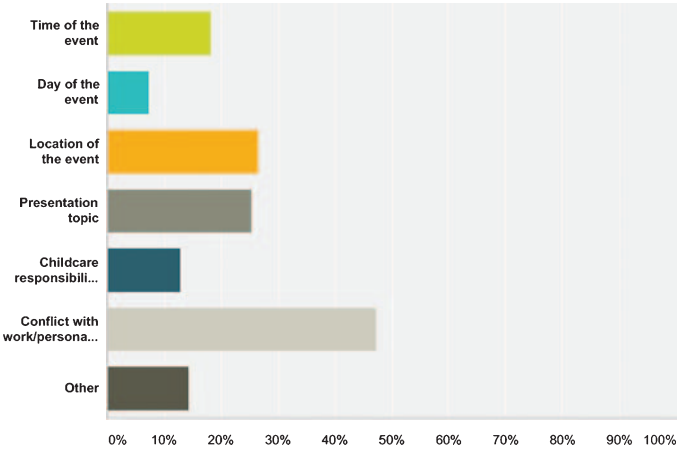


Figure 3. *The response to Question 4 'Which of these reasons prevent you from attending more events?' (n = 324).*

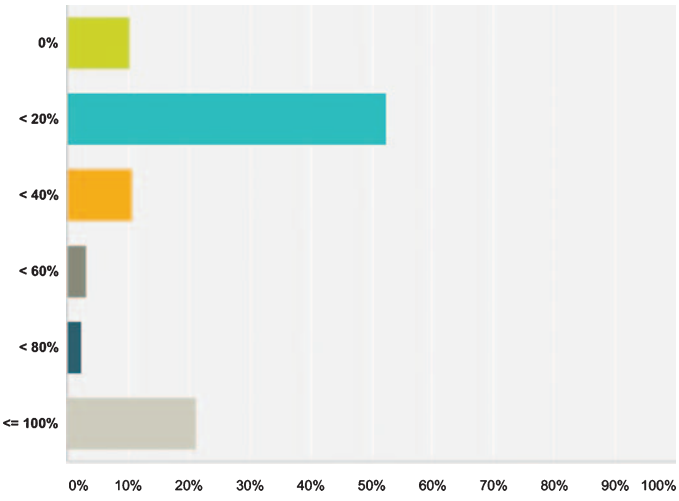


Figure 5. *The response to Question 6 'What proportion of each year do you spend outside of Australian capital cities?' (n = 340).*

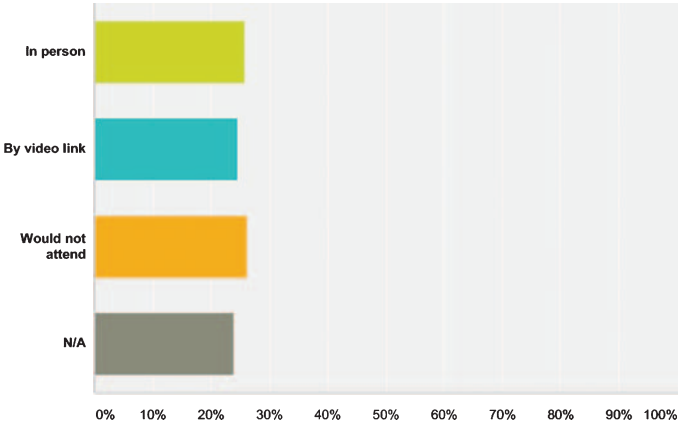


Figure 6. *The response to Question 7 'Would you attend events outside of Australian capital cities if offered?' (n = 340).*

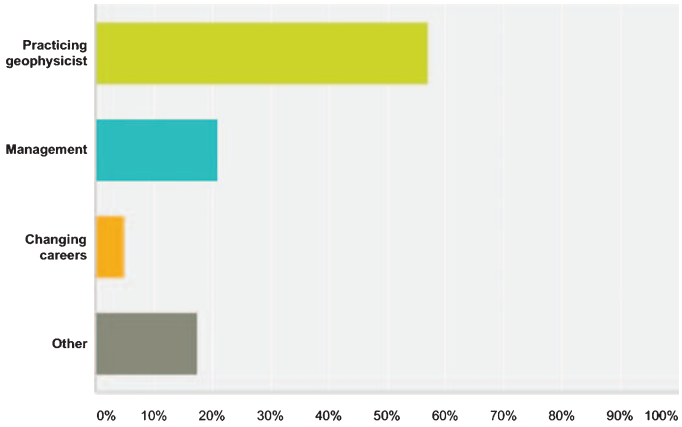


Figure 9. *The response to Question 10 'Please select the following options that best describe your current and future career: Future career –' (n = 340).*

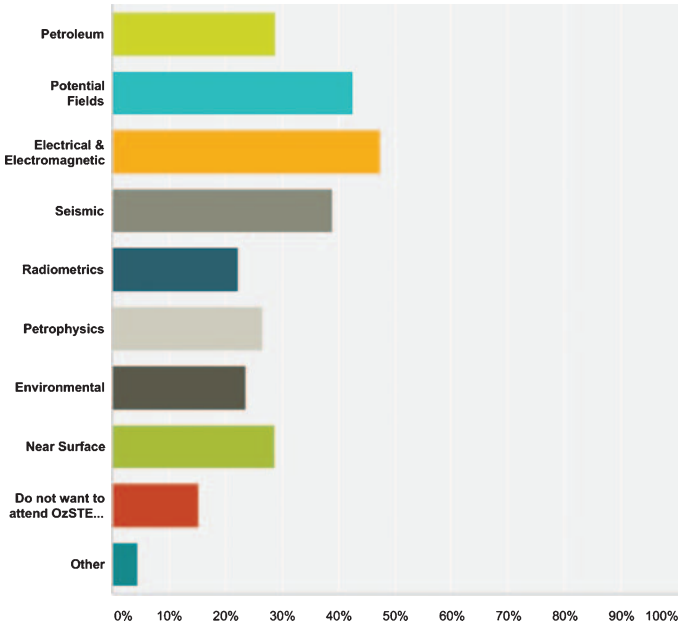


Figure 7. *The response to Question 8 'Which topics would you attend as an OzStep course, please select all that apply' (n = 340).*

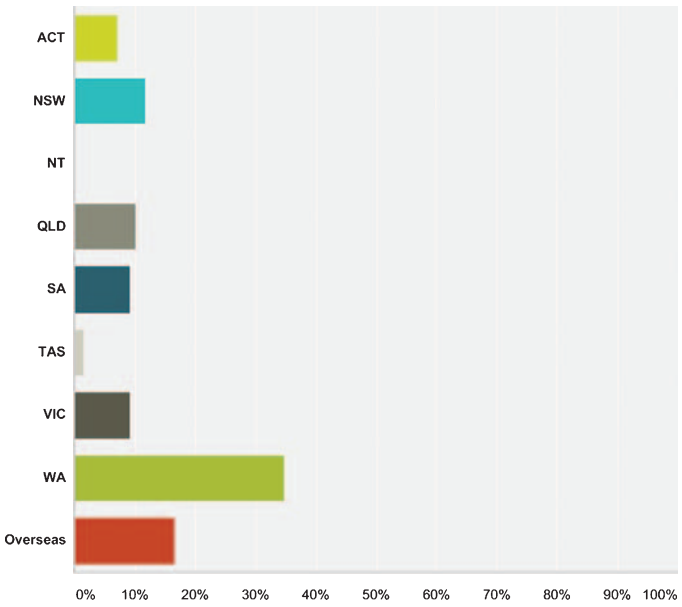


Figure 10. *The response to Question 11 'In which state is your Membership held?' (n = 340).*

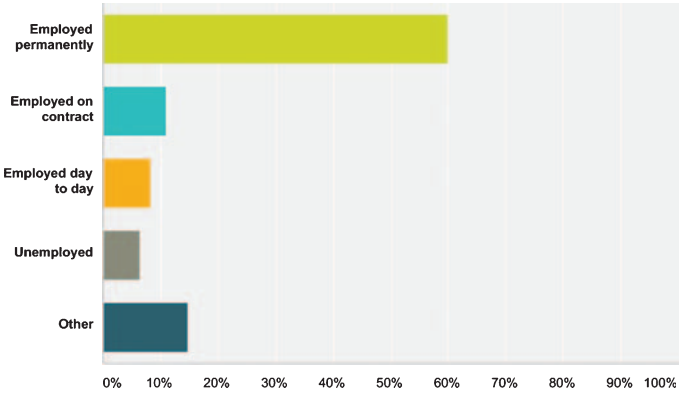


Figure 8. *The response to Question 9 'Please select the following options that best describe your current and future career: Current career –' (n = 340).*

Geophysics on the final frontier

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Introduction

Geophysics in the broad sense, the direct sensing physical properties in space, has been a key part of space exploration from the start. The first satellites were launched in the International Geophysical Year (IGY). Sputnik 1 provided data on the ionosphere, upper atmospheric drag, and micrometeorites. Sputnik 2 measured radiation intensities, although the significance of the readings was not realised until Explorer 1 mapped the Van Allen radiation belts. Sputnik 3 was an orbiting geophysical laboratory massing over 1.3 tonnes and carrying 12 different instruments. All these satellites, along with Explorer 3 and Explorer 4, and Vanguard 1, were launched during the IGY (Siddiqi 2003; McDonald 2008; McLaughlin Green and Milton 1970).

The first spacecraft to escape earth's gravity and enter solar orbit also had a strong geophysical focus. Luna 1, which flew past the Moon on 4 January 1959, refined understanding of the strength of the lunar gravitational field through its orbital perturbation, while its on-board magnetometer showed that the Moon lacked a magnetic field. The probe also measured cosmic radiation. A near duplicate probe, Luna 2, successfully impacted on the Moon's Mare Imbrium on 14 September 1959 (Harvey 2007*a*). Since then spacecraft have returned data from all of the nine 20th century planets of the Solar System, as well as many moons, asteroids, and comets. Most recently the New Horizons spacecraft has returned new data from Pluto during a flyby.

This article will not review all of these missions but will focus on missions that have investigated specific aspects of the surfaces and sub-surfaces of other bodies in the solar system; investigations that will be familiar to geophysicists exploring the earth.

Challenges

There many constraints to geophysical exploration in the solar system. Instruments must perform in extreme environments, and few environments are more extreme than those encountered by the series of Venera landers on Venus. These landers had to deal with surface temperatures of 460°C, pressures of 92 bars, and an atmosphere of supercritical CO_2 laced with acid gasses. It is a great tribute to the mission engineers that they were not only able to meet these goals but to engineer landers that lasted well in excess of their designed operating life, not once, but eight times (Harvey 2007*b*).

All missions have to cope with noise and vibration during launch, cosmic rays, high accelerations during launch and, in some cases, entry and landing, micrometeorites, and erosion by ionised gases in orbit. Some missions have to deal with particular challenges such as the low temperatures on Titan, the high solar flux in orbit round Mercury, the intense radiation belts surrounding Jupiter, and the abrasive dust on the surface of the Moon and Mars. Engineers must build instruments to withstand these conditions with extreme mass, volume and power constraints. It is not surprisingly, therefore, that instrument design and scientific objectives are driven as much by what is possible as by what is desirable. Nor are budgetary and time constraints to be ignored. More than one instrument has been left off a mission because it was not ready in time, or because it cost too much to build. These constraints mean that instruments have limited ability to adapt to unexpected conditions or even to collect desirable data.

Instrument design is particularly challenging when the interaction between the instrument and the environment is complex. Passive sensors, such as a camera, are the easiest to design and operate. Active sensors, such as ground penetrating radar (GPR), are more difficult, those that require manipulation of the environment, such as inserting a probe, more difficult still. The instruments that require samples, especially of surface materials, to be taken on-board and processed are especially challenging, and prone to problems due to complexity of the sampling process and the likelihood of encountering situations outside the parameters to which they have been designed.

In addition to these design constraints are the operational constraints of limited bandwidth, a narrow communications window, and communication latency. These factors reflect a combination of interplanetary distances and the limited spacecraft power resources. The Opportunity Mars rover, for example, has a direct-to-Earth transmission rate of 3.5–12 kbs. The data rate using orbiters, such as the Mars Reconnaissance Orbiter, as a link is higher; a constant 128 kbs. However, an orbiter passes over the rover for about eight minutes per sol (Martian day). About 60 megabits of data (about 1/100 of a CD) can be transmitted to an orbiter in that time. That same 60 Mb would take between 1.5 and 5 hours to transmit direct to Earth and the rover can only transmit direct-to-Earth for at best three hours a day (http://mars.nasa.gov/mer/mission/comm_data.html). Power is similarly limited. The triple junction gallium arsenide cells on Opportunity provide a typical 410 Wh per sol (http://mars.nasa.gov/mer/technology/bb_power.html). Power, bandwidth, and communications time, are all heavily rationed in consequence. Even if they were not, the time lag between Earth and other bodies (4.5 hours in the case of the New Horizons Pluto flyby) reduces direct control of unmanned operations except for the Moon. The robotic excavator arms on the Surveyor lunar landers were controlled directly from Earth, as were the Lunokhod rovers. Even with the Moon, however, the time lag is such that many operations, though commanded from Earth, have to be carried out autonomously. The Luna 16 spacecraft landed, drilled a core sample, loaded the sample into

Self-portrait of the Curiosity rover on Mars, the most complex unmanned mission to the surface of another solar system body. (Source: NASA).

the return capsule, and launched the sample back to Earth, all autonomously during the lunar night. Such operations are vulnerable if situations beyond the capability of the hardware and software arise.

Professional cultural differences among the teams of a score or hundreds of mission scientists and between scientists and engineers can pose additional challenges. For example, during the unmanned lunar missions leading to the Apollo landings, there was constant friction between the 'sky scientists' – interested in particles, fields, and global spectra – and 'earth scientists' – who wanted cameras and other instruments to characterise specific sites. The earth scientists had to fight very hard to include cameras on the missions because the data such instruments recover were seen to be qualitative rather than quantitative, and there was a systematic failure amongst the sky scientists to appreciate the importance of context and site specific data, the core of much geology and geophysics (Wilhelms 1993).

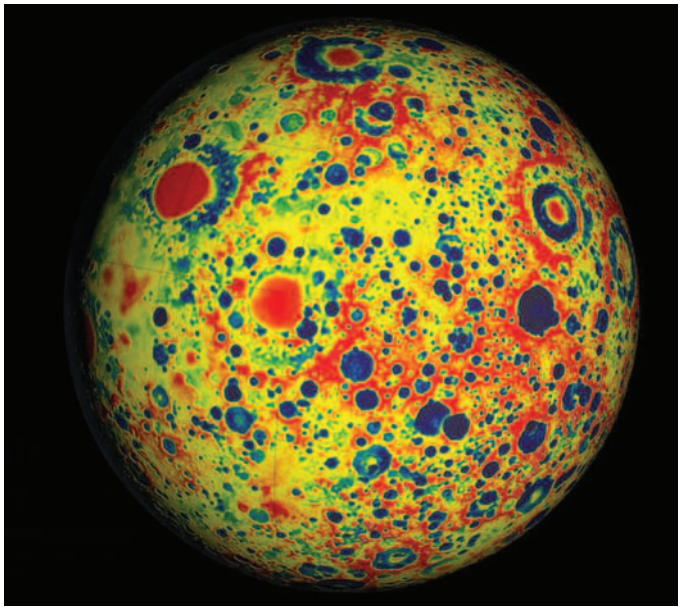
Lunar and planetary missions during the 60s and early 70s were generally sequential, each building on the technology of the previous missions, for example the, Mariner, Surveyor and Venera missions. More recent missions, particularly those from the US, have been unique, with missions and instruments selected by a competitive process, rather than as a result of an evolving program. This can make comparison between different datasets difficult, as they may have been collected by very different instruments with different design assumptions and technologies.

Some examples

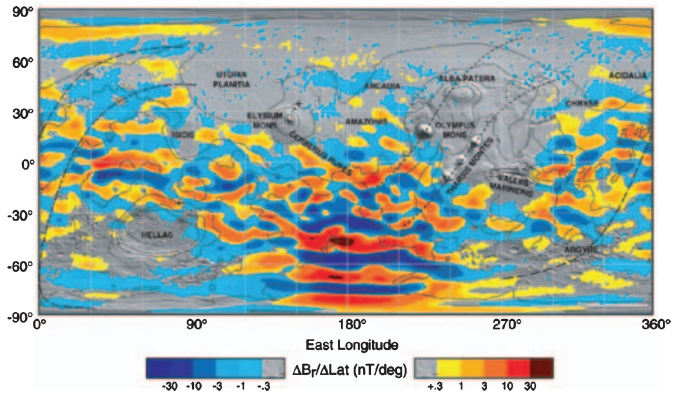
Despite these issues a great diversity of geophysical instruments have been flown on space missions. Some examples of past and present unmanned missions follow. Gravity and magnetic fields have been mapped from orbit, for example the GRAIL mission for the Moon (Zuber et al. 2013) or the Mars Global Surveyor (MGS) mission for Mars (Acuna et al. 1998). These surveys are much lower resolution than airborne surveys on earth, being flown at much higher altitudes (50 km for GRAIL, 171 km for MGS). Despite such limitations, these missions have revealed much about the nature of the crust and evolution of these bodies. The GRAIL, similar in concept and operation to the terrestrial GRACE mission, used gravity gradiometry to show a population of linear gravity anomalies with lengths of hundreds of km associated with early expansion of the lunar lithosphere (Andrews-Hanna et al. 2013), and mapped in unprecedented detail the distribution of lunar mascons, positive gravity anomalies mostly associated very large impact basins (Zuber et al. 2013). One of the major geophysical discoveries of the MGS mission (Connerney et al. 1999) was that crustal magnetisation, mainly confined to the most ancient, heavily cratered Martian highlands of the southern hemisphere, frequently was an east-west–trending pattern of linear features, the longest extending over 2000 km. Crustal remanent magnetisation exceeds that of terrestrial crust by more than an order of magnitude. These formed groups of quasi-parallel patterns of alternating magnetic anomalies. They are reminiscent of similar magnetic features associated with terrestrial sea floor spreading but on a much larger spatial scale. They may be a relic of an era of plate tectonics on Mars.

Seismology has been attempted on two planets, Mars and Venus. The Viking 1 and 2 landers in 1976 both carried seismometers, but both failed to yield useful data. The Viking 1 seismometer failed to uncage after landing, so no data were collected. The Viking 2 seismometer did uncage, but engineering constrains meant that the instrument had to be mounted on the deck of the lander. As a result any potential seismic signals were generally lost in the noise generated by Martian winds blowing over the lander (Ezell and Ezell 1984). No seismic events were recorded during the still periods, but the usefulness of these data must be questioned given the poor mounting of the instrument. More successful were the seismometers set to Venus on Veneras 13 and 14 (Ksanfomaliti et al. 1982) as part of the Gronza 2 instrument. These instruments, which included a kilohertz radio sensor and a uniaxial seismometer, also collected signals from lightning, the probes' drills and the wind, as well as several microseismic events. The microseismic events may be due to the location of the landing sites on the flanks of a possibly volcanic edifice called Phoebe Regio.

The surface properties of the moons and planets in the solar system are important data for engineers designing future missions and for providing ground truth for other data. Much can be determined from engineering performance data, for example comparing the distance travelled against the number of revolutions of the wheels of a vehicle provides data on the mechanical properties, as does the depth to which the landing pads sink into the surface.



Gravity globe of the Moon, projected from data collected by the GRAIL mission. Source: NASA.

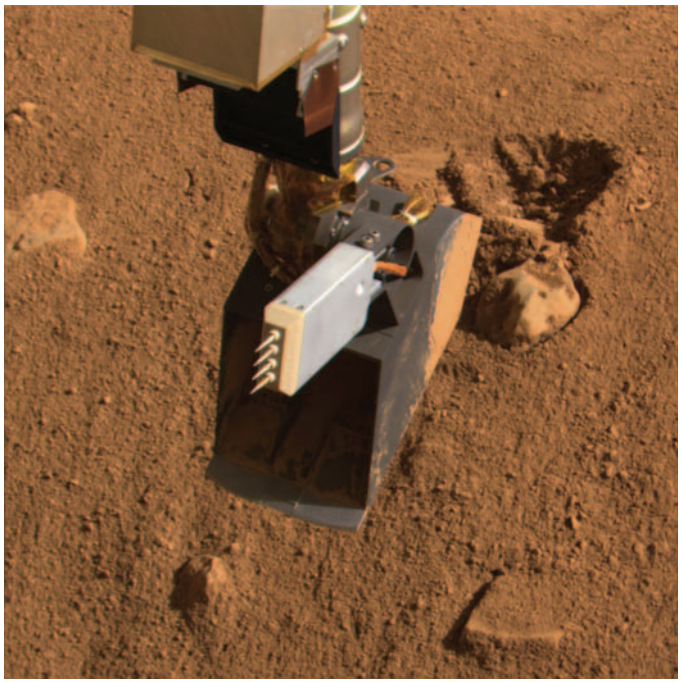


Linear magnetic anomalies in the southern highlands of Mars, mapped by the Mars Global Surveyor spacecraft. Source: NASA.

Physical properties have been measured almost from the first mission. Luna 13 in December 1966 was the third spacecraft to safely land on the Moon and it carried a gamma densitometer to measure regolith density (Harvey 2007*a*). Advances in instrumentation over the past 40 years mean that modern spacecraft are able to carry out many more and more sophisticated measurements of surface properties. The Phoenix Mars lander touched down in the north polar regions of Mars in 2008. Among its many mission objectives was the characterisation of the physical properties of the Martian regolith using the thermal and electrical conductivity probe or TECP (Zent et al. 2010). The TECP, which consisted of a series of probes that could be pushed into the Martian regolith, measured thermal conductivity, heat capacity, temperature, electrical conductivity, and dielectric permittivity throughout the mission.

The December 2013 landing of Chang'e 3 on the Moon was the first mission to the lunar surface since 1976. This large, complex mission deployed a rover, Yutu, while the lander itself carried out astronomical observations. Yutu carried a GPR, the first to be deployed beyond Earth, that operated at two frequencies, 60 Ghz and 500 Ghz. Yutu was damaged and immobilised on its third lunar day of operation, but while mobile it collected data on the stratigraphy of the Moon's Mare Imbrium (Xiao et al. 2015). After landing near the rim of a young crater Yutu drove 114 m across the ejecta blanket. In addition to imaging the surface and scattered rocks and collecting geochemical data, the GPR probed through the subsurface stratigraphy to a depth of over 360 m. More than nine subsurface layers were identified in the returns, indicating that this region has experienced a complex geological history of flow events separated by periods of development of impact regolith.

A different technique of exploring the subsurface has been used by the Curiosity Mars rover. This mission landed in Gale Crater in August 2012 and carried a pulse neutron generator (DAN) to map the distribution of water in the shallow subsurface. Operational and planetary protection constraints precluded the mission from being sent to areas with shallow, subsurface ice at latitudes poleward of 45 degrees in each hemisphere. However, DAN has been mapping the distribution of water of hydration and elements responsive to the neutron pulse such as chlorine. DAN operates in active and passive modes and is able to differentiate between shallow and deep water contents (Litvak et al. 2014). One DAN observation campaign consisted of active measurements every 0.75–1.0 m to search for the variations of subsurface hydrogen content along a 15 m traverse across geologic contacts on the floor of Gale Crater. The results



The Phoenix thermal and electrical conductivity probe mounted on the sampler arm and used to measure the physical properties of Martian regolith. Source: NASA.

showed that several subunits within each identified formation could be characterised by different depth distributions of water-equivalent hydrogen (WEH) and chlorine-equivalent abundances. The top 60 cm of the subsurface contained up to 2–3% WEH. Chlorine-equivalent neutron absorption abundances ranged within 0.8–1.5%. These results reflect variations in content of water-bearing minerals including sulphates and clays, known from XRD data collected by Curiosity, and of salts.

The future

Several forthcoming missions may be of interest to geophysicists. These include the 2016 InSight mission, the Chang'e 4 and ExoMars Rover missions, both in 2018, and the 2020 Mars rover.

InSight will be the first dedicated geophysical mission sent to the surface of Mars. The lander, based on the 2008 Phoenix design, carries a range of instruments, mostly of European origin, to study the interior of Mars. The instruments will measure heatflow, record seismic events (this time using an instrument lowered onto the Martian surface and isolated from wind interference), and the planet's rotation using the X-band radio. The mission is scheduled to launch in March 2016 and land on the plains of Elysium (https://en.wikipedia.org/wiki/InSight#Landing_site).

The ExoMars Rover mission is phase 2 of a series of missions planned by the European Space Agency in its ExoMars program. The first is a 2016 Mars orbiter. The 2018 mission will consist of a mid-sized rover with the capability to drill to depths of up to 2 m. The mission is essentially focussed on the search for past and/or present life in the Martian subsurface. Supporting these goals are two geophysical instruments, the WISDOM GPR and the ADRON neutron probe. WISDOM will operate across a range of frequencies (0.5–3 GHz0), which will allow penetration to depths of 2–3 m and provide cm scale resolution of shallow

radar reflectors. ADRON is an improved version of DAN, like the earlier instrument it will map the presence of water and chlorine to a depth of approximately 1 m (https://en.wikipedia.org/wiki/ExoMars_rover).

Also scheduled to fly in late 2018 or 2019 is the Chang'e 4 mission. Like Chang'e 3, this mission is targeted for the lunar farside, the first lander to do so. This will require a relay satellite, probably in an L-2 halo orbit, to communicate with earth. The lander and rover are largely complete and the final experiment package is in the process of being finalised. The rover will, once again, carry a GPR to study shallow structure. The mission is also planned to study the particle radiation environment and the deep interior. This suggests some type of magnetic and plasma observatory and a seismometer, perhaps carried on the main lander (CNSA 2015).

The 2020 Mars rover will be based on the current Curiosity mission, although hopefully with more robust wheels. The mission's objectives are to document, collect, and cache samples for future return to Earth by an as yet unfunded mission. Once again a GPR will be carried. The instrument, the Radar Imager for Mars' Subsurface Experiment or RIMFAX, is being supplied by the Norwegian Defence Research Establishment (https://www.nasa.gov/press/2014/july/nasa-announces-mars-2020-rover-payload-to-explore-the-red-planet-as-never-before). No landing site or formal name has yet been assigned for this mission.

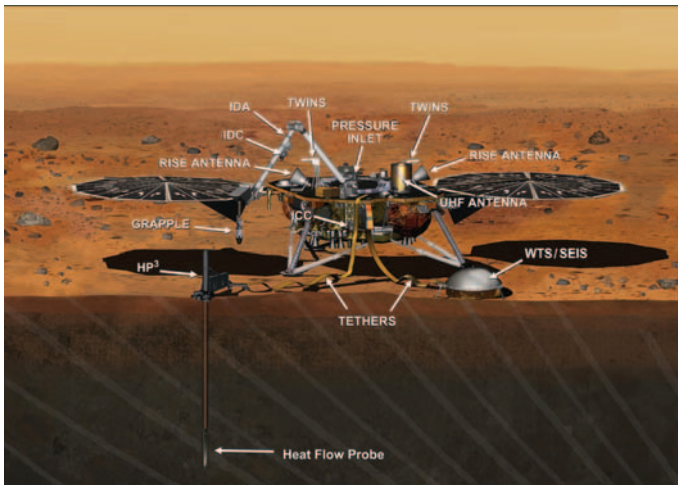
Geophysicists in space

All the missions that have been described are unmanned. Despite media anthropomorphism and Twitter accounts, these missions can do no more than they are instructed, with the previously outlined limitations. More sophisticated geophysical techniques, for example those requiring complex surface installation, deployment of large sensor arrays on planetary surfaces and rapid or large amounts of power, are beyond the capability of any unmanned mission for many decades to come, despite the hype about future planetary robotics technologies.

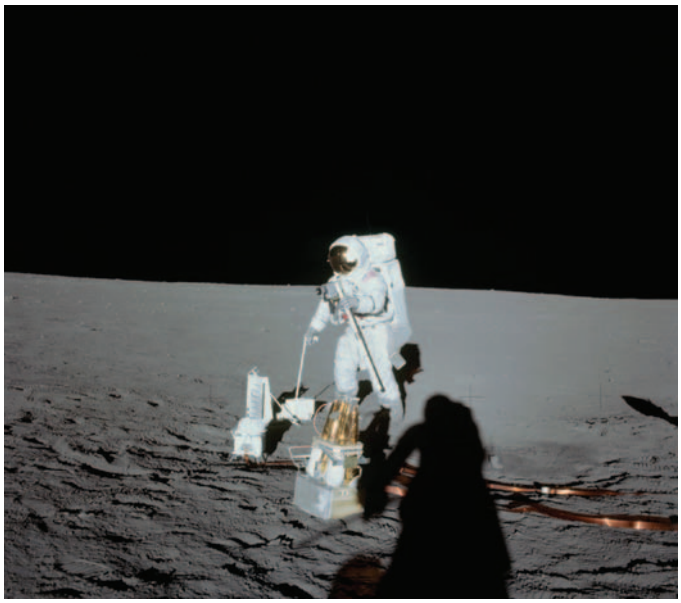
The Apollo missions are our only guide to the potential of direct human geophysical exploration of other solar system bodies. Despite the primitiveness of the technology, the achievements of Apollo in this respect were enormous. The largest unmanned mission to date, the Curiosity Mars rover, had a science payload of 75 kg. In contrast, five of the six successful Apollo Moon landings carried an Apollo Lunar Science Experiment Package (ALSEP), each one of which massed up 90 kg (Bates et al. 1979). Fifteen different experiments were carried, mostly of a geophysical nature, and these included the deployment of active seismic arrays, seismometers, plasma and magnetic recorders, heat flow probes, gravity meters, solar wind collectors, dust collectors, and laser ranging reflectors. The observations that were made, in many cases still not duplicated by later unmanned missions, were a small part of a much more comprehensive exploration of the lunar surface over the course of six landings. In less than 14 days of operations not only were almost half a tonne of instruments deployed across the lunar surface, but cores were drilled to depths of 3 m, almost half a tonne of samples collected and over 90 km of the lunar surface traversed (Wilhelms 1993).

Crawford (2012) carefully compared the returns on the Apollo program compared with the returns on the unmanned exploration of the Moon and Mars, focussing on sample return and rover missions. He showed that per day of field work, as measured by output of peer reviewed science papers, Apollo was three orders of magnitude more productive than the Spirit and Opportunity rovers on Mars. This is in line with the qualitative assessment made by Squyres (2005), based on his experience as principal investigator of the Mars rover missions, and the empirical study of Snook et al. (2007). While the cost of human exploration is often used as a justification for not sending people into space, Crawford (2012) pointed out that the cost of the Apollo program as a whole, allowing for inflation, was only 12 times that of the Curiosity Mars mission, and has proved to be much more productive, based on scientific publications. Crawford (2012) also showed that that science component of the Apollo missions was only 1.2% of the overall mission costs, making the science expenditure of the program extremely cost effective.

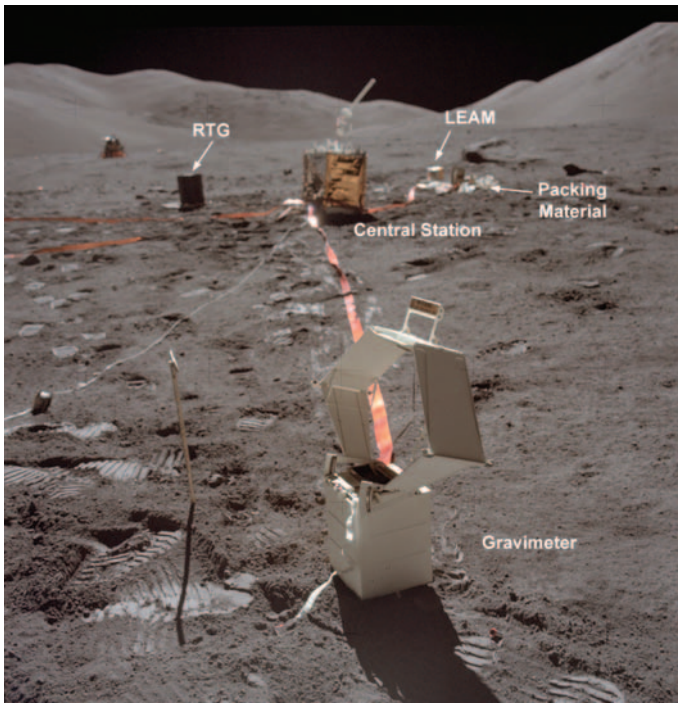
At present there are no funded programs by any space faring organisation to return people to the Moon or to go beyond to Mars or asteroids. However, such missions are within the capability of our technology. If we wish to develop a better



Labelled diagram of the forthcoming 2016 Insight mission to Mars, which will place a geophysical observatory on the surface. Source: NASA.



Astronaut Al Bean deploying the ALSEP during the Apollo 12 mission. Source: NASA.



Components of the Apollo 17 ALSEP on the lunar surface. Source: NASA.

understanding of the character of the solar system then, sooner or later, geophysicists will need to travel to that final frontier.

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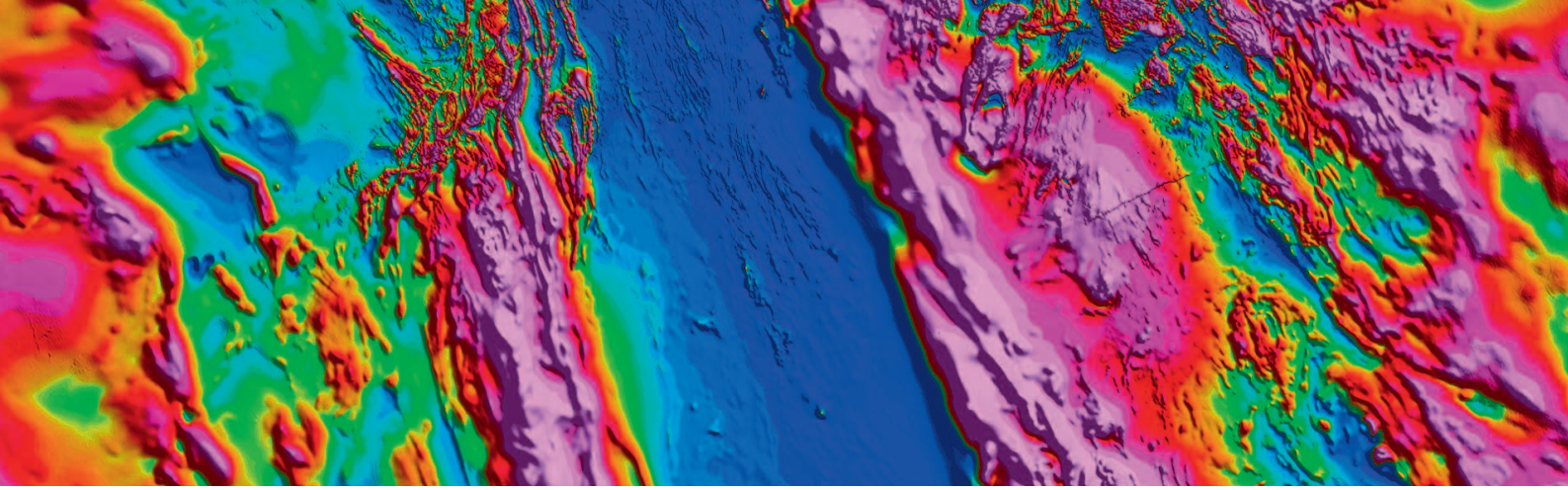

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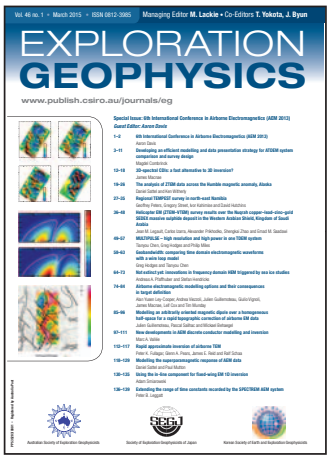

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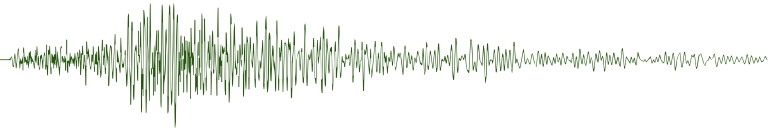

October	**2015**		
5–8	8th Congress of Balkan Geophysical Society http://www.eage.org/event/index.php?eventid=1313&Opendivs=s3	Chania	Greece
7–9	Bowen Basin Symposium www.bbsymposium.com.au	Brisbane	Australia
18–23	SEG International Exhibition and 85th Annual Meeting http://www.seg.org	New Orleans	USA
November	**2015**		
15–18	International Conference on Engineering Geophysics http://conferences.uaeu.ac.ae/iceg/en/	Al Ain	UAE
18–20	12th SEGJ International Symposium http://www.segj.org/is/12th/	Tokyo	Japan
December	**2015**		
4–6	11th Biennial International Conference and Exposition 2015, Society of Petroleum Geophysicists, India http://spgindia.org/	Jaipur, Rajasthan	India
7–9	9th International Petroleum Technology Conference http://www.iptcnet.org	Doha	Qatar
February	**2016**		
7–10	Fourth Australian Regolith Geoscientists Association Conference http://regolith.org.au	Thredbo, NSW	Australia
March	**2016**		
20–24	29th Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) http://www.eegs.org/sageep-2016	Denver, Colorado	USA
April	**2016**		
3–6	AAPG-SEG International Conference & Exhibition http://www.aapg.org/events/conferences/ice	Barcelona	Spain
May	**2016**		
30 May–2 June	78th EAGE Conference and Exhibition http://www.eage.org/	Vienna	Austria
June	**2016**		
26–30	Australian Earth Sciences Convention http://aesc2016.gsa.org.au/	Adelaide	Australia
August	**2016**		
21–24	ASEG-PESA-AIG 2016: 25th Geophysical Conference and Exhibition http://www.conference.aseg.org.au/	Adelaide	Australia
October	**2016**		
16–21	SEG International Exhibition and 86th Annual Meeting http://www.seg.org	Dallas	USA
June	**2017**		
12–15	79th EAGE Conference and Exhibition 2017 http://www.eage.org/	Paris	France
July	**2017**		
17–19 (TBC)	3rd Near-Surface Geophysics Asia-Pacific Conference (website TBA)	Cairns	Australia

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

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All editorial contributions should be submitted to the Editor by email at previeweditor@aseg.org.au.

For style considerations, please refer to the For Authors section of the *Preview* website at: www.publish.csiro.au/journals/pv.

Preview is published bimonthly in February, April, June, August, October and December. The deadline for submission of material to the Editor is usually the second Friday of the month prior to the issue date. The deadline for the December 2015 issue is 13 November 2015. For the advertising copy deadline please contact Doug Walters on (03) 9545 8505 or doug.walters@csiro.au.

The ASEG SA/NT Branch is pleased to be able to present the following wines to ASEG members. These wines were found by the tasting panel to be enjoyable drinking and excellent value. The price of each wine includes GST and bulk delivery to a distribution point in each capital city in early December. Stocks of these wines are limited and orders will be filled on a first-come, first-served basis.

Please note that this is a non-profit activity carried out by the ASEG SA/NT Branch committee only for ASEG members. The prices have been specially negotiated with the wineries and are not available through commercial outlets. Compare prices if you wish but you must not disclose them to commercial outlets.

2015 ASEG WINE OFFER

orders close Monday 2nd of November 2015

Schild Estate Barossa Valley Shiraz 2013

2013 saw warm and dry conditions, but without any significant periods of severe heat. Yields were low and many red varieties ripened evenly, with great flavour depth and some firm prominent tannins which have softened well during maturation. As a result, many of the wines from the year show great structure and framing when young and look to have the ability to genuinely age well too.

Gold Medal 2015 AWC Vienna Awards
Silver Medal 2015 San Francisco International Wine Comp.

ASEG PRICE $158/dozen (RRP $264)

The Green Room Riesling 2015

The Green Room 2015 Riesling can't wait to get on stage and sing "look at me". It is pale straw yellow with spice and lemon rind on the nose. It drenches the palate with a full orchestra of citrus – lemon, lime, mandarin and even orange. An over-achieving show-off that won't take "no" for an answer – so why resist? You may as well join in and drink now!

Gold Medal 2015 Winewise Small Vigneron Awards
Silver Medal 2015 Royal Perth Wine Show

ASEG PRICE $138/case (RRP $300)

Please order online at www.aseg.org.au (click on "Wine Offer") and pay by credit card, or fill in below order form

Name: _____ Daytime telephone: (___) _____ Email address _____

Address: _____ Capital city for collection: _____

I would like to pay by: [ ] Cheque – payable to ASEG SA/NT Wine Offer (enclosed)

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Card Account number: __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ Signature: _____

Number of dozens	Wine	Price per Dozen	Total
	Schild Estate Barossa Valley Shiraz 2013	$158	
	The Green Room Riesling 2015	$138	
		TOTAL	

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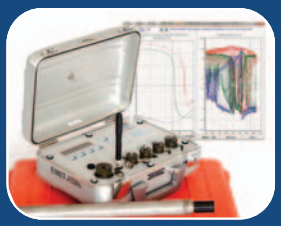
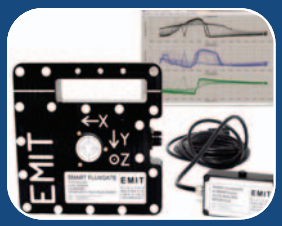


DigiAtlantis

Three-component digital borehole fluxgate magnetometer system for EM & MMR with simultaneous acquisition of all components



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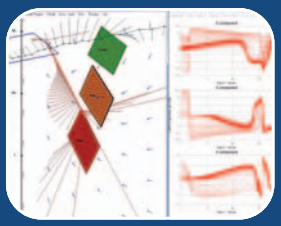

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