Preview

Australian Society of Exploration Geophysicists

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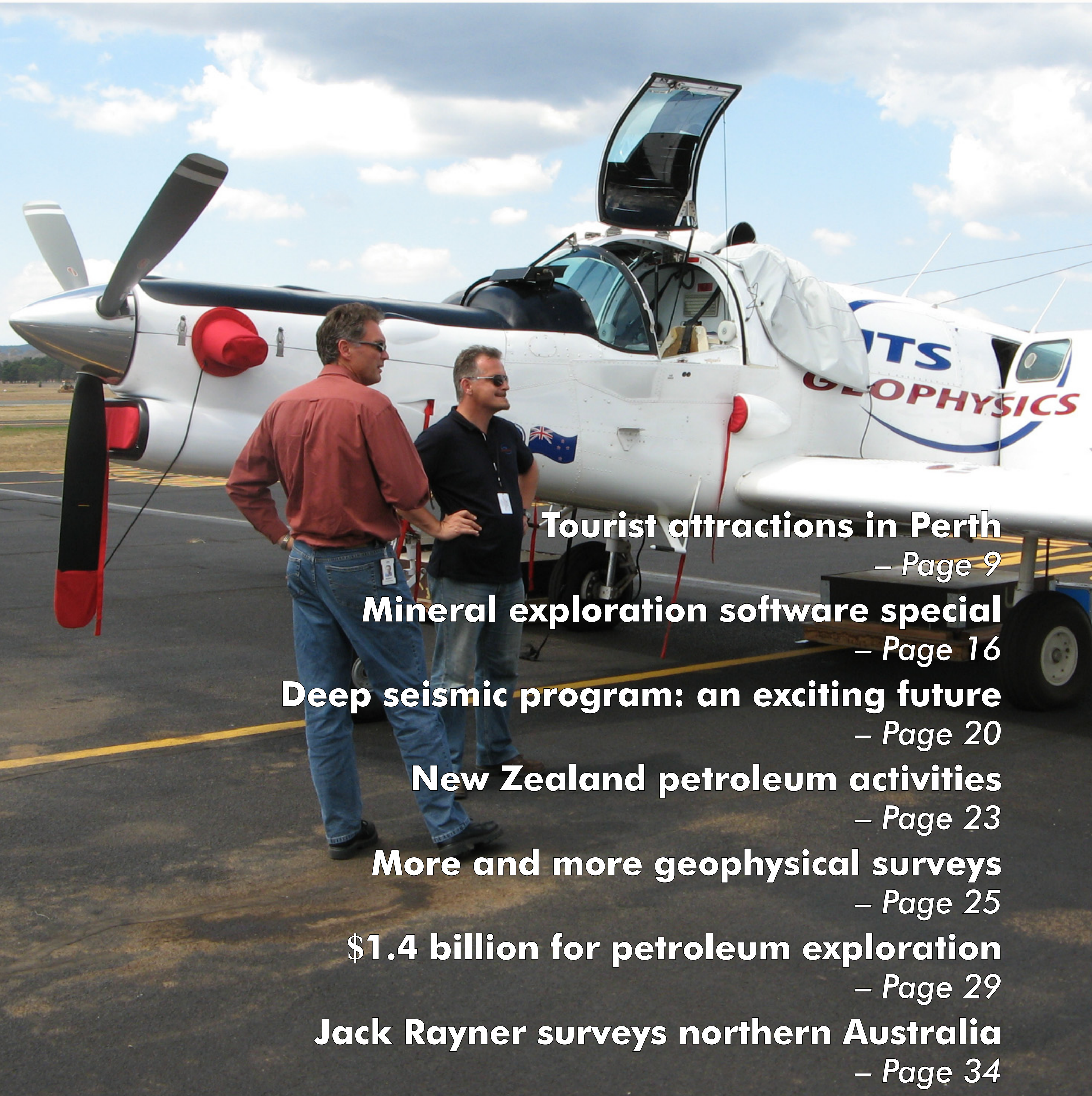

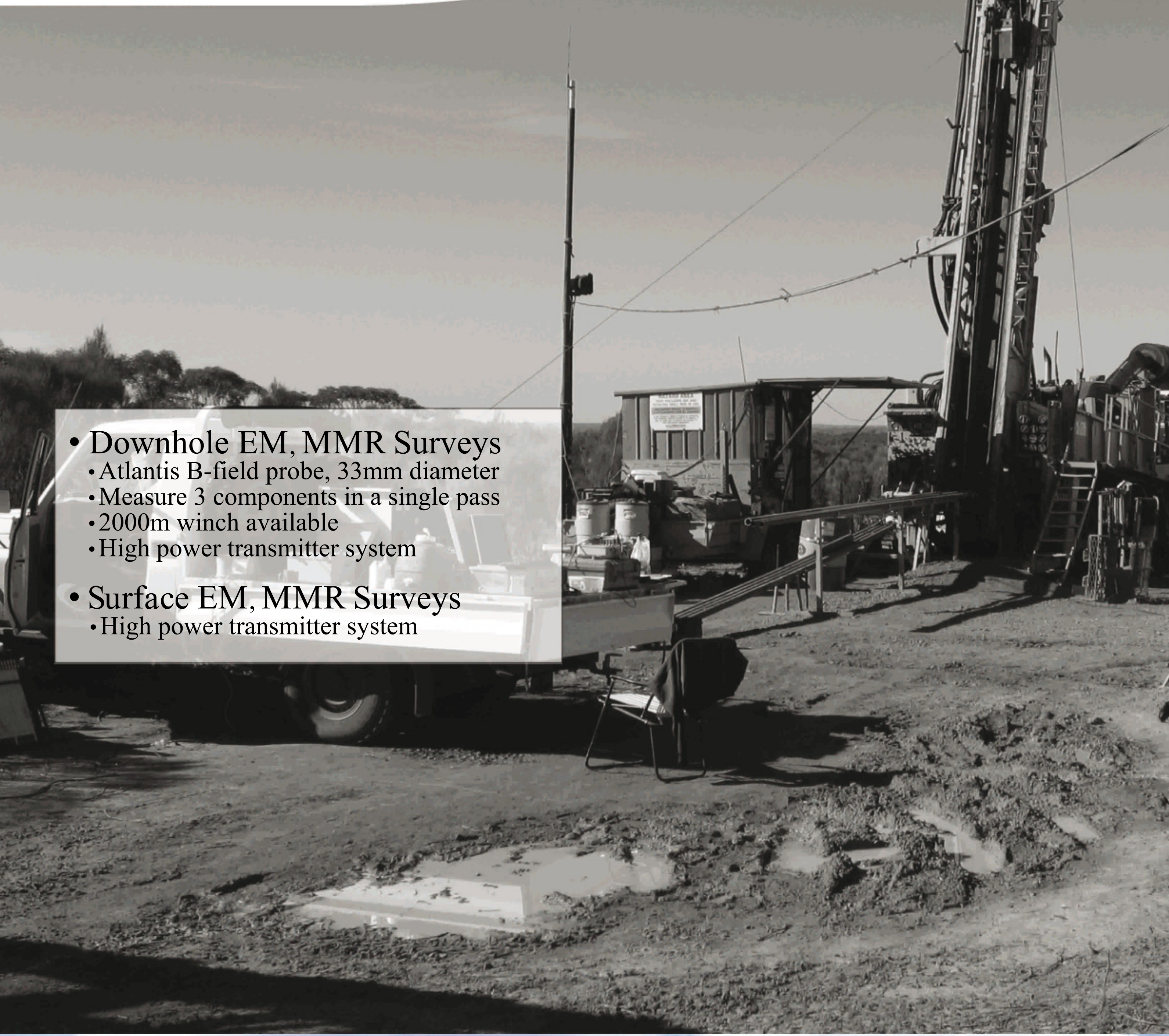

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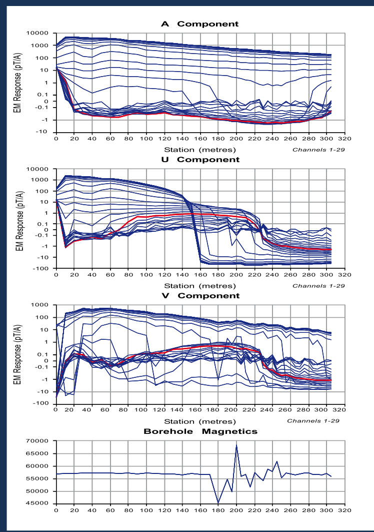

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- Display profile, decay, spectrum, plan, 3-D model and primary fields.
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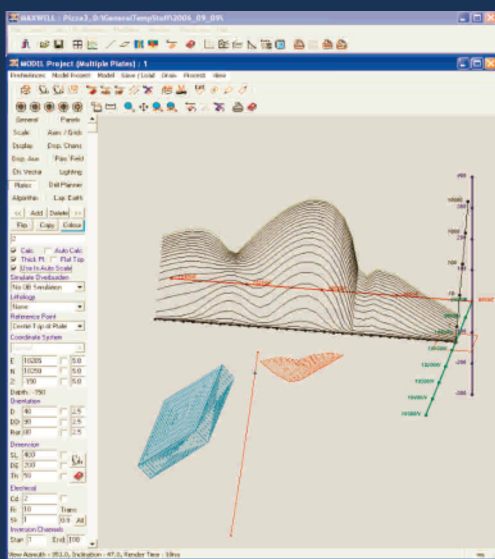

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Cover photograph shows Murray Richardson (on the left), Project Leader, and Nino Tufilli, Managing Director, UTS Geophysics, at Canberra airport, supervising the radiometric calibration of a survey aircraft. The concrete calibration pads can been seen next to the wheels and under the wings of the aircraft.

David Denham

New faces on Executive Committee

By the time we go to press the ASEG will have a new Executive in place. Joe Cucuzza takes over from James Reid as President and Peter Elliot of Elliot Geophysics International will be the President Elect. His company specialises in geology and geophysics for mining and mineral exploration and has offices in Perth, Jakarta and Manilla. Our new Secretary is Troy Herbert from BHP Billiton. He takes over from Lisa Vella who has been Honorary Secretary since the 2002 AGM. She has done a sterling job in the last 5 years and I would like to take this opportunity to thank her for all the help she has given me, as Preview Editor, during this time. In the August Preview we will report on the AGM and provide more information on our new office bearers. We may still have the services of John Watt for a few more months. He has been Honorary Treasurer, also for 5 years.

Share market at all time high

The resources boom never seems to stop. The total market capital of the top 150 resource stocks listed on the ASX reached a record $270 billion in May 2007. BHP Billiton's market capital is now about $104 billion followed by RioTinto at $42 billion. They have each doubled their value in 3 years – remarkable achievements for large multinational companies. And of course the growth is not restricted to the majors. Paladin is now worth about $5 billion, which is three times what it was worth just over a year ago, and Zinifex is valued at 6 times what it was three years ago and is now worth more than $8 billion. The achievements are quite remarkable and here's hoping the good times continue.

Unfortunately, there is a major problem finding staff who are able and willing to work in the resource industries. Geoscientists are now as rare as hens' teeth. As a society of exploration professionals we must keep lobbying the appropriate authorities wherever and whenever we can to ensure that the geosciences are included in the schools and university curricula.

In this issue

Back to Preview. In this issue we have an interesting set of articles. For the petroleum people, we look at which offshore areas are available for bidding later this year as well as the list of successful bidders from the 2006 bidding round. A record 52 bids were received for 20 of the 22 areas on offer during 2006. The successful bidders plan to invest more than $1 billion over the next 6 years searching for oil and gas.

We also have a contribution from New Zealand. There are now several ASEG members based in New Zealand and Chris Uruski has provided an overview of exploration potential in and around the two main islands. I hope that Chris will be able to provide us with more items of interest in future issues.

For the mineral explorers we have contributions on modelling and interpretation and then we have book reviews and a nice piece of history when John Rayner writes about the life and times of his father Jack, when he worked in the Aerial Geological and Geophysical Survey of Northern Australia.

I hope you enjoy the reading.

David Denham

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.

Editor
David Denham
Tel. & Fax: (02) 6295 3014
Email: denham@webone.com.au

Publisher
CSIRO Publishing
Production Editor: Lauren Webb
Tel: (03) 9662 7559
Fax: (08) 9662 7611
Email: lauren.webb@csiro.au

Advertising: Elspeth Gardner
Tel.: (03) 9662 7668
Fax: (03) 9662 7555
Email: elspeth.gardner@csiro.au

Associate Editors

Petroleum: Mick Micenko
Email: micenko@bigpond.com

Petrophysics: Don Emerson
Email: systems@lisp.com.au

Minerals: Peter Fullagar
Email: p.fullagar@mailbox.uq.edu.au

Book Reviews: David Robinson
Email: david.robinson@anu.edu.au

Web Waves: Jennie Carson
Email: jennie.carson@gmail.com

Geophysical History: Doug Morrison
Email: sth.lands@optusnet.com.au

ASEG Head Office & Secretariat

Ron Adams
Centre for Association Management
Tel.: (08) 9427 0838
Email: secretary@aseg.org.au
Web site: http://www.aseg.org.au

Content

James Reid
james@geoforce.com.au

A year has gone by very quickly, and this will be my final President's Piece. I extend my best wishes to the incoming president, Joe Cucuzza, who took over the reins at the AGM on 30th May. I also take this opportunity to thank all of the members of the Federal Executive for their dedicated efforts over the last year.

Without doubt the major achievement of the past year has been the transition to our new publisher, which has seen the first electronic issues of Exploration Geophysics and Preview appear over the last few months. Electronic publication of our journals has been long overdue, and I thank the Publications Committee, journal editors and other members of the Federal Executive for their hard work in preparing the new publications tender, evaluating the submissions received, and in streamlining the transition from RESolutions to **CSIRO** PUBLISHING.

Federal Webmaster

I am pleased to announce that Wayne Stasinowsky of the Queensland Branch has agreed to take on the position of Federal Webmaster. Wayne's first brief will be to review the content and functionality of the current site, and to recommend changes and upgrades to the Federal Executive. A key area that we would like to see developed is a fully functional online membership database, with facility for online membership application and renewal. Look forward to improvements in our website and online services over the coming year, and thanks to Wayne for taking on this role.

Federal Executive

Lisa Vella will be standing down from the position of Federal Secretary at this year's AGM after around 5 years in the job. Thanks to Lisa for her tireless efforts over the years, despite also having a very busy day job! Tony Herbert was elected Secretary at the AGM and more details will be contained in the next edition of *Preview*.

We are still seeking nominations for the positions of Federal Treasurer and Chair of the Technical Committee. Our current treasurer John Watt has indicated his desire to stand down after many years outstanding service. John has agreed to continue serving in the position in the short term and has agreed to overlap with the new incumbent to streamline the transition. The main responsibility of the Technical Committee is to provide local organisation for the SEG Distinguished Instructor Short Course (DISC), as well as other ASEG technical presentations and continuing education courses. Anyone interested in taking up either of these positions can contact any member of the Federal Executive.

Conference

Preparations for the upcoming Perth Conference are in full swing, and all indications are that it will be a great success. Once again, ASEG and PESA are co-convenors, and I am also pleased to announce that the Formation Evaluation Society of Western Australia (FESWA) will also hold a full-day session within the conference.

In order to encourage the next generation of geophysicists, the Federal Executive will again provide a subsidy for student members of ASEG – check upcoming conference announcements for details.

Joe Cucuzza
joe.cucuzza@amira.com.au

The role of the professional society

In thinking about what to write in my first President's Piece, I reflected on a number of issues that have the potential to significantly affect the future of the ASEG. Issues like the implication of the current industry boom, the increases in exploration spending and the severe skills shortage, as well as the movements of highly trained and research-capable geoscientists into industry. However, in thinking about these issues one thought took hold in my mind, ***What is the role of the professional society in the 21st century?***

So I have decided to focus my first article on a preliminary exploration of this question and will postpone discussing the other issues for future articles.

Professional societies like the ASEG potentially have many different roles. Trawling through the Web to establish what other societies see as their role, I have compiled the following list, which I am sure is not exhaustive:

- Publishing both scholarly and popular: dissemination of ideas, opinions, experiences and information on availability and application of new technologies
- Public outreach including educating society about geophysics and the role it plays in mining
- Custodian of knowledge in the form of previous publications
- Providing a forum for information exchange on all matters relating the profession
- Introducing students to technical, entrepreneurial and societal aspects of the profession
- Nurturing student and young professionals
- A rallying point for the collective professionalism of field of geophysics
- Forum for networking through conferences and other special meetings
- Promoting and enhancing professional standards and conduct and offering process for disciplining members that put the profession in disrepute
- Process for publicising the achievements of particular members, including offering special awards for deserving members
- Encouraging industry to support universities
- An avenue for industry contractors and suppliers to promote their products and services

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ASEG Conference update

The Call for Abstracts was sent out and closed at the end of May 2007. At the time of writing (mid-May) the 250-word abstracts have been trickling in slowly with an even distribution between mining and petroleum geophysical technologies. Environmental abstracts are slow to lift off the ground so we welcome more environmental papers from the exploration and production industries.

The pre- and post-conference workshops and field trips are being firmed up, with the likelihood of an EAGE course on Seismic Multiple Removal by Eric Verschurr, and other courses on CSEM, radar remote sensing, basin studies using potential fields, seismic applications in mining and seismic anisotropy (Leon Thomsen) being features of this conference.

Field trips are also gathering momentum, having secured the services of Harry Butler to lead a group to Barrow Island (courtesy of Chevron) and the Burrup Peninsula, while miners are being catered for by a field trip to Kalgoorlie. The PESA golf day is another 'field trip' feature of the Thursday following the conference, while the sailing regatta is gathering support on the Friday.

Sponsorship is proceeding well with a number of petroleum and service companies having agreed to support the conference at Gold level. Exhibition booths sold has passed the 60 mark and we aim to have at least 100 booths in operation. We expect to provide companies with their booth locations later in the year.

The conference has prospects of being a great success, both technically and socially so we look forward to seeing you there.

Brian Evans and Howard Golden
Co-Chairs, ASEG Perth 2007

Calendar of Events 2007/2008

2007

2–13 July
International Union of Geodesy and Geophysics XXIV General Assembly
Venue: Perugia, Italy
Contact: Secretariat, Research Institute for Geo-Hydrological Protection
Email: secretary@iugg2007perugia.it
Website: www.iugg2007perugia.it

25–27 July
Exploration and Mining Project Management
Venue: Perth, WA
Website: www.ausimm.com/main/events/mining_and_exploration.php
Contact: Roxanne Drakopoulos, AusIMM
Tel: 03 9662 3166
Email: conference2@ausimm.com.au

9–12 September
5th Decennial International Conference on Mineral Exploration (Exploration 07)
Theme: Exploration in the new millennium. Exploration 07 will review the current state of the art in geophysics, geochemistry, remote sensing, data processing and integration
Venue: Toronto, Canada
Website: www.exploration07.com

23–28 September
SEG International Exposition & 77th Annual Meeting
Venue: San Antonio, Texas, U.S.
Website: http://seg.org/meetings/calendar

27–30 September
4th International Symposium on 3D Electromagnetics (3DEM-4)
Venue: Freiberg, Germany
Contact: Klaus Spitzer (klaus.spitzer@geophysik.tu-freiberg.de)
Website: http://www.geophysik.tu-freiberg.de/3dem4

2–5 October
Greenhouse 2007
Venue: Sydney, New South Wales, Australia
Contact: P. Holper, CSIRO
Tel: 61-3-9239-4661
Email: info@greenhouse2007.com
Website: www.greenhouse2007.com

22–26 October
2007 SAGA Biennial Technical Meeting & Exhibition
Theme: Making Waves
Venue: Wild Coast Sun Resort, Durban, SA
Contact: events@rca.co.za
Website: http://www.sagaonline.co.za/2007Conference/2007conference.htm

18–22 November
ASEG's 19th International Conference and Exhibition
Venue: Perth, WA
Contact: Brian Evans (brian.evans@geophy.curtin.edu.au)
Website: http://www.promaco.com.au/2007/aseg
Email: promaco@promaco.com.au

25–29 November
5th International IAHS Groundwater Quality Conference
Venue: Fremantle, Australia
Contact: W. Whitford,
Tel: 61 8 9333-6273
Email: Wendy.Whitford@csiro.au
Website: www.clw.csiro.au/conferences/GQ07

10–14 December
American Geophysical Union, Fall Meeting
Venue: San Francisco, California
Website: http://www.agu.org/meetings

2008

6–9 April
2008 APPEA Conference & Exhibition
Venue: Perth Convention & Exhibition Centre
Contact: Julie Hood
Tel: 07 3802 2208
Email: jhood@appea.com.au

9–12 June
70th EAGE Annual Conference & Exhibition
Venue: Rome, Italy
Website: http://www.eage.org/events/

20–25 July
19th AGC, The Australian Earth Sciences Convention 2008
Joint Geological Society of Australia and Australian Institute of Geoscientists Meeting, Perth, WA
Website: http://www.gsa.org.au/events/calendar.html

5–14 August
33rd International Geological Congress
Venue: Oslo, Norway
Contact: A. Solheim, Norwegian Geotechnical Institute
Tel: 47 2202 3000, Email: as@ngi.no
Website: www.33igc.org

9–14 November
SEG International Exposition and 78th Annual Meeting
Venue: Las Vegas, Nevada, U.S.
Website: http://seg.org/meetings/
Contact: meetings@seg.org

15–19 December
American Geophysical Union, Fall Meeting
Venue: San Francisco, California
www.agu.org/meetings

Continued from p. 3

- Promoting equality of opportunities for women and minorities
- Promoting the interest of its members in political and public discourse
- Promoting the development of sustainable earth science departments
- Promoting the science of geophysics and allied disciplines
- Stimulating and guiding research and promoting integrity in research
- Supporting students in undertaking industry relevant research
- Promoting innovation
- Accrediting degrees
- Promoting continuous education and life-long learning
- Promoting career development
- Promoting occupational health safety
- A forum for open debate on issues affecting the profession and society
- Analysing government policy initiatives that affect the profession
- Promoting sustainability and the environment
- Promoting the value to society of the industries within which we work
- Promoting employment opportunities for its members
- Liaising with allied learned societies on issues of mutual interest
- Preparing submissions to government enquiries on matters relevant to the profession

I am not aware of any learned society that does all the above, or indeed does them well. Consequently I would not expect the ASEG to come close to addressing them all.

Nevertheless it's interesting to consider what the ASEG's scorecard with respect to the above roles would be or perhaps more importantly what are the defining attributes of the ASEG that its members identify with? I can only answer the latter and only from my own personal standpoint. However, first a reality check is necessary. The ASEG, unlike some professional societies, survives largely on volunteers. Because its principal officers serve in an honorary capacity, there is only so much that can be done without a fulltime supporting professional secretariat with the skills to undertake many of the above diverse roles. Thus, by necessity, the ASEG can only focus on those items that are more immediate, while addressing the rest on an ad hoc basis. Consequently, and not surprisingly, the scorecard is mixed and heavily influenced by what can be achieved with the limited resources available. So getting back to the question on what ASEG's key roles, from my standpoint four roles come to the top.

Firstly, the dissemination of ideas, opinions, experiences and information on availability and application of new technologies or the novel application of existing technologies is in my view one of its principal roles. It does this well through its scholarly journal and other publications and of course the very successful conferences.

Secondly, as a forum for networking. This is achieved through conferences and local chapter meetings. However, the latter are very patchy and heavily dependent on the numbers in the States.

Thirdly, to promote continuous education and life-long learning through its Distinguished Lecturers programs.

Fourthly, to support students in undertaking industry relevant research. The ASEG Research Foundation has been assisting students for well over 10 years.

I welcome members' views on what they see as the ASEG's role and indeed what else should be done to address some other undoubtedly important issues. What do members expect from the ASEG? Answering this question will assist us in crafting a value proposition that will help attract more members, which in turn may provide more resources to allow the ASEG to deliver more value to members.

Federal Executive 2007/08

President: Joe Cucuzza
Tel: (03) 8636 9958
Email: joe.cucuzza@amira.com.au

President Elect: Peter Elliott
Tel: (08) 9258 3408
Email: elliottgeophysics@aol.com

1st Vice President: Jenny Bauer
Tel: (07) 3858 0601
Email: jenny.bauer@upstream.originenergy.com.au

Immediate Past President: James Reid
Tel: (08) 9209 3070
Email: james@geoforce.com.au

Secretary: Troy Herbert
Tel: (08) 9479 0503
Email: troy.herbert@bhpbilliton.com

Treasurer: John Watt
Tel: (08) 9222 3154
Email: john.watt@doir.wa.gov.au

2nd Vice President and International Affairs: Koya Suto
Tel: (07) 3876 3848
Email: koya@terra-au.com

Membership: Emma Brand
Tel: (07) 3858 0601
Email: emma.brand@upstream.originenergy.com.au

Publications: Phil Schmidt
Tel: (02) 9490 8873
Email: phil.schmidt@csiro.au

States' Representative: Megan Evans
Tel: (08) 9382 4307
Email: meganevans@mail.com

ASEG Research Foundation: Phil Harman
Tel: (03) 9909 7699
Email: phil.harman@gcap.com.au

Technical Committee: Vacant

Webmaster: Wayne Stasinowsky[1]
Tel: (04) 0017 5196
Email: stazo@bigpond.com

ASEG Branches

ACT

President: Matthew Purss
Tel: (02) 6249 9383
Email: matthew.purss@ga.gov.au

Secretary: Hugh Tassell
Tel: (02) 6249 9267
Email: hugh.tassell@ga.gov.au

New South Wales

President: Mark Lackie
Tel: (02) 9850 8377
Email: mlackie@els.mq.edu.au

Secretary: Bin Guo
Tel: (02) 02 9024 8805
Email: bguo@srk.com.au

Northern Territory

President: Jon Sumner
Tel: 0407 089 261
Email: jon.sumner@nt.gov.au

Secretary: Roger Clifton
Tel: (08) 8999 3853
Email: roger.clifton@nt.gov.au

Queensland

President: Nigel Fisher
Tel: (07) 3378 0642
Email: kenmore_geophysical@bigpond.com

Secretary: Emma Brand
Tel: (07) 3858 0601
Email: emma.brand@upstream.originenergy.com.au

South Australia

President: Luke Gardiner
Tel: (08) 8433 1436
Email: luke.gardiner@beachpetroleum.com.au

Secretary: Michael Hatch
Tel: (04) 1730 6382
Email: michael.hatch@adelaide.edu.au

Tasmania

President: Michael Roach
Tel: (03) 6226 2474
Email: michael.roach@utas.edu.au

Secretary: James Reid
Tel: (03) 6226 2477
Email: james.reid@utas.edu.au

Victoria

President: Suzanne Haydon
Tel: (03) 9658 4515
Email: suzanne.haydon@dpi.vic.gov.au

Secretary: Ashley Grant
Tel: (03) 8687 8179
Email: ashley_grant@ghd.com.au

Western Australia

President: Megan Evans
Tel: (08) 9382 4307
Email: meganevans@mail.com

Secretary: Julianna Toms
Tel: (08) 9266 3521
Email: julianna.toms@postgrad.curtin.edu.au

New Members

The ASEG welcomes the following new members to the Society. Their membership was approved at the Federal Executive meetings held on 28 March and 6 May 2007.

Name	Organisation	State
Yousuf Yaqoub Al-Jabri	Curtin University	WA
Frazer Barclay	Schlumberger	WA
Jake Gordon Berryman	PGS	New Zealand
Sergey Birdus	CGG Veritas	WA
Steven Carroll	Woodside Energy Ltd	WA
Carlos Cevallos	NSW DPI Geological Survey	NSW
Marina Costelloe	Geoscience Australia	ACT
Adam Star Davey	Occam Technology Pty Ltd	SA
Terrence Folkers	Woodside	WA
Masamichi Fujimoto	INPEX	WA
Dana Iwachow	Woodside	WA
Diane Kemp	Department of Education	NSW
Gary Koo	Fugro Seismic Imaging	WA
Alexander Maekivi	Chevron	WA

[1]Webmaster is not an Executive position but Wayne is listed here because of his new appointment.

Name	Organisation	State
Laura McAllan	Fugro Seismic Imaging	WA
Louise McAllister	Petratherm Ltd	SA
Glen Measday	Woodside	WA
Daniel Millard	Woodside	WA
Dariush Nadri	Curtin University	WA
Alan Nanini	Woodside	WA
Karen Pandya	CGG Veritas	WA
Tim Rawling	University of Melbourne	Vic.
Judith Elizabeth Scrimshaw	Chevron Australia Pty Ltd	WA
Peter Scruton	Fugro Seismic Imaging	WA
Wayne Darryl Stasinowsky	Newcrest Mining	Qld
Peter Strauss	Santos Ltd	SA
Alex Tan	Fugro Seismic Imaging	WA
Charmaine Michelle Thomas	Woodside Energy Ltd	WA
Paul Wellington	Chevron	WA
Scott Wilkinson	Fugro Seismic Imaging	WA

Congratulations to the following people who are now active members of the ASEG

Name	Organisation	State
Mark William Donaldson	GAP Geophysics Australia	WA
Brett Johnson	Fugro Airborne Surveys Pty Ltd	WA
Katherine McKenna	GPX Airborne	WA
Gregory John Maude	Gem Geophysical Surveys	WA
Kate Elizabeth Wilkinson	Geological Survey of Queensland	Qld

Australian Society of Exploration Geophysicists, Honours and Awards 2007

ASEG members are invited to submit nominations for the next round of ASEG Honours and Awards. Nominations that are judged to be appropriate and are then subsequently selected will be presented at the 19th ASEG Conference, in Perth, 18–22 November 2007. Details of the available awards follow:

1. ASEG Gold Medal

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

2. Honorary Membership

For distinguished contributions by a member to the profession of exploration geophysics and to the ASEG over many years. Requires at least 20 years as a member of the ASEG, except where the nominee is a recipient of ASEG Gold medal.

3. Grahame Sands Award

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

4. Lindsay Ingall Memorial Award

For the promotion of geophysics to the wider community. This award is intended for an Australian resident or former resident for the promotion of geophysics, (including but not necessarily limited to applications, technologies or education), within the non-geophysical community, including geologists, geochemists, engineers, managers, politicians, the media or the general public. The nominee does not need to be a geophysicist or a member of the ASEG.

5. ASEG Service Medal

For outstanding and distinguished service by a member in making major contributions to the shaping and the sustaining of the Society and the conduct of its affairs over many years. The nominee will have been a member of the ASEG for a significant and sustained period of time and will have at some stage been one of the following:

- Federal President, Treasurer or Secretary
- State President, Conference Chairman or Standing Committee Chairman
- Editor of Exploration Geophysics or Preview

6. ASEG Service Certificates

For distinguished service by a member to the ASEG, through involvement in and contribution to State Branch committees, Federal Committees, Publications, or Conferences.

Nomination Procedure

For the first four award categories, any member of the Society may nominate applicants. These nominations are to be supported by a seconder, and in the case of the Lindsay Ingall Memorial Award by at least four geoscientists who are members of an Australian geoscience body (eg GSA, AusIMM, AIG, IAH, ASEG or similar). Nominations for the ASEG Service Medal and the ASEG Service Certificates are to be proposed through the State and Federal Executives with their backing.

All aspects of the criteria should be addressed, and a nomination must be specific to a particular award. To gain some idea of the standard of nomination expected, nominees are advised to read past citations for awards as published in Preview.

Nominations including digital copies of all relevant supporting documentation are to be sent electronically to:

Roger Henderson
Chairman, ASEG Honours and Awards Committee
Email: rogah@tpg.com.au

The absolute deadline for applications is 15 September 2007.

New South Wales – by Mark Lackie

In April, Dave Robson gave a presentation on what's happening in the Geological Survey of NSW during 2007. To a quite a large and let's say cheerful audience Dave spoke about the NSW Government's New Frontiers initiative. As well, he outlined geophysical and geological activities that the department is currently undertaking including new interpretations, imminent surveys, planned releases and publications, and staff changes. Dave outlined new products soon to be released including a series of interpretation maps and accompanying notes covering specific 1 : 250 000 map sheets in the frontier regions of NSW. He also spoke about two major helicopter assisted gravity surveys that are about to get underway, together with stratigraphic drilling over the Thomson Orogen. Dave outlined future seismic acquisition in the Rankins Springs/Griffith region and the Gunnedah Basin, and several airborne magnetic and radiometric surveys in the Gunnedah Basin.

In May, the 2007 SEG Spring Distinguished Lecturer, Len Srnka gave a presentation on *Illuminating Reservoirs with Electromagnetics* (CSEM). Len spoke to a large audience about marine controlled-source electromagnetics, about the promise and challenges that lie ahead for this technique. Some of our colleagues from PESA also attended the meeting. Post presentation moved on to dinner and the finer points of CSEM were discussed in detail.

The presentation for the forthcoming June branch meeting will be a look at aspects of seismic processing. A branch dinner is planned for July.

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 at the NSW Branch website.

Queensland – by Emma Brand

In April the Queensland Branch participated in a joint cocktail party with SPE and PESA in order to promote harmonious relations between the three petroleum-related societies. It was an excellent evening held at the Port Office Hotel in Brisbane with more than 40 people from the different societies attending. The Queensland Branch of the ASEG wishes to thank Deidre Brooks, President of the Qld/NT Branch of PESA, for organising such a splendid event. It is expected that the monthly technical meetings will recommence in June, with a talk by Randall Taylor about Origin Energy's new acreage in Kenya.

South Australia – by Luke Gardiner

The SA Branch has had two recent talks on different applications of EM. The first was given by Graham Heinson in March, whose presentation, Imaging the Australian lithosphere using magnetotellurics, provided a good crowd with an update on the results of magnetotelluric surveys and research in southern, central and western Australia, in both hydrocarbon and mineral exploration provinces.

In April, Thomas Sjøberg from EMGS presented *Finding hydrocarbons using Seabed Logging*. Thomas provided an entertaining and informative insight into the emerging field of Controlled-Source EM, and its applications in offshore hydrocarbon exploration.

The SA Branch holds technical meetings monthly, usually on a Thursday night at the Historian Hotel, from 5:50 pm. New members and interested persons are always welcome. Please contact Luke Gardiner (luke.gardiner@beachpetroleum.com.au) for further details.

Western Australia – by Julianna Toms

On the 16th of April, the WA Branch held the SEG/EAGE Distinguished Instructor Short Course (DISC) on *Concepts and Applications in 3D Seismic Imaging*. The instructor was Biondo Biondi, who is an Associate Professor in Geophysics at Stanford University (USA). The course was well attended by local and interstate geophysicists and geoscientists, with a turnout of approximately 85 people. As a large proportion of the audience were involved in the processing of seismic data, the day-long course was tailored towards those interests. Some of the specific topics discussed were: how different 3D acquisition geometries affects the choice of processing techniques; reduction of computational cost and time of processing 3D data, by using data dimension reducing techniques like stacking after NMO and common azimuth migration (AMO) or reduction in data complexity by splitting computations along different data axes. Thanks go out to Biondo for making his way down to Oz and sharing his expertise and experience with us.

On the 9th May, we held a technical evening featuring a presentation on Quantitative Interpretation (QI). Drs Matthew Lamont and Troy Thompson of Down Under Geophysics gave a very interesting talk on *Bayesian Based Fluid and Lithology Prediction Using Seismic Inversion, Prior Geologic Knowledge and a Stochastic Rock Physics Model*. They demonstrated how information gained from petrophysics, rock physics, geology and geophysics can be utilised in a work flow, which takes into account uncertainty (or collective errors) in order to predict fluid content and lithology away from the well bore.

For those of us interested in finding hydrocarbons it proved to be a very interesting talk, we thank both presenters for their time and efforts.

Jennie Carson
jennie.carson@gmail.com

Perth in November 2007

The 2007 ASEG Conference and Exhibition, which takes place from 18–22 November, is drawing nearer and it should be an outstanding event. I thought I would pass on a few helpful websites to those of you who do not know what the 'most isolated city in the world' has to offer. 'Perth hosts a number of world class events each year, from major sporting competitions which attract world class athletes to festivals celebrating wine, food and music, to local events where tourists can enjoy themselves and feel right at home.'

Top5

The Top5 website index page (http://www.top5guide.com.au/events.php) provides a selection calendar which allows the client the opportunity to select specific events of interest, ranges of dates, keyword and regional searches. The happenings are well sorted and the design of the site allows the user easy navigation.

A side menu offers links to the local weather, news of the day, etc. Most concert and sport bookings are only available via the BOCS (http://www.bocsticketing.com.au/) and Ticketmaster (http://www.ticketmaster.com.au/) websites and Top5 will direct the user to the correct site.

This site is the best for visitors who only have a day or so of free time and want to make the most of their short visit.

Perth Tourist Centre

The Perth Tourist Centre (http://www.perthtouristcentre.com.au/events.htm) is a fantastic access point to the local and rural events in West Australia. The site is a must for travellers who plan on bringing their families along and are looking for activities the entire group can enjoy.

The site organises listings in a monthly fashion so navigation through it is needed to find future events. Carnivals and Festivals are advertised on the main page with a side menu featuring options such as Beach Safety, Bus and Ferry, a Map of Perth and directions to the prime shopping locations.

Swan Valley

The Swan Valley site (http://www.swanvalley.com.au/win.html) is focused on Western Australia's oldest wine-growing region. It advertises that many of the vineyards are still owned by descendants of the European emigrants who settled here in two waves, in the 1920s and after World War Two. Over half of all the wines produced in the Swan Valley region are available only at cellar door so some true treasures can be found. Call 08 9379 9400 or email: visitorcentre@swan.wa.gov.au.

Rottnest Island

Rottnest Island (http://www.rottnestisland.com/en/default.htm) is advertised as 'Western Australia's very own Island Getaway, featuring a casual atmosphere, picturesque scenery and some of the world's finest beaches and bays, is located just 19 kilometres off the coast of Fremantle'.

The island has been long established as a quick vacation away from city life with snorkelling, diving and long cycles along the coastline (no cars are allowed in the island). There are various accommodation options available and the website covers every query and booking option a visitor could ever have. It is a paradise not to be missed and is best appreciated with an overnight stay.

City of Fremantle

Just south of Perth is the **City of Fremantle** (http://www.freofocus.com/main/html/default.cfm). It was revitalised during the Australia II's bid at maintaining Australia's ownership of the America's Cup. The City of Fremantle provides the 'Fremantle Focus'. The aim of Fremantle Focus is to provide an opportunity for visitors to explore the city of culture to optimise their experience. It is advertised as the largest metropolitan retail centre outside Perth and attracts over 2 million visitors annually.

Freo, as it is known, is a fantastic treasure trove of every socio-dynamic West Australia has to offer. There is the Cappuccino Strip featuring restaurants and pubs and local personalities. Fishing Boat Harbour has fantastic sea fare in all manners of presentation, e.g. fried to raw. Fremantle make all feel welcome from hippy to yuppy, it is an experience not to be missed.

Beaches

Forget Bondi! Perth has a beach for everyone (http://www.dpi.wa.gov.au/imarine/coastaldata/1319.asp). Scarborough and Trigg are thriving with surfers and sun-worshippers. Cottesloe is a must with the Sunday Sessions at the Ocean Beach Hotel or the Cottesloe Hotel with uninterrupted views of the sunsets.

The Coast Cams function is to provide users with a real-time visual image of the Perth metropolitan coastline, as well as producing an archive of beach and ocean conditions. There are currently eight cameras located around the metropolitan area, from Fremantle to Hillarys Boat Harbour (twenty minutes north of Perth City).

The website also offers past images via an Archive, which gives users the opportunity to get an idea of what conditions are like during their November visit.

A mixed bag in the 2007 Budget

by Eristicus

More for education and…

Funding of $6.5 billion in 2007–08 marks the highest amount ever spent by any Australian Government on science and innovation programs, although FASTS estimates that is, at 0.57% of GDP, the lowest amount in two decades as a share of GDP.

The big plus in the 2007 Budget was a $3.5 billion package for education called ***Realising Our Potential*** and the establishment of a $5 billion ***Higher Education Endowment Fund***.

Most of the changes to universities are related to their teaching/education roles. There were no substantial measures for university research and the ARC allocation of $577 million was only $2 million more than last year's funding. In real terms it is going backwards (see Table 2).

Some of the key education measures are:

- A new funding model for universities
- Universities go to 3-year triennium funding agreements.
- Caps removed on full fee paying domestic courses once funded places filled – including medicine.
- Discipline clusters reduced from 12 to 7 and the funding base changed (maths gets good increase).

As part of the package, $557 million will be provided over 4 years to simplify university funding structures and provide additional funding for key disciplines particularly in areas of skills need. All disciplines get an increase, except accounting, administration, economics and commerce.

Table 1 shows some of the changes in annual government funding as they affect courses in the science sector. Notice that mathematics and statistics gets a very large increase of nearly $3000 per year.

The 'big ticket' item is the $5 billion investment in the Higher Education Endowment Fund. This fund is analogous to the Future Fund and the first installment in 2007–08 comes from the 2006–07 budget surplus. The Fund will earn income that will then be allocated on a competitive basis by the Minister for capital works and research facilities. All returns on the capital will be provided to the sector and the Government estimates that it will contribute $900 million over three years from 2008–09.

… a new research Flagship on minerals for CSIRO

CSIRO will receive $2.8 billion including $244.5 million for new measures over the next four years – a 19.5% increase in the coming 4 years compared to the previous period. Of interest to the ASEG is the announcement of a new CSIRO Research Flagship: Minerals Down Under.

The government will contribute $34.6 million over 4 years to further develop research into critical challenges facing Australia's Minerals sector. Research will focus on discovery through the development of advanced exploration systems, drilling and development of future mining systems, processing technologies for resources, and development of solutions for sustainable processing. Peter Lilly the current Chief of CSIRO's Exploration and Mining Division will lead the new Flagship.

Table 2 shows the funding provided by the Australian Government for some of Australia's key scientific research organisations. These numbers are taken from the budget papers, including the forward estimates for future years.

CSIRO has quietly put aside its unrealistic plans to raise huge amounts of money by selling services. As shown in Table 3, the target for the percentage of external earnings has fallen from 75% in 2003/04 to a more manageable 50% now. For example in the 2003/04 forward estimates for 2006/07 the ratio was 75%, while now the estimates for 2008/09 and beyond are about 50%.

Most agencies obtained healthy increases. Geoscience Australia (GA), for example, has an increase of $20 million over last year's appropriation to a very healthy $145 million and the Bureau of Meteorology's (BoM) appropriation increased by $21 million to $235 million. The National Health and Medical Research Council also did well with an increase of $64 million to $530 million. Next year the NH & MRC will receive more that the ARC!

….but a scatter gun approach to the environment and climate change

However, the environment and climate change fared very badly. There is no indication of a long-term plan for sustainability, greenhouse emissions or water management. There are no big ideas in the Budget needed to tackle these vital issues. It's all about how to boost the economy and increase GDP, without articulating what goals we should be aiming for in the long term. It is no good having a strong economy just for the sake of the economy.

Let me give you a few examples of what I call the scatter gun approach.

The government gives Boy Scouts $17.7 million to install water tanks across the nation and yet the import duty on fuel-efficient hybrid cars is twice what you would have to pay on gas guzzling V8 four wheel drives.

We are investing $200 million to try and preserve rainforests overseas and yet in Australia, we are still felling trees faster than we are planting them.

We are supposed to be reducing greenhouse emissions and yet we are encouraged, because of the taxation system, to drive our leased cars at least 40 000 kilometres each year.

We are still extracting both surface and ground water at unsustainable levels in most of our catchment areas – and this has been known for at least 10 years.

We are spending $52.8 million on providing information pamphlets and websites to 'help households and small businesses become more efficient and potentially carbon neutral.' In other words, more paper for the recycling bin. There appears to be no real carrot and stick approach for us to be more energy efficient with our heating, cooling and and transport activities.

We are fortunate now to be riding on the back of a resources boom. However, rather than locking up money in things like future funds, we should be identifying what needs to be done and investing the money **now!**

Table 1. Some relevant changes in the Science Sector

New cluster funding model	Funding from Government in 2007	Funding in 2008
Mathematics and statistics	$5381	$8217
Behavioural sciences and social studies	$7233	$8217
Education	$7950	$8217
Computing built environment	$8057	$8217
Engineering, science, surveying	$13 411	$14 363

Table 2. Appropriation from Government for key science agencies							
Agency	**Appropriation from Australian Government in $M**						
Year	***2004–05***	***2005–06***	***2006–07***	***2007–08***	***2008–09***	***2009–10***	***2010–11***
CSIRO	577	594	610	664	682	703	730
ARC	482	582	575	577	590	604	614
NH & MRC	426	457	466	530	631	721	727
DSTO	287	320	341	381	?	?	?
CRC Program	194	208	189	212	182	197	152
BoM	191	211	214	235	245	254	261
ANSTO	111	118	142	152	164	156	157
GA	102	107	125	145	140	131	134
Antarctica	87	101	102	107	108	110	108
AIMS	22	23	24	27	28	28	28

Table 3. Estimates of [goods & services income]/[government revenues] for CSIRO in % for eight financial years								
Budget/year	***2003–04***	***2004–05***	***2005–06***	***2006–07***	***2007–08***	***2008–09***	***2009–10***	***2010–11***
2003–04	55	62	67	75				
2004–05	55	55	60	71	69			
2005–06		49	51	53	55	55		
2006–07			50	50	51	54	55	
2007–08				50	46	48	50	52

ASEG Research Foundation

Project results

The ASEG Research Foundation has been supporting students in all facets of Applied Geophysics at the BSc (Honours), MSc and PhD (or equivalent) levels for 16 years. In this issue of *Preview* we provide a summary of a research project undertaken at the Curtin University of Technology, Western Australia.

Student: Jeanie Powell; BSc Honours Student 2006 at Curtin University of Technology

Supervisor: Milovan Urosevic

Funding: $5000

AVO modelling at Tiof, West Africa

Past inversions were performed on the *Tiof* using reprocessed near, mid and far stack data to better discriminate pore fill and reservoir quality in the sands. The inversion was to reiterate a previously attempted AVO inversion where it was recognised that it was impossible to separate brine sands and shale using any combination of attributes derived from the seismic data. The results were again disappointing. Inconclusive AVO inversion results at *Tiof* have led to a variety of possible and often conflicting geological models, which have lowered the overall confidence in the reservoir.

Therefore, an integrated approach, combining 3D seismic gathers, 3D near and far offset data and borehole log measurements (sonic and VSP), was needed for a two-part study of the statistical AVO probability[1] at the *Tiof* reservoir and the extent of the shale anisotropy existing within the cap rock. First, the study focused on the quantification of the AVO response at the field via probability distributions maps for the underlying lithology and the resulting distributions of the seismic-derived reflectivity parameters leading to the calculation of the probability for hydrocarbon predictions. Secondly, an analysis of the impact shale anisotropy (directly above the reservoir) at the wellsite-1 was completed, which could lead to the potential improvement of the seismic imaging process.

Near-offset Bayes updated mapping indicated that lithology and brine contacts could be discerned at a field level but because the maps revealed no real overlap between the two lithologies (as seen in the probability density function (PDF) distribution), it was concluded that the model was erred (see Figures 1–5). Due to the lack of a consistent horizon thickness it would be advisable to complete an inversion on the datasets and repeat the

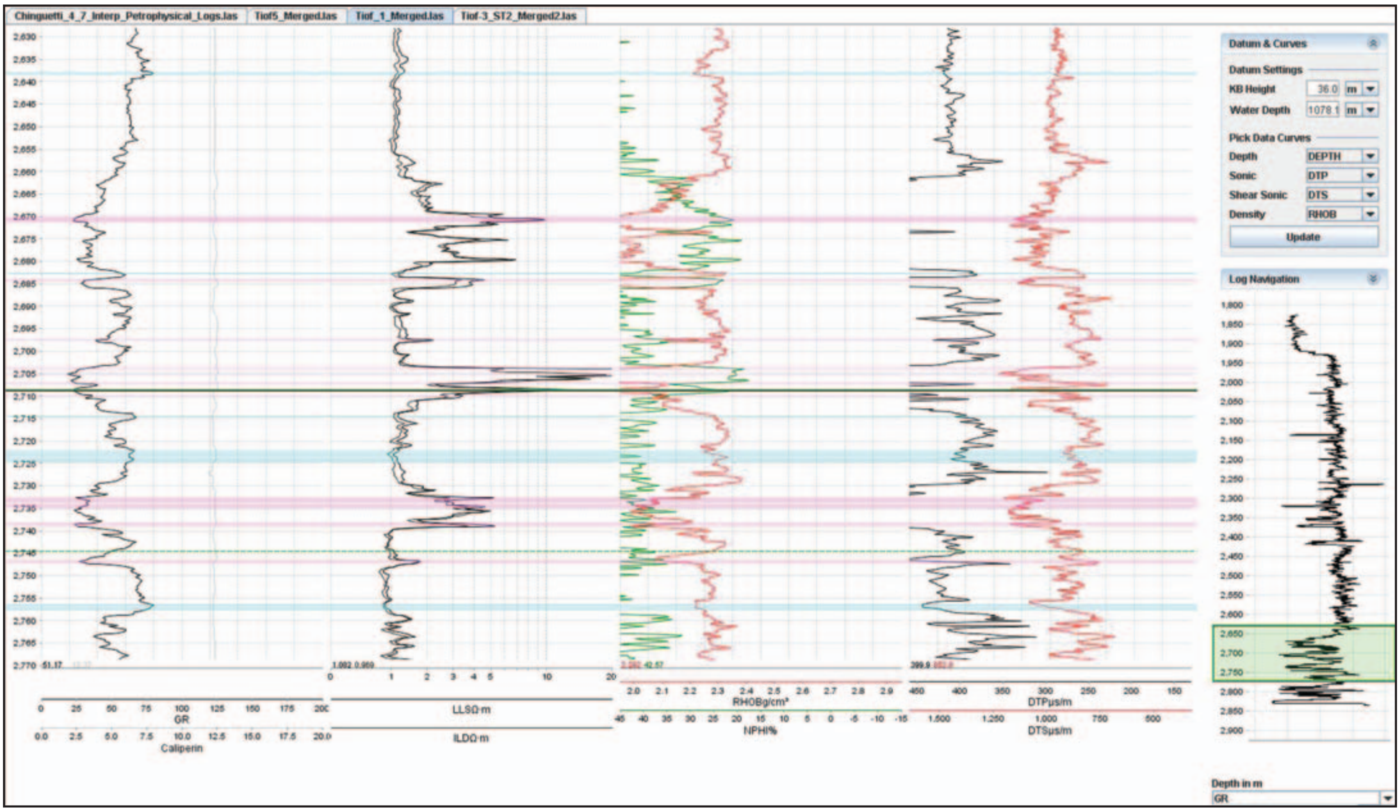

Fig. 1. Example of end-member picks at Tiof-1 (pink, sandstone; blue, shale).

[1] Probability modelling was completed using DownUnder Geosolutions Software. I would like to thank the staff at DownUnder for their generosity and guidance.

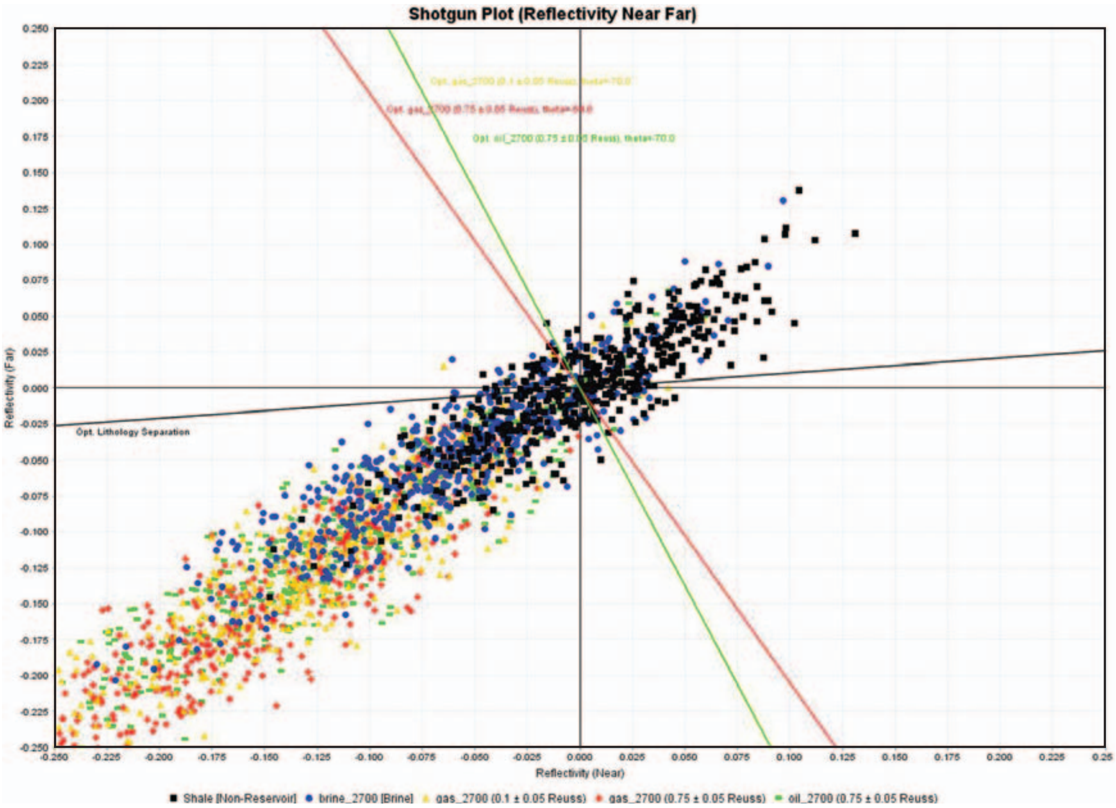

Fig. 2. Far and near offset reflectivity scatterplot results at 2700 m depth.

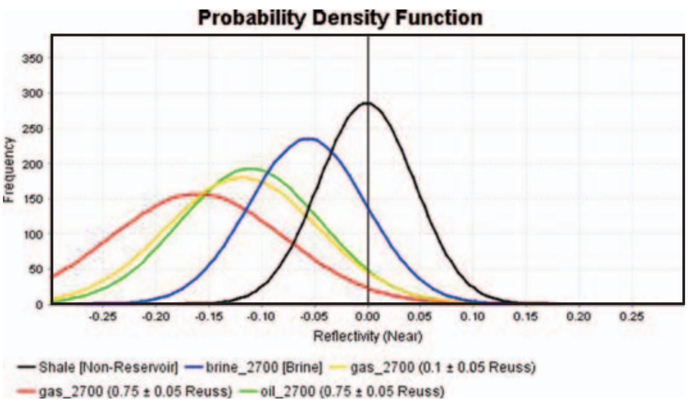

Fig. 3. Near offset reflectivity pdf results at 2700 m depth.

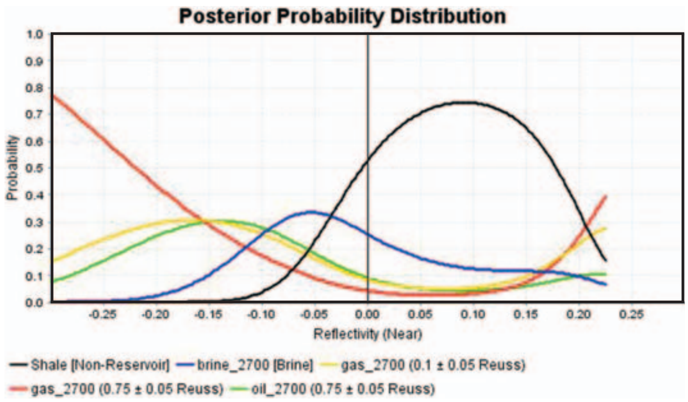

Fig. 4. Near offset reflectivity bayesian probability results at 2700 m depth.

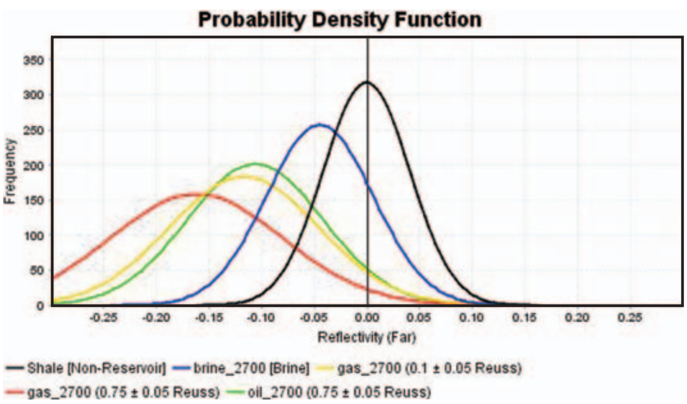

Fig. 5. Far offset reflectivity pdf results at 2700 m depth.

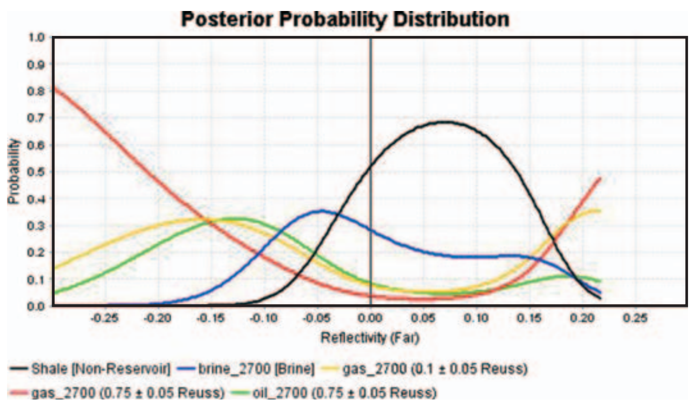

Fig. 6. Far offset reflectivity bayesian probability results at 2700 m depth.

analysis. Deterministic synthetics should be created for all the wellsites and compared with our probabilities based on the stochastically modeled distributions of rock properties based on the uncertainties in our rock physics model. The thin sandstone bedding in sections of the horizon have lead to inaccuracies in the Gaussian distribution of the PDFs increased due to potential tuning effects that were not accounted for within the forward modelling parameters. Quantifying the issue of thin bedding sands in the reservoir should be considered to aid in further minimising the extent of uncertainty of our probability maps (see Figures 6–9).

It is well known that shale comprise on average 70% of the sediments. Shales are also intrinsically anisotropic (polar anisotropy) and as such could significantly affect propagation of seismic waves at other then normal incidence direction (Slater 1997). It is also known that shales can have detrimental effect on AVO gradient and overall on inversion of seismic data (Besheli and Urosevic 2005). The study of anisotropy revealed the presence of vertical transverse isotropy, which could have an

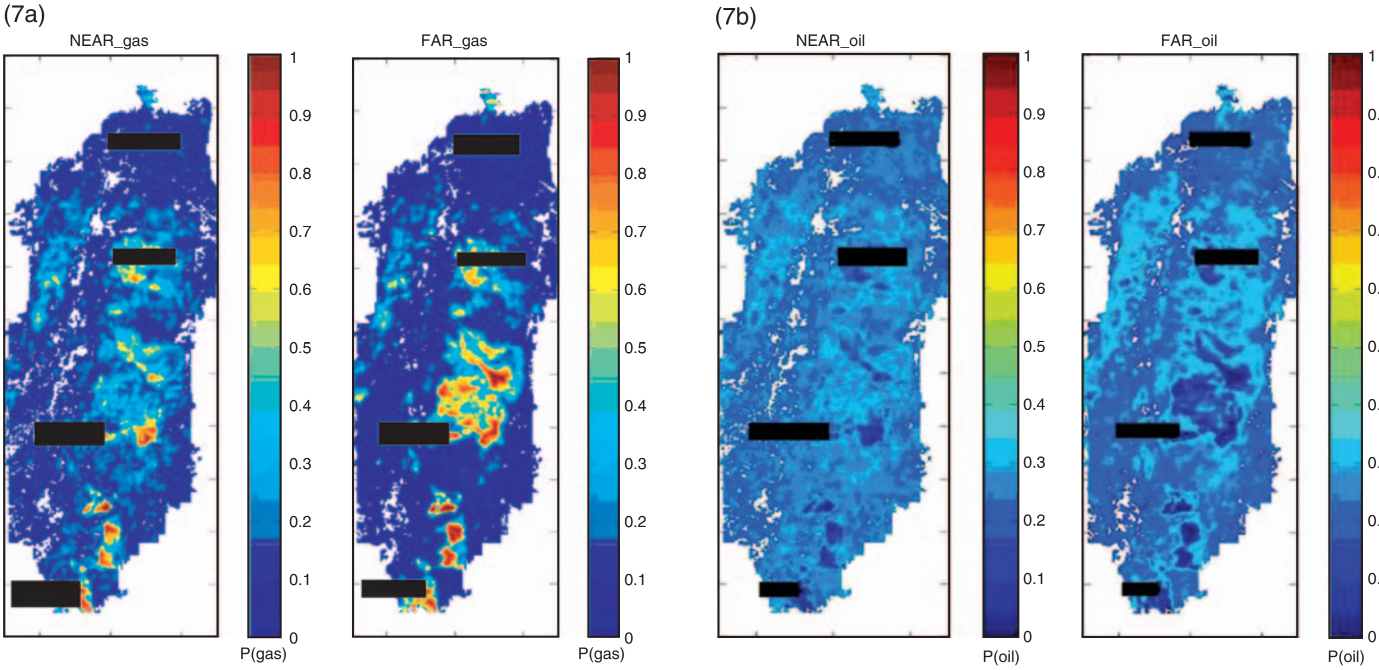

Fig. 7. Bayes update of Horizon-X near and far offset for the probability of gas (7a) and oil (7b) accumulation (0 = no hydrocarbon present (blue) and 1 = highest probability of hydrocarbon presence (red)).

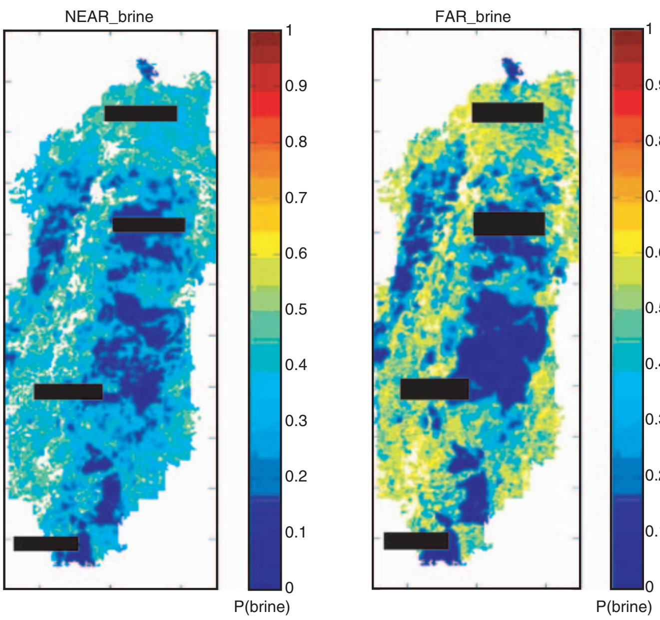

Fig. 8. Bayes update of Horizon-X near and far offset for the probability of brine (0 = no brine present (blue) and 1 = highest probability of brine presence (red)).

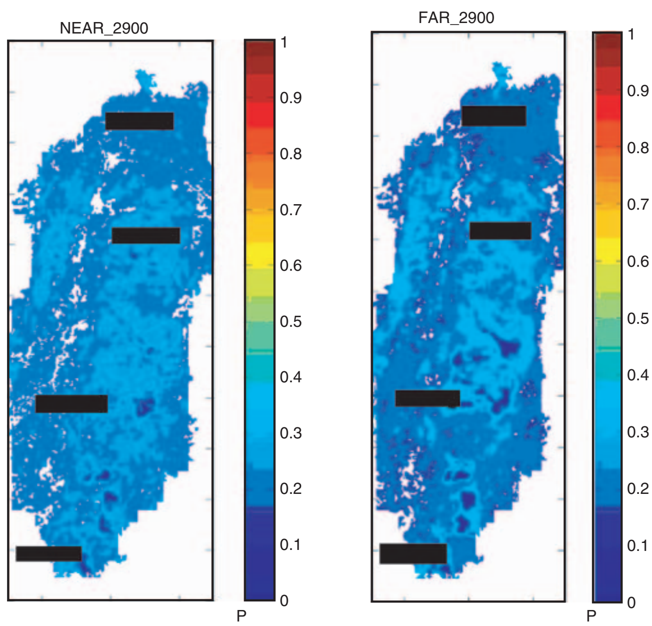

Fig. 9. Bayes update of Horizon-X near and far offset for the probability of shale (0 = no shale present (blue) and 1 = highest probability of shale presence (red)).

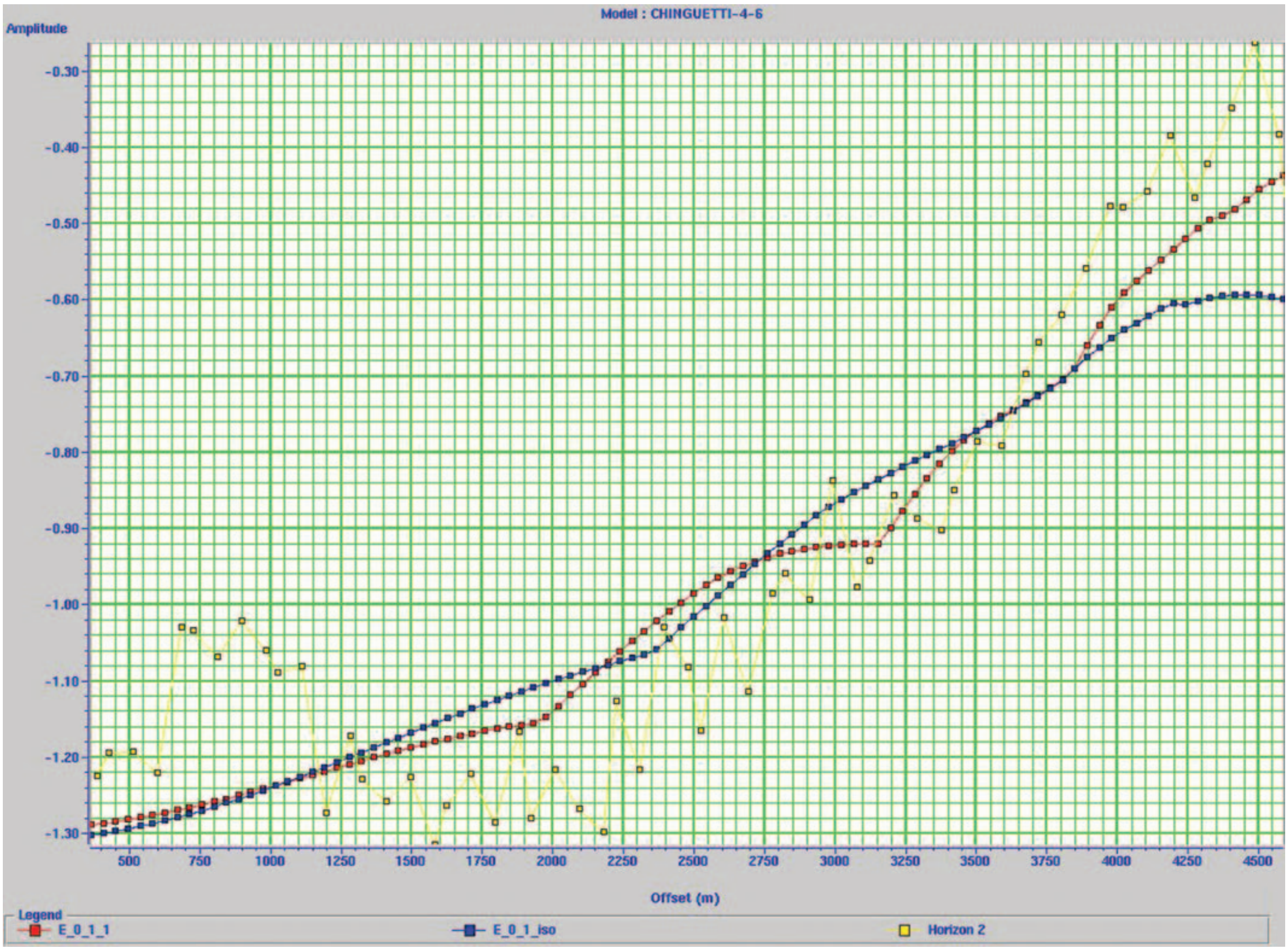

Fig. 10. AVO result σ_H data (yellow) to isotropic (blue) and the anisotropic fit (red) synthetics.

impact on the seismic imaging process (Figure 10). Horizontal transverse isotropy was concluded as being less significant at wellsite-1, suggesting that alignment of elastic properties under asymmetric stress conditions is not an issue.

References

Besheli, S., and Urosevic, M., 2005, The effect of seismic anisotropy on reservoir characterisation: SEG Expanded Abstracts **24**, 150.

Slater, C., 1997, Estimation and modelling of anisotropy in vertical and walkaway seismic profiles at two North Caucasus oil fields: PhD dissertation, University of Edinburgh.

Integration of polyhedral and voxel-based inversion strategies

Summary

Geophysical inversion of magnetic and gravity data provides an effective method for replacing or supplementing tedious manual methods of modelling field data. As there can be no unique inversion for any given potential field data set, manual effort is still required to provide inversion constraints in order to extract realistic geological information.

A lot of research literature is devoted to developing automated methods that incorporate a constraint style that avoids the need for manual interaction with the data. The objective is to produce the best, unbiased inversion possible, with the least manual intervention. The output of automated inversions usually requires a high level of interpretation of the output results and an awareness of the strengths and limitations of the inversion method. By contrast, manually constrained inversions include the interpretation as part of the process with a subsequent knowledge of the quality of the result. Our industry emphasises the use of physical measurements from drilling and outcrop to provide a-priori information for inversion, but geological inference can provide a surprising amount of control without a single measurement being required.

A comparison of polyhedral model inversion with voxel-based inversion strategies provides insights into the benefits of both methods. Integration of the two methods provides the opportunity to embed geological knowledge derived from polyhedral modelling within a voxel model. This geological information is then used to constrain the inversion and provide new information not available to the methods when used in isolation.

The San Nicolas deposit in Mexico is used as a case study of inversion methodologies and the use of a-priori information in constrained inversion. The deposit has been extensively drilled and the limits of the deposit are well defined. The gravity and magnetic methods have been chosen for a practical evaluation of inversion strategies and the quality of the geological outcomes by comparison with the drilling results.

The study results show that the polyhedral inversion strategy would have produced the best precision for siting of the first drill hole, but the constrained voxel inversion would produce the best method for optimizing the location of subsequent holes.

David Pratt
Encom Technology, Australia
david.pratt@encom.com.au

Introduction

The San Nicolas volcanogenic massive sulfide deposit was discovered in 1997 near Zacatecas, Mexico by Teck Corporation. Geophysical and drilling data from the deposit have been used for the evaluation of the UBC GRAV3D voxel inversion using constraints derived from the ModelVision Pro polyhedral forward and inverse modelling system.

A variety of geophysical data sets has been collected over this deposit including airborne magnetic data, ground magnetic data, induced polarisation, CSAMT, DIGHEM and gravity. The gravity method (Figures 1 and 2) has been selected to show how polyhedral modelling can be used to improve the voxel inversion results by embedding geological constraints within the voxel model.

Geophysical inversion of gravity data provides an effective method for replacing

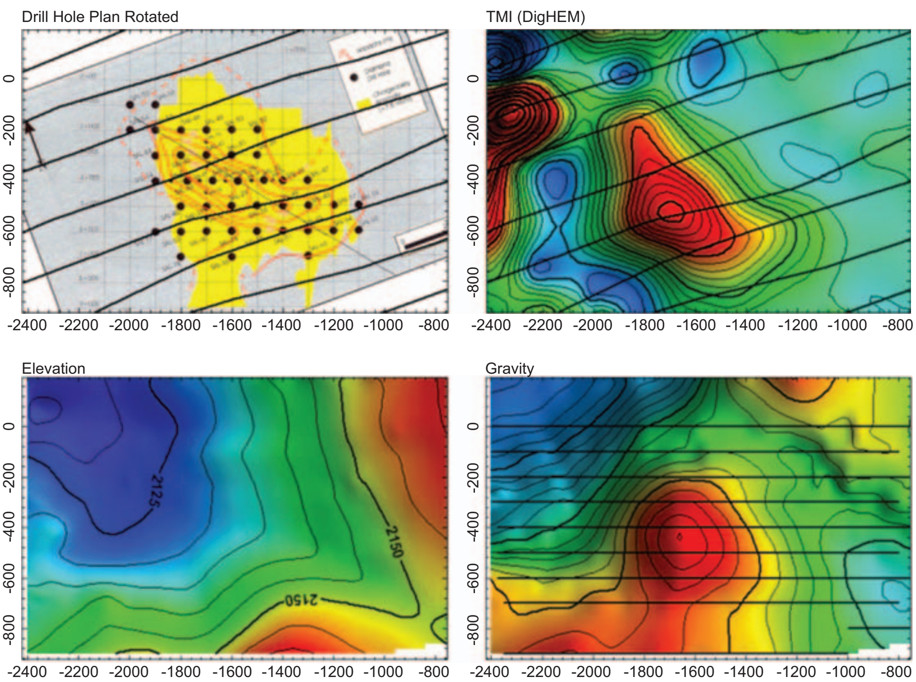

Fig. 1. Images of data used in the inversion (clockwise) of drillhole patterns, total magnetic intensity (2 nT contour intervals), Bouguer gravity (0.2 mGal contour interval) and terrain elevation (5 m contour interval). The amplitude pseudo-colour scales increase from blue to red.

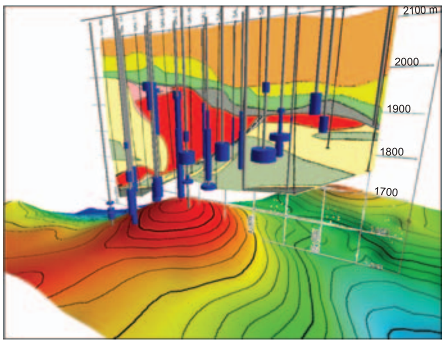

Fig. 2. 3D image of the Bouguer gravity grid, geological section (Johnson et al. 1999) and Cu assay (blue) drilling data for the San Nicolas deposit, Mexico. The red component of the section contains massive sulfides (mainly pyrite) with minor components of copper, lead and zinc. The drillholes show the distribution of copper assays where the diameter of the drillhole diameter in the blue section is expanded in proportion to the copper assay values.

or supplementing manual methods of modelling field data. As there can be no unique inversion for any given potential field data set, manual effort is still required to provide inversion constraints in order to extract realistic geological information.

The unconstrained voxel inversion of the San Nicolas gravity data shown in Figure 3 illustrates the fundamental problem of an unconstrained inversion. The high-density massive sulfide deposit is located beneath an unconformity about 160 m below the ground surface and the unconstrained voxel inversion shows that the high density core leaks through the unconformity.

Table 1. Density bounds	
Lithology	**Density Bounds**
Cover	–0.05 to +0.05 g/cc
Deposit	+0.3 to +3.0 g/cc
Host	–2.0 to +2.0 g/cc

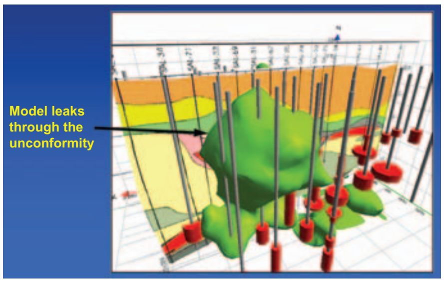

Fig. 3. The green isosurface shows the distribution of the density values from the unconstrained UBC GRAV3D voxel inversion program. Without sensible geological constraints, the density distribution leaks through the unconformity to produce a geologically unrealistic solution.

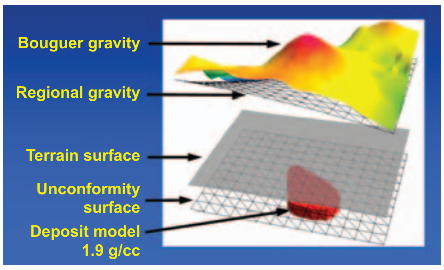

Fig. 4. ModelVision Pro 3D display showing the main model and data elements used to seed the UBC voxel inversion. The regional grid and Bouguer gravity grids are shown in the same context where the vertical separation is controlled by the modelling process. The best fit model for the main anomaly is shown in red with the model unconformity surface aligned with its upper surface.

How can we improve the outcomes before we have any drilling data? Soft a-priori geological information can be derived from polyhedral-based modelling of the gravity with the application of simple geological inference principles. 'The deposit has a high density contrast and is localised/terminated by an unconformity surface.'

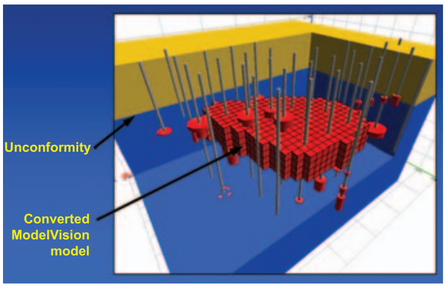

Fig. 5. Illustrates the results of the conversion of the ModelVision Pro physical property model to a UBC GRAV3D voxel model (red outlined blocks). The overburden is shown in yellow and host rock in blue. The model is visualized in Profile Analyst. The drill holes with Cu assays (red barrels) have been included to provide context to the model.

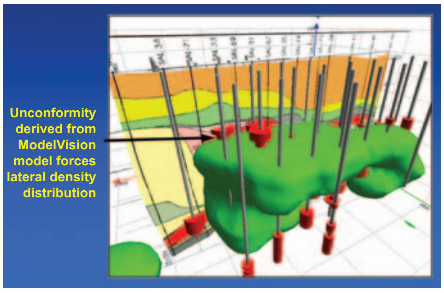

Fig. 6. Shows an isosurface view (green) of the constrained GRAV3D inversion where the anomalous mass is forced to spread under the unconformity rather than leak through it. The anomalous spread is in the direction identified by drilling.

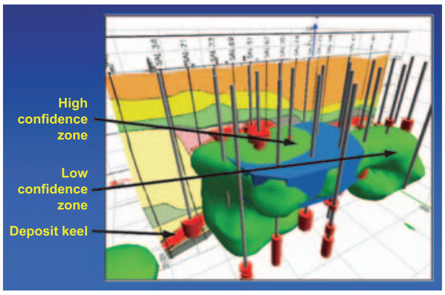

Fig. 7. The isosurface model from Figure 6 (green) is combined with the original constraining ModelVision Pro model (blue). This combination allows for simple identification of high confidence and lower confidence zones within the anomalous mass distribution provided by the GRAV3D inversion.

Inversion modelling in ModelVision Pro was used to derive the depth and approximate density distribution beneath the postulated unconformity using an initial density contrast of 1.9 g/cc. The polyhedral model was then used to populate the UBC GRAV3D voxel model with appropriate density contrasts. Note that the initial polyhedral modelling overestimated the depth to the unconformity by approximately 10%.

The modelling process was also used to model and remove the regional gravity field in a manner consistent with the presence of the unconformity surface. This process is very important for achieving realistic outcomes from the voxel inversion. Figure 4 illustrates the interpretation elements used in polyhedral modelling where the anomalous density material is suspended in a uniform density background.

The model was then used to create a starting model for the voxel inversion with different density bounds assigned to the overburden, deposit and host rock. Table 1 lists the values used to set the density bounds.

Figure 5 illustrates the distribution of the lower bound density values as distributed within the voxel model. Note the polyhedron representing the deposit has been converted to the high-density group of voxels shown in red.

The initial polyhedral model (Figure 4) derived by ModelVision Pro produces a more realistic outline of the deposit than the unconstrained voxel inversion (Figure 3). The drill holes shown in Figure 5 are used to provide a framework for the quality of the predicted location of the deposit and are not used to influence the modelling process.

The constrained voxel inversion results (Figure 6) show a more useful outcome than unconstrained inversion (Figure 3). The high-density material is forced laterally beneath the unconformity and the distribution reflects more accurately the ultimate shape of the deposit established by drilling. Importantly, this result was established without the need for a single drill hole constraint. Only the depth of cover information derived from the polyhedral inversion models was required to achieve the improved voxel inversion model.

Superimposition of the polyhedral model with the voxel inversion as shown in Figure 7 provides a method for visualizing the confidence in the voxel inversion outcomes.

The polyhedral model (blue) would provide a high confidence zone for

Continued on p. 24

Gravity and magnetic inversion with Oasis montaj

Louis Racic
Geosoft Product Management Director,
Toronto, Canada
louis.racic@geosoft.com

The inversion of potential field data requires flexibility in model definition, the ability to constrain the initial model, and visualisation capabilities. Geosoft offers several inversion packages that meet these requirements. These packages are licensed as extensions and are fully integrated with Oasis montaj, Geosoft's flagship product.

PotentQ, developed by Geophysical Software Solutions (GSS), is used for rapid semi-automatic modeling of single magnetic and/or gravity anomalies. GM-SYS Profile and GM-SYS 3D, developed by Northwest Geophysical Associates (NGA), are used for 2D, 2¾D and 3D modeling of regional gravity and magnetic data.

Single anomaly inversions

Single magnetic and gravity anomalies can be rapidly processed using PotentQ, a simplified version of Potent, the GSS mainstream tool for potential field modelling. PotentQ is closely integrated with Geosoft Oasis montaj, which speeds up and streamlines the modelling process. Typically, one would identify an anomaly in Oasis montaj, model it in PotentQ (including depth and dip determination), and post the result back to a montaj map.

A PotentQ model consists of a single body described by one of seven geometries: Rectangular prism, Ellipsoid, Sphere, Polygonal prism (2D or finite length), Cylinder (possibly with sloping end), Slab (2D or finite length), or Dyke (2D or finite length).

A specially formulated inversion scheme generally requires no user intervention while modelling well-defined anomalies either on a profile or a map. PotentQ enables simultaneous modelling of up to three gravity and magnetic components, either total or gradient. It can work with multi-component down-hole data, and lets you include remanent magnetization and anisotropic susceptibility.

Figure 1 shows a 3D inversion example for a magnetic anomaly observed on a profile cutting across the Schönberg maar in Upper Lusatia, East Saxony (Lindner *et al.* 2006).

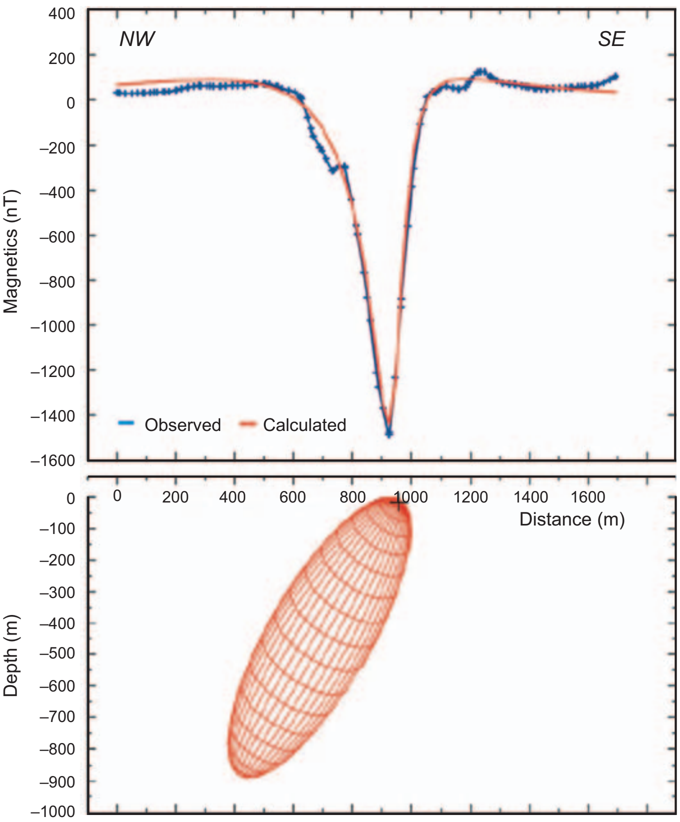

Fig. 1. Inversion of the Schönberg magnetic anomaly in East Saxony, Germany

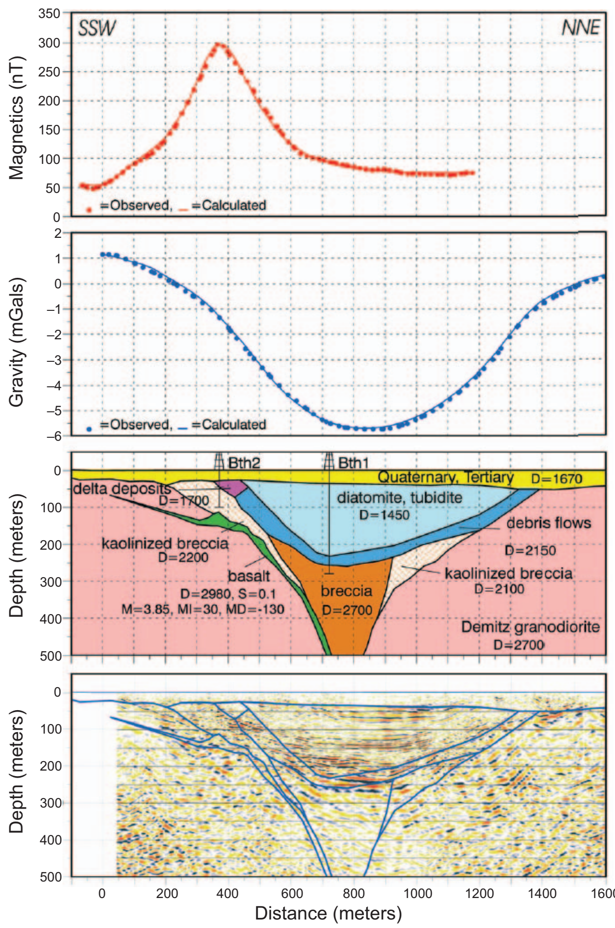

Fig. 2. Forward modelling of the Baruth anomalies and seismic bitmap. Blue lines in the seismic bitmap represent the boundaries defined by the potential fields.

The basaltic intrusion responsible for the observed magnetic anomaly of –1377 nT was modelled using an inclined ellipsoid dipping 40° NE. The model enabled accurate calculation of the intrusion surface at 23 m. Note the close fit of the observed and calculated graphs, which was made possible by the adequate definition of the intrusion geometry and magnetic properties.

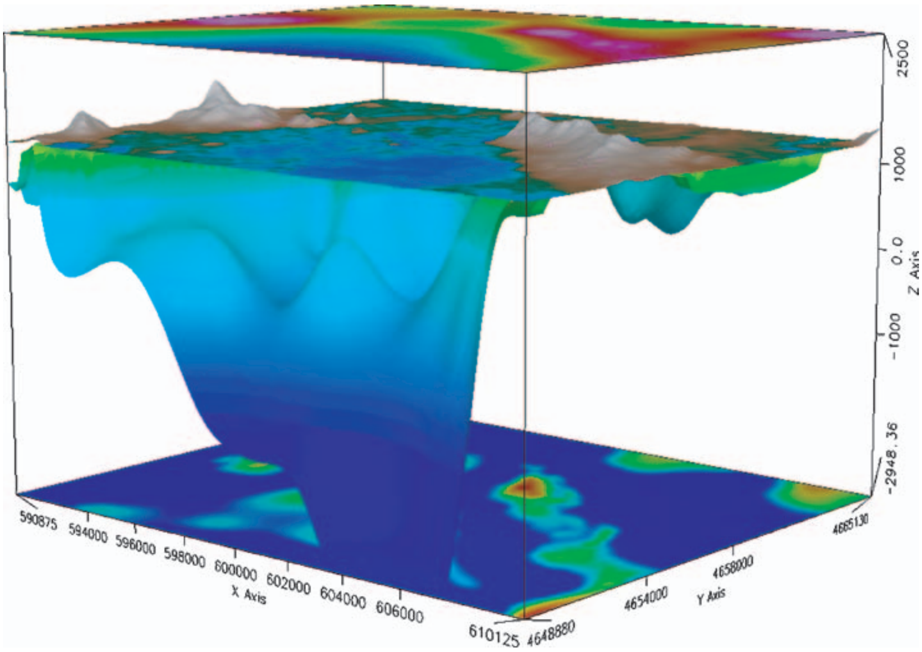

Fig. 3. 3D gravity model of the Klamath Basin in Southern Oregon, USA. The data cover an area 20 km × 27 km. The axes are UTM coordinates. The top most layer is the Bouguer gravity grid, which displays a deep low of ~36 mGal over the south end of the basin. The second grid layer is the topography. The third grid layer is the inverted gravity results displaying the basin geometry. The bottom most grid shows the variation in basement density, ranging from 2.69–2.74 t/m³.

2D and 3D regional data inversions

Large-scale inversions of potential field data, often combined with the known geology, seismic measurements, and petrophysics, are performed with the use of the GM-SYS and GM-SYS 3D packages. These packages support 2D, 2¾D, and 3D models, and offer numerous options that can be used to control the inversion. The GM-SYS inversion packages provide many options for constraining magnetic, gravity, and joint magnetic-gravity models with user-defined weighting.

Geology of the modelled area can be very complex yet the GM-SYS models can adequately reflect this complexity. For example, an inversion block does not have to have a single attribute value. Attribute values within blocks can be distributed vertically and/or horizontally, according to the various models.

Creation of regional models is typically a complex, time-consuming task. However, the latest versions of GM-SYS and GM-SYS 3D significantly simplify and speed up this task, especially for the initial model creation. These packages enable fast, intuitive modification of modelling parameters per modeling block. GM-SYS Profile responds in real-time to any changes made to the block parameters.

The GM-SYS and GM-SYS 3D packages ensure complete control over the inversion process. Individual points and surfaces of the designed models can be restricted on specific iterations based on information from additional sources, such as drill holes, seismic bitmaps, or 3D segments. These additional data can be visualized to ensure that the final inversion surfaces make geologic sense.

Figure 2 shows a combined (magnetic and gravity) 2¾D model of the Baruth maar in Upper Lusatia, East Saxony (Lindner et al. 2006). The combined model includes the seismic results as a constraint, in order to reduce the inversion ambiguity.

2D models can serve as a starting point for 3D models, which consist of stacked Oasis montaj elevation or depth grids. A model block is defined as the space between two grids. Blocks may extend to infinity or terminate where two grids make contact. There is no practical limit to the size or number of grids that may be used in the model. As in the real world, each block may have an internal variance in density and susceptibility.

Figure 3 shows a 3D gravity model of the Klamath Basin in Southern Oregon, USA (French *et al*. 2003). The model includes constraints from basement outcrops, two seismic reflection profiles, wells and 2D modelled profiles. The Bouguer gravity map (shown as the top layer) displays a deep low of ~36 mGal over the south end of the basin. Using all of the known geological constraints available for the basin the residual gravity was inverted to determine the basin geometry and the variation in basement density shown by the bottom grid in the figure.

The 3D models can be written to Geosoft voxels, UBC, or GOCAD formats. Conversely, gravity responses can be calculated from Geosoft density voxels. Time models can be built using seismically-derived time horizons and velocities, then converted directly to depth models.

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Australian deep seismic reflection activities: an exciting future

Bruce R. Goleby
Onshore Energy and Mineral Division
Geoscience Australia
bruce.goleby@ga.gov.au

Tim J. Barton
Onshore Energy and Mineral Division
Geoscience Australia
tim.barton@ga.gov.au

Introduction

From the late 1940s to today, Geoscience Australia has been acquiring high quality deep seismic reflection data as part of its ongoing program of providing data and information towards understanding the structure and evolution of the Australian Continent. The coverage of the onshore part of the Australian Continent now reaches a degree where many of the more economically significant geological provinces and terranes have at least one seismic section providing glimpses of the structure of the crust. Australia's current deep seismic reflection coverage is shown in Figure 1.

This continent-wide seismic reflection program is made possible through a combination of Geoscience Australia's own requirements to understand Australia's third dimension, its involvement in collaborative research programs with the State and Territory Geological Surveys; and its involvement in ANSIR, the National Facility for Earth Sounding. For the last 9 years, the seismic acquisition component of the program has been coordinated through ANSIR. ANSIR's success has encouraged its owners, the Australian National University and Geoscience Australia, to enhance and continue this earth imaging facility. Over this time, ANSIR has been responsible for acquiring in excess of 30 regional deep seismic reflection surveys, totalling over 3000 line kilometres of deep seismic reflection data (Figure 1). ANSIR is also responsible for acquisition of portable broadband and short-period seismic acquisition and a summary of this work has recently been published (Kennett 2006).

Geoscience Australia continues to provide expertise in deep crustal seismic reflection processing and mineral province interpretation to all collaborative research programs. Today, these seismic reflection programs focus on understanding the architecture and mineral systems within 'hard-rock' mineral provinces.

Recent surveys results

The continuing success and increasing demand for similar continent-wide seismic reflection programs is attributed to three linked areas. Firstly, conducing projects that focus on clearly- targeted, often regional-scale scientific objectives that can be solved by seismic reflection techniques.

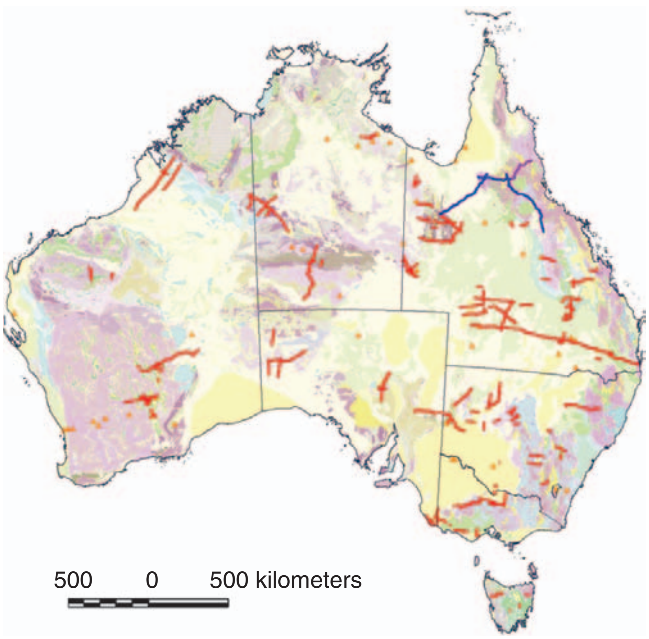

Fig. 1. Geology map of Australia showing distribution of deep seismic reflection traverses. Red lines are completed seismic traverses. Orange triangles are early seismic sounding locations. The blue lines are the position of a survey currently being acquired. The purple line is the location of the first AuScope Survey that will be collected in August this year.

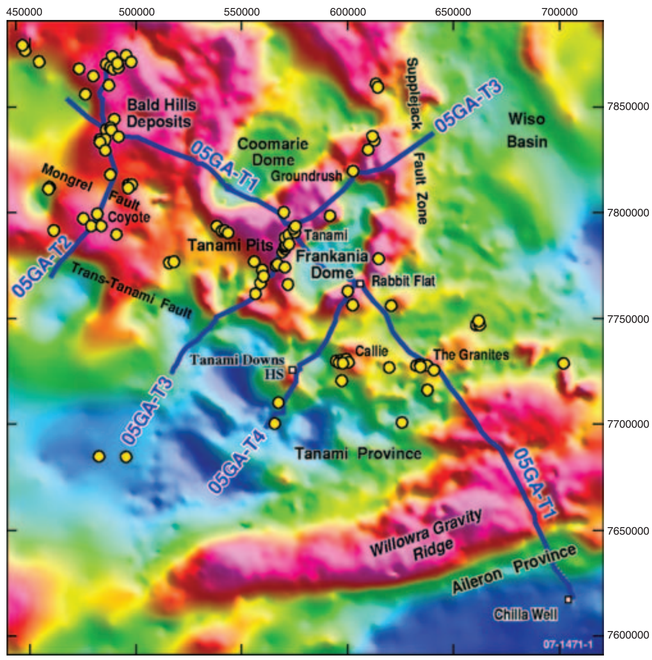

Fig. 2. Gravity image of the Tanami region, northern Australia, showing location of the four Tanami traverses (05GA-T1 through to 05GA-T4). Image from Goleby et al. (2007).

Secondly, processing data to achieve the best overall results that are also representative of the signal, and thirdly, interpreting the data using seismic methods in conjunction with multi-skilled teams.

The seismic reflection data processed within Geoscience Australia is processed using the DISCO/FOCUS seismic processing package. Geoscience Australia's extensive deep-seismic 'hard-rock' processing expertise has been crucial in improving the quality data of the 'hard rock' seismic data. Critical processing steps include application of correct refraction residual statics corrections, geologically consistent velocity analysis, spectral equalisation, and correct migration of the data.

In recent times, deep seismic reflection surveys undertaken include 720 km in the 2005 Tanami Survey, 288 km in the 2005 Thompson–Lachlan Survey, 397 km in the 2006 Victorian Survey and 900 km in the 2006 Mt Isa Survey. Each of these surveys operated as a collaborative survey and involved at least three parties. Results from the Thompson-Lachlan, Victoria and Mt Isa surveys are currently being processed and are scheduled to be available by the end of this year.

The 2005 Tanami Seismic Research project was a joint project between Geoscience Australia, Northern Territory Geological Survey, Geological Survey of Western Australia, Newmont Exploration Pty Ltd and Tanami Gold NL. Its objective was to define the crustal architecture of the Tanami region. This was achieved through the acquisition of seismic data in a grid of four deep seismic traverses 05GA-T1 through 05GA-T4 (Figure 2).

The seismic survey showed the crustal architecture of the Proterozoic Tanami and Arunta regions and identified structural anomalies, some of which appear to control gold mineralisation, and helped in generation of exploration targets (Goleby 2005; Goleby *et al*. 2007).

The seismic reflection sections show a well-defined reflective Moho on almost all of the four traverses. The crust in the Tanami region thickens from approximately 35 km in the north-west to approximately 42 km in the south-east, near The Granites mine. From this point southwards there is a rapid thickening of the crust to approximately 60 km. This thickening of the crust in the south-east coincides with changes in the regional gravity field that define the east-northeast-trending Willowra gravity ridge (Figure 2).

The regional seismic section, 05GA-T1 (Figure 3), shows a series of tectonically significant structures. The section shows the presence of a series of east-dipping crustal-penetrating structures that extend from the surface to the Moho boundary. One particular crustal-scale features is interpreted as the boundary between the Tanami region and Arunta region (Figure 3). There is also a partitioning of the crust into a less reflective upper crust and a more reflective middle to lower crust. These structures record a fundamental architecture emplaced during the evolution of the Tanami region and the establishment of the current geometry of the region.

Within the upper crust, the seismic sections image a series of structures that link the mid-crust to 'thin-skinned' structures within the uppermost crust. These secondary structures appear to control Tanami Group deformation. The seismic has also clearly imaged the regional granite bodies, showing them as shallow and relatively thin bodies that are less than 3 km thick.

There is also a strong association between the location of ore deposits and prospects and the location of near-surface structural anomalies, which include shallowly dipping thrusts, 'pop-up' structures, and ramp anticlines (Figure 3). The seismic shows that known ore deposits are all located within the more complexly deformed zones and therefore deposits have a direct association with structural anomalies. The seismic sections show several additional structurally anomalous areas that might be considered to have mineral potential and therefore ultimately will benefit both the State and Territory and Australian economies.

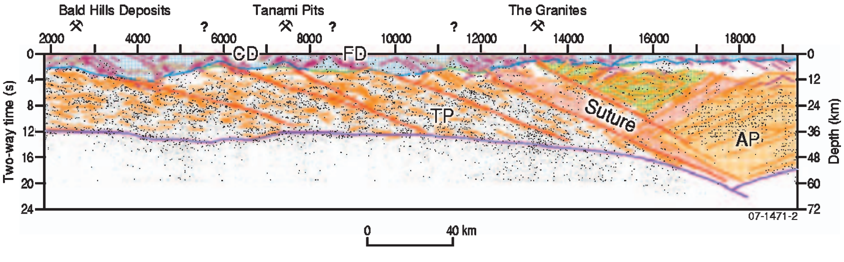

Fig. 3. Schematic diagram showing main features of the 2005 Tanami traverse 05GA-T1. Purple line is Moho, red lines are key structures, orange lines are reflection trends, while remaining lines represent interpreted units. Shading represents different crustal blocks. The mine symbols show the locations of major mines within the area. CD – Coomarie Dome, FD – Frankania Dome, TP – Tanami province. AP – Aileron province. Image from Goleby et al. (2007).

Future Australian deep seismic reflection activities

Future seismic activities will build on the earlier work and expand the role of deep seismic reflection into a new era. These deep seismic reflection surveys will continue to be one of the main components of any regional geological project, as reflection seismic methods are one of the few methods that reliably and clearly image fundamental structures within a region. These surveys will continue to provide exciting images, therefore providing the necessary depth constraints constraining 3D geological models of a region. Three-dimensional models are essential in understanding tectonic evolution, as well as providing important information on possible mineral systems associated with the tectonics.

Two new exciting programs that are just starting will provide a significant increase in deep seismic reflection acquisition levels. The first is the Australian Government's, *Onshore Energy Security Initiative* program. This initiative has provided approximately $20 million for targeted deep seismic reflection profiling over the next five years. The objectives of this initiative are aimed at promoting investment in exploration for energy-related minerals and petroleum resources, especially in greenfields areas. Project outputs will be aimed at improving discovery rates for energy-related resources. Figure 4 shows the suggested locations of the currently proposed seismic reflection traverses planned to investigate the occurrence of mineral and energy resources in greenfields areas.

The first of the Onshore Energy Security projects is the Isa–Georgetown–Charters Towers Seismic Surveys. Its location is shown on Figure 4. This project involves the acquisition of deep seismic reflection and add-on earth imaging data along a series of traverses extending from the eastern edge of the Mt Isa Inlier, across the Georgetown Province, then southeast into

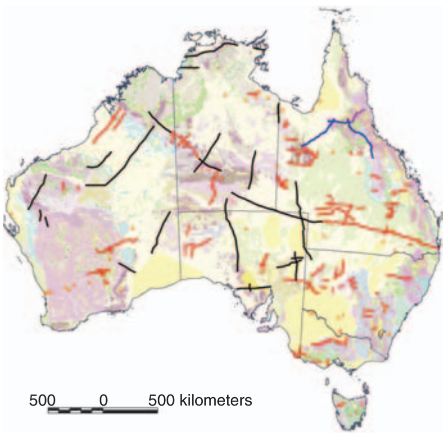

Fig. 4. Geology map of Australia showing the same distribution of deep seismic reflection traverses as shown in Figure 1. Black lines are proposed Onshore Energy Security Initiative seismic traverses. Locations of these seismic traverses will be further refined to ensure optimal locations for understanding Australia's Energy Resources.

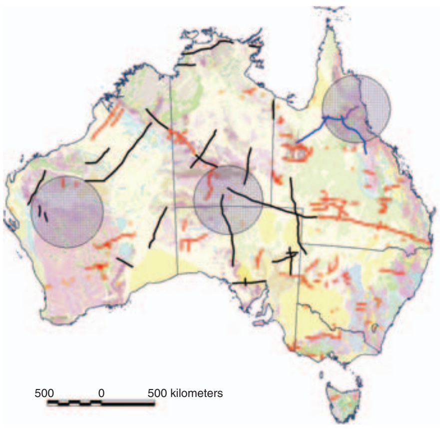

Fig. 5. Geology map of Australia showing the same distribution of deep seismic reflection traverses as shown in Figure 1. Shaded circles indicate regions where initial AuScope traverses have been proposed.

the Drummond Basin. The project, a collaborative project between Geoscience Australia and the Geological Survey of Queensland, aims to map the three-dimensional geology of the Mt Isa to Georgetown to Drummond Basin region to improve our knowledge of the deeper structure and likelihood of energy, mineral, and geothermal resources within the region, as well as providing a fundamental dataset to assist in understanding how the geology of the region evolved.

The second of these programs is the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS) initiative, under the Australian Government's Backing Australia's Ability package. The Australian earth sciences have, for the first time, been recognized as part of Australia's key scientific capability. The earth sciences bid was awarded $42.8 million to support infrastructure to understand the Structure and Evolution of the Australian Continent. This new capability is being managed through AuScope (http://www.auscope.org.au/).

AuScope will establish world-class research infrastructure to characterise the structure and evolution of the Australian continent in a global context, from surface to core in space and time; and provide better understanding of the implications for natural resources, hazards and environment, all contributing to future prosperity, safety, and a sustainable environment for Australian society.

Of AuScope's four key components, the Earth Imaging and Structure component is focused on providing a unique data- and knowledge-base of the third dimension of geologically important regions. This will be achieved through the collection of GeoTransects. AuScope will collaborate with, and use the services of ANSIR to achieve this.

Initial AuScope projects suggested include research into the Capricorn Orogeny and the links between the Pilbara and the Yilgarn Cratons, research into the relationship between the Musgrave Province and the Gawler Craton, and research into the three dimensional geometry of the Tasman Line in far north Queensland, where it is best exposed. These areas are shown on Figure 5. With the Onshore Energy Security work going ahead in north Queensland, the Tasman Line project in far north Queensland has become the first AuScope Traverse (Figures 4 and 5). This survey links with the Isa–Georgetown–Charters Towers survey and together, will provide an exceptional opportunity to image this important region of Australia crust in three-dimensions. Future AuScope transects will be targeted towards similar major scientific problems and selected through proposals from the academic community. AuScope will encourage co-investment from other partners, as this will allow extension of such work and, where possible, such work should be augmented with acquisition of additional geological and geophysical data.

ANSIR is currently facilitating the establishment of a National GeoTransects Committee following on from recommendations within the *2003 National Strategic Plan for the Geosciences*. This committee will assist Australian earth scientists identify key geological problems solvable by seismic methods, and will prioritise possible GeoTransects to provide fundamental information on the Australian tectonic plate, from its basic structure and evolution through to its mineral and petroleum systems and surficial processes. Further information on the *National Planning for a Geotransect Program* discussion paper is available on the ANSIR website (http://rses.anu.edu.au/seismology/ANSIR/geotransect.html).

Conclusions

The deep seismic reflection surveys being undertaken by Geoscience Australia and its collaborators are providing clear and exciting images of the crustal architecture within various Australian mineralised regions. They provide constraints on possible tectonic histories and likely mineral systems within that region. The seismic data have imaged key geological structures within that region and have provided the important depth constraints necessary to construct 3D geological models of the region. The seismic data have also shown their worth in constraining possible mineral systems that operated in the region, allowing explorers to be more targeted in assessing the mineral potential of an area.

Acknowledgments

The seismic reflection data presented here was all acquired by ANSIR, the National Research Facility for Earth Sounding. We thank them for their efforts and expertise. We also thank ANSIR's facilities manager, Terrex Seismic Pty Ltd for their professionalism in acquiring the seismic reflection data.

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New Zealand petroleum doings!

Petroleum exploration and development activities in New Zealand have, overall, been buoyant in response to the continued healthy oil price. Although Taranaki, the country's mainstay, is where the bulk of this activity has been concentrated, Deepwater Taranaki, Northland, the East Coast, Canterbury, Great South and the Western Southland Basins have received varying degrees of attention.

Development projects

The four development projects in Taranaki, Pohokura, Kuoe South, the Tui cluster and Maari are receiving the lion's share of activity, with records set in drilling deviated wells as Pohokura POW-3 was drilled to a TD of 7409 m (ahbkb). Pohokura has been flowing commercial gas for partners Shell, Todd and OMV from its onshore extended reach wells since September 2006 and gas was landed from the first offshore well in March.

The Ensco 107 jack-up rig is now scheduled to drill development wells for Kupe South starting in September. Meanwhile rock 'mattresses' have been built to support the pipeline across the uneven seabed and two horizontal, directionally drilled tunnels are in place to bring the pipeline under the south Taranaki cliffs to the onshore receiving and processing station, which is now being constructed.

Although replacement gas for the declining Maui field is of prime importance for New Zealand, perhaps the projects of most interest to the international community are the oil field developments of the Tui cluster and Maari. Three oil accumulations were discovered in Paleocene 'F' sands in the stable platform to the west of Maui: Tui, Pateke and Amokura. Although these are not large, their cumulative recoverable oil is around 34 million barrels and other nearby structures are yet to be drilled. To date three subsea wellhead completions have been installed, horizontal production wells have been drilled in each structure and the FPSO vessel Umaroa is now on station. First oil is expected to be delivered at the end of June. The Tui cluster partners are AWE, Mitsui and NZOG.

The Maari project is 40% complete according to partners, OMV, Todd, Horizon and Cue. The FPSO vessel, Raroa is being converted in Singapore and drilling of production and injection wells is now scheduled to begin in March 2008. In addition, an exploration well is to be drilled in the Manaia satellite structure. Approximately 50 million barrels of oil are expected to be recovered from Maari over its projected 10-year life, from Middle Miocene Moki Formation turbidite sands.

Although on a smaller scale, onshore Taranaki has had its successes too. In particular, Greymouth is producing gas from the Turangi Field just to the south of Pohokura, while the Cheal oil development has been successful for Austral Pacific.

So what does all of this mean for New Zealand? Despite the billions of dollars being invested in the above development projects, these projects are relatively small in a global context. Although the oil and gas from the current projects will be a very welcome stop-gap, New Zealand has not yet achieved energy security. The demand for more discoveries is high and exploration companies are responding to the challenge, particularly in the offshore basins.

Highlights of Exploration

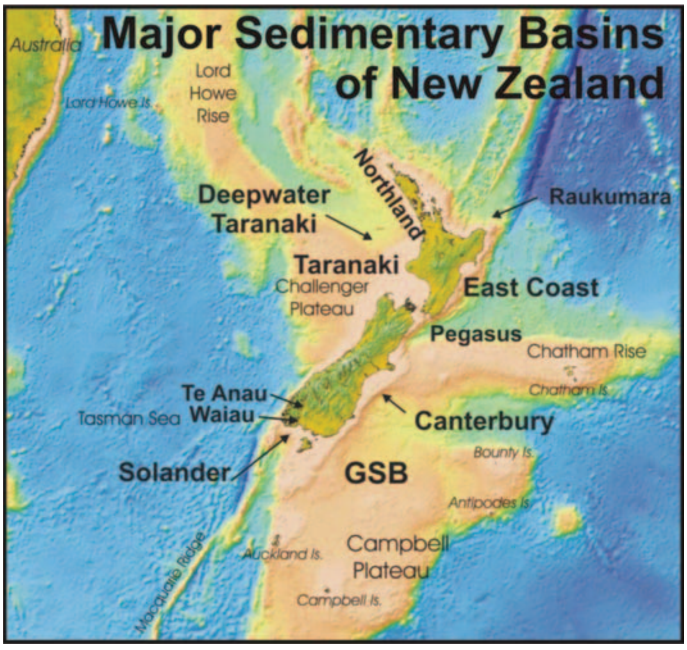
This report is not intended to cover every aspect of exploration in all of New Zealand's sedimentary basins, just highlights from each. It is intended to present a more thorough treatment of prospectivity for each basin in turn in future articles.

The offshore **Northland Basin** is, at least in part, a continuation northwards of the Taranaki Basin. Three permits cover the southern part of the basin. PEP 38612 is a small block surrounding the Karewa gas discovery, which Todd holds and has recently announced that it plans to develop. PEP 38618 and PEP 38619 are both held

Chris Uruski
GNS Science, Lower Hutt, New Zealand
c.uruski@gns.cri.nz
Photograph from GNS Science, NZ

by Origin and OMV and operated by Origin. The CGG-Veritas vessel, Pacific Titan recently completed the 400 km^2 Nimitz 3D and the 1910 km Pantheon 2D seismic surveys in PEP 38619, followed by the 1200 km Akira 2D survey in PEP 38618, one well is expected to be spudded in each of these blocks by March 2010 under the terms of the licences.

The **East Coast Basin** differs from other basins in New Zealand as it is the most highly tectonised basin which still retains good reservoir characteristics, being essentially the accretionary subduction prism of the Pacific Plate below North Island. Stratigraphy is very complex in this basin and the three offshore wells drilled so far have each proved different from the others. The offshore basin covers an area of more than 70 000 km^2, approximately a third of which is a single exploration permit (PEP 38344) held 100% by Pogo of



Houston. Other licences include five large onshore licences and a block in Cook Strait held by Discovery Geo (PEP 38343). Pogo are presently acquiring some 2000 km of 2D seismic data using a second CGG-Veritas vessel, the Duke (formerly Multiwave's, Polar Duke). On completion of Pogo's survey, the Duke will be conducting a 2000 km 2D survey for Crown Minerals in the Raukumara Sub-basin to the north of the Raukumara Peninsula and in the Pegasus Sub-basin off Cook Strait. Both of these areas were excluded by Crown Minerals (the NZ regulating authority) from application by interested companies until they have acquired, processed and interpreted the new data, when the acreage may be offered in a new licensing round. Both areas contain very thick sedimentary successions, the Raukumara Basin up to 13 km, possibly including a Cretaceous rift basin and Pegasus is filled mostly with Neogene turbidites derived from South Island on a Cretaceous and Paleogene potentially source-rich substrate.

The **Canterbury Basin** is covered by a range of permits, both onshore and off. TAG holds PEP 38256 onshore and Greengate holds PEP 38260 and 263, 260, which is partly onshore and mostly offshore. They plan to drill Kate-1 in the offshore part soon and have acquired some 500 km of 2D seismic data from their offshore permits. Cutter-1 in PEP 38259 was recently drilled by TAP, AWE, Beach and Anzon in their offshore block across the Canterbury Shelf, although gas shows were reported, the target horizons were water bearing. Origin holds the remaining blocks in the deeper water regions of the basin. It has recently acquired two 2D seismic surveys in their two blocks; about 1000 km in PEP 38262 last year and approximately 2000 km in that block and in PEP 38264, which lies outboard of 262 and in deeper water. These blocks appear to overlie the hydrocarbon kitchen for the basin and contain large structures.

The **Great South Basin** licensing round closed on 1st April and Crown Minerals are planning to announce the results on 31st July. Forty blocks were offered, each approximately 9000 km^2. Several blocks cover both onshore portion as well as offshore and some include areas already under licence, particularly those west of Stewart Island in what is really the Solander Basin. Rumours about the applications abound, but the only statements to have come from parties involved so far are:

'*We are pleased with the applications*' (Harry Duynhoven, Associate Minister of Energy).

'*We are bidding on our own*' (Mark Dunphy, Managing Director, Greymouth Petroleum).

'*Shell has taken a long, hard look at it and we have decided not to bid*' (Shell spokesman).

Provided a reasonable acreage is taken up after July, the New Zealand industry can look forward to a large-scale effort in the region as much of the basin is covered by relatively deep water, averaging about 750 metres water depth, so the unwritten sub-text is 'only serous explorers need apply'.

The **Western Southland Basins** include the offshore Solander Basin and the Waiau and Te Anau Basins onshore. Three licences are held by L&M, which was recently floated on both the New Zealand and Australian stock markets. L&M have acquired 2000 km of new 2D seismic data across their offshore block (PEP 38228) and have recently interpreted this new data set, together with several thousand kilometres of older data to define drilling targets. Onshore, they have started a 4-well drilling campaign in the Waiau Basin (PEP 38226) and the Te Anau Basin (PEP 38230), following good shows in last year's Sharpridge-1 well.

The **Taranaki Basin** is due to experience a new wave of drilling, including the Hector prospect due to be drilled later this year by the Tui partners once the Ocean Patriot has completed development drilling the Tui cluster to the northeast. NZOG plans involvement in four wells in the coming months, including Taranui-1, a Tui look-alike, Mohomo to the southeast of the Kupe development and Felix or Opoto to be drilled from onshore northern Taranaki. Pogo and their partners Mighty River Power and Mitsui are planning to drill Kanuku when their slot with the Ocean Patriot becomes available and they may also drill a shallow-water prospect with a jack-up rig later.

PEP 38451 in **Deepwater Taranaki** was awarded to Global Resource Holdings LLLP of Denver. It is the largest permit in New Zealand at present, being 55 830 km^2 in area. It contains a large Late Cretaceous Delta, voluminous source rock sequences, a range of large structures and a thick sedimentary succession. In many ways it is geologically similar to the Great South Basin, but is yet to be drilled. Instead of the Neogene carbonate succession preserved in the Great south Basin, Deepwater Taranaki received large volumes of clastic sediments originating in the Southern Alps. Very large channel and turbidite successions are mapped and these too form large, if subtle structural closures and may be analogous to deepwater turbidites along the West African margin. Most deepwater basins being explored today are salt basins, there is no salt in Deepwater Taranaki, and companies used to exploring in salt basins may be unfamiliar with the relatively gentle, but large structures encountered there.

Continued from p. 17

targeting the first drill hole, while the lower confidence extension provides some indication of the possible extent of the deposit. The first drill hole will providenew information such as density and unconformity depth for revision of the ModelVision Pro model. The refined constraint model could then be used to re-run the UBC voxel inversion.

This method provides a logical approach to reducing risk, while improving the probability of success with greenfield exploration from the voxel inversion.

References and suggested reading

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Geological surveys of Queensland, Western Australia, Northern Territory, Tasmania and Geoscience Australia

The acquisition of geophysical data over the Australian continent just goes from strength to strength. The tables below indicate the investments that continue to be made by the Australian and the State and Territory governments. As you can see (Table 1) over 1 million line-km of new airborne data are being acquired and released at cost of transfer in the public domain. In addition more than 45,000 gravity stations are being observed over an area covering nearly half a million square kilometres (Table 2). A very impressive and commendable program of work.

The locations of these surveys are also shown in the Figures below and the Tables contain the survey progress as of 10 May 2007.

For more information please contact Murray Richardson of Geoscience Australia at murray.richardson@ga.gov.au and for the Western Australian program the contact is David Howard at david.howard@doir.wa.gov.au. Final data releases are available by download from the Geoscience Australia Data Delivery System at www.ga.gov.au/gadds. For WA, releases of preliminary data, generally at about 50% and 100% of the data acquisition stage, are made on the GSWA website (www.doir.wa.gov.au/GSWA) 'Maps and Images' page.

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
Ashburton	GSWA	GA	UTS	4 Aug 06	105,840	400 m 60 m N/S	34,920	27 Dec 06	9 Mar 07	121 – Apr 06 (p. 35)	Released 4 Apr 07
Southern Officer Basin	GSWA	GA	GPX	15 Aug 06	105,200	400 m 60 m N/S	37,330	18 Jan 06	16 Mar 07	121 – Apr 06 (p. 35)	Released 28 Mar 07
Isa South-East	GSQ	GA	Fugro	8 Aug 06	101,200	400 m 80 m E/W	35,800	19 Nov 06	12 Mar 07	118 – Oct 05 (p. 41)	Released 4 Apr 07
North-East Tas.	MRT	GA	GPX	18 Mar 07	52,000	200 m 90 m E/W	8,600	44% complete @ 8 May 07	TBA	123 – Aug 06 (p. 39)	TBA
Flinders Island	MRT	GA	UTS	9 Jan 07	17,900	200 m 90 m E/W	2,900	31 Mar 07	11 May 07	123 – Aug 06 (p. 39)	TBA
East Isa North	GSQ	GA	UTS	3 Apr 07	113,000	400 m 80 m E/W	39,940	33% complete @ 6 may 07	TBA	125 – Dec 06 (p. 32)	TBA
East Isa South	GSQ	GA	Fugro	10 Mar 07	145,900	400 m 80 m E/W	51,560	61% complete @ 6 may 07	TBA	125 – Dec 06 (p. 31)	TBA
AWAGS2	GA	GA	UTS	29 Mar 07	145,350	75 km 80 m N/S	7,659,861	19.8% complete @ 6 May 07	TBA	124 – Oct 06 (p. 15)	TBA
Croydon	GSQ	GA	UTS	15 May 07	100,230	400 m 80 m E/W	335,310	TBA	TBA	127 – Apr 07 (p. 35)	TBA
Tanumbirini	NTGS	GA	UTS	8 Jul 07	69,463	400 m 80 m E/W	24,047	TBA	TBA	126 – Feb 07 (p. 35)	TBA
Canning Basin	GA	GA	Fugro	20 Apr 07	102,656	800 m 80 m N/S	70,192	7% complete @ 30 Apr 07	TBA	127 – Apr 07 (p. 26)	TBA
South Kimberley (see Figure 1)	GSWA	GA	GPX	TBA	163,000	400 m 60 m N/S	57,920	TBA	TBA	This issue	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**
Isa Area C	GSQ	GA	Fugro	19 Oct 06	9,236	2 and 4 regular	68,500	100% complete @ 10 Feb 07	TBA	124 – Oct 06 (p. 29)	Released 4 Apr 07
Murchison	GSWA	GA	Fugro	10 Feb 07	3,600	2.5 regular	24,800	17 Mar 07	TBA	123 – Aug 06 (p. 39)	Released 11 May 07
Isa Area D	GSQ	GA	Daishsat	At end of Isa Area E Survey	4,903	4 regular	75,460	TBA	TBA	125 – Dec 06 (p. 32)	TBA
Isa Area E	GSQ	GA	Daishsat	1 Feb 07	6,233	4 regular	97,420	82% complete @ 7 May 07	TBA	125 – Dec 06 (p. 32)	TBA
Western Tanami (see Figure 3)	GSWA	GA	TBA	TBA	3,700	2.5 regular	23,000	TBA	TBA	This issue	TBA
Cooper Basin North	GA	GA	Daishsat	TBA	3,537	4 regular	56,590	TBA	TBA	This issue	TBA
Charters Towers (see Figure 2)	GSQ	GA	TBA	TBA	15,310	2 and 4 regular	133,950	TBA	TBA	This issue	TBA

TBA: To be advised
Locality diagrams for the South Kimberley survey follows at the end of this document

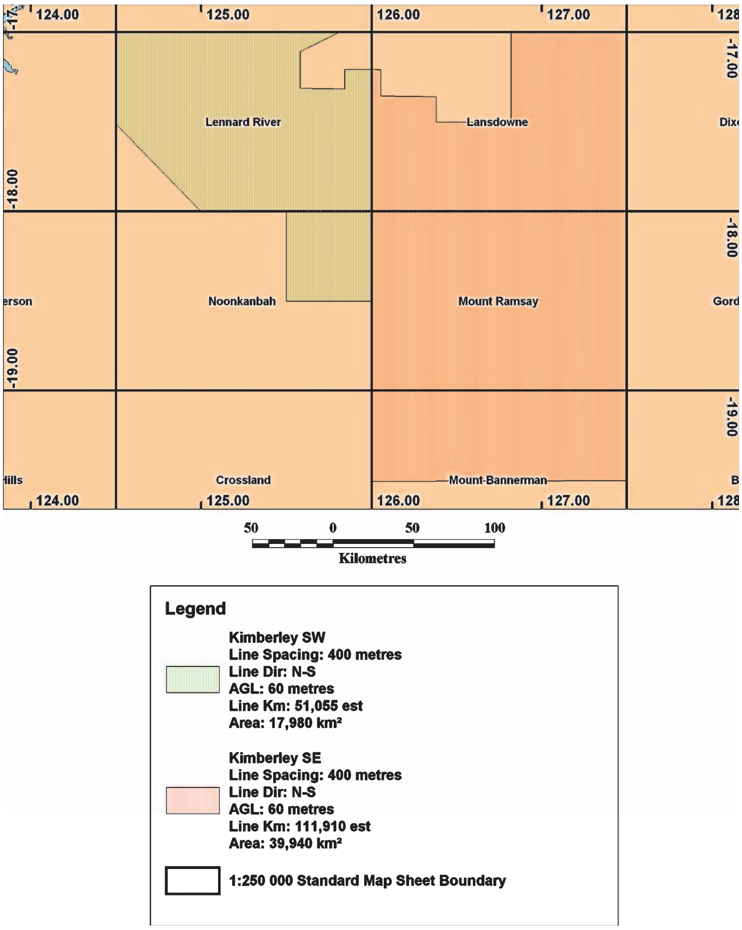


Fig. 1. Location of the South Kimberley airborne geophysical survey (see Table 1).

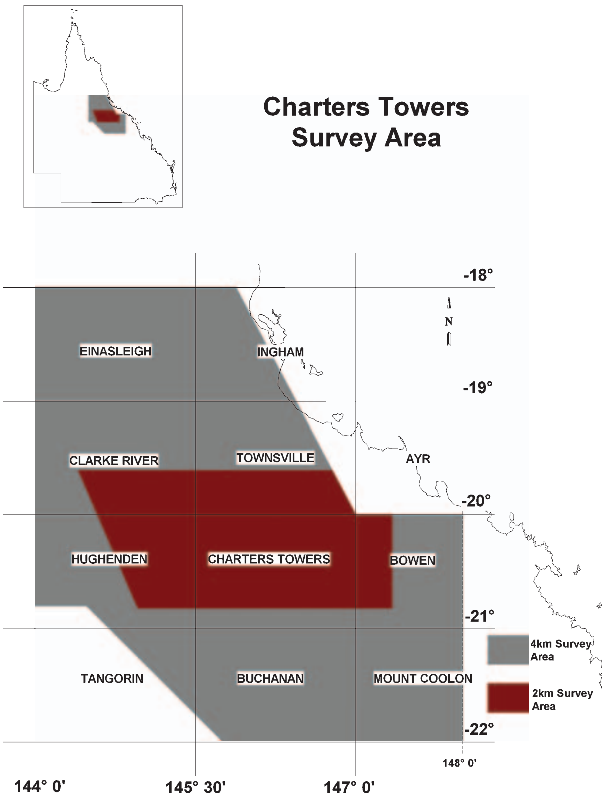


Fig. 2. Location of planned Charters Towers gravity survey (see Table 2).

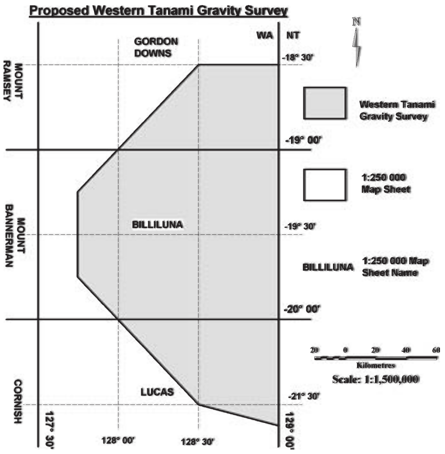


Fig. 3. Location of planned Western Tanami gravity survey (see Table 2).

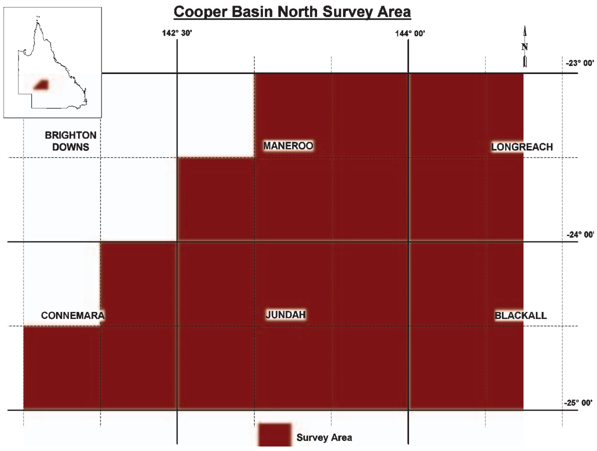


Fig. 4. Location of planned North Cooper Basin Survey (see Table 2).

New results from geophysical surveys in Mount Isa region

On 11 April, the Queensland Government formally released the results from two airborne geophysical surveys to help stimulate mining exploration activity in the North West Queensland Mineral Province.

The first survey had been an airborne geophysical survey covering the Isa South (East) district, south of Springvale, and the second gravity survey was conducted over the Isa C district, south of Mount Isa (see Tables 1 and 2).

These surveys are part of the Government's Smart Exploration initiative, which comprises a $20M project targeting four areas across Queensland that have the highest potential for the discovery of additional mineral and energy resources.

Geoscience Australia: seismic reflection surveys

The Isa–Georgetown–Charters Towers Project, a collaborative project between Geoscience Australia and the Geological Survey of Queensland, commenced on the 19 May 2007. The Project consists of three separate surveys each consisting of a long regional traverse and in total is just less than 1300 km in length. The project extends from the eastern edge of the Mt Isa Inlier to the Georgetown Province, then southwards through Charters Towers to the Drummond Basin. A map of the route was published in the previous Preview Issue. The seismic operations are being undertaken by ANSIR, the National Facility for Earth Sounding (see http://rses.anu.edu.au/seismology/ANSIR/ansir.html), with supervision by Geoscience Australia staff. ANSIR is collaborating with Terrex Seismic Pty Ltd to undertake the data acquisition. In addition to the seismic reflection work, ANSIR is also arranging the acquisition of both gravity and magnetotelluric add-on surveys to enhance our imaging and understanding at depth,

In addition to the Isa–Georgetown–Charters Towers seismic reflection survey, ANSIR will also be acquiring the first data collection for AuScope (see http://www.auscope.org.au/). This AuScope Far North Queensland Project is approximately 200 km long and extends from the Mt Surprise region towards Mareeba, crossing the Palmerville Fault and Tasman Line; the latter is assumed to be a fundamental structure in the assembly of Australia. The AuScope Survey also links to the Isa–Georgetown–Charters Towers survey and thereby collectively provides a remarkable opportunity for Earth Scientists to understand the structure and evolution of Australian.

Planning continues on the Gawler–Curnamona seismic reflection survey. This survey is a collaborative project between Geoscience Australia and the PIRSA. The project aims to increase investment in energy-related exploration in SA that will lead to new discoveries of geothermal and onshore energy resources as well as reducing risks to exploration and increasing efficiency of discovery in greenfields areas.

Additional surveys in the initial preparation phase include a traverse across the Darling Basin, NSW and a traverse across the Cooper, Queensland.

For further info please contact Bruce Goleby +61 2 6249 9404 or bruce.goleby@ga.gov.au

Activities in Victoria

Seismic survey peels back the layers

The geological structure of central Victoria is beginning to emerge from interpretations of seismic data collected during June 2006, as part of a project of the Cooperative Research Centre for Predictive Mineral Discovery (pmd*CRC).

These new images of Victoria's ancient past could form the basis of a dramatic new understanding of the state's mineral prospectivity and lead to the discovery of significant new ore deposits in the future.

Processed data from the first two of four seismic traverses carried out across central Victoria was examined at data interpretation workshops held at GeoScience Victoria in March and May 2007. Workshop participants included Geoscience Australia, GeoScience Victoria, the University of Melbourne and member companies of the pmd*CRC project.

The seismic traverses examined at the workshops stretch from Glenorchy (northwest of Stawell) eastwards to Rushworth (east-northeast of Bendigo) over a distance of 249 kilometres (see Figure 5).

The data more accurately highlight the position of faults and boundaries between different rock types at depth in the earth's crust, enabling better predictions of the pathways along which mineralising fluids moved during the formation of gold deposits in the region.

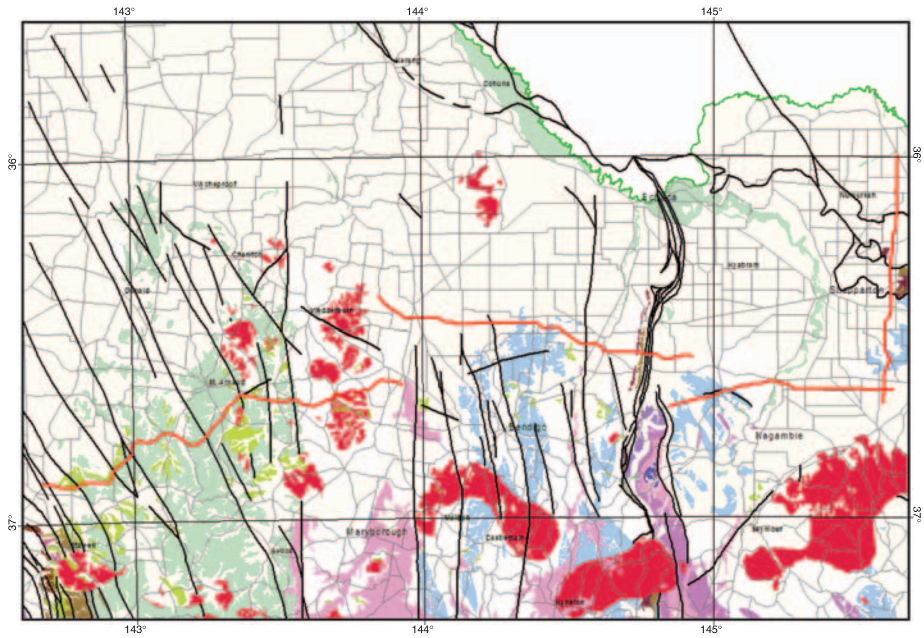


Fig. 5. Location of deep seismic traverse and proposed MT survey in northern Victoria (red line) overlying schematic geology.

Results of the interpretation are being used to update a regional scale 3D geological model of Victoria currently being built within another pmd*CRC project.

Data processing for all traverses will be completed by August 2007 and a final report documenting the results of data interpretation is expected to be released in December 2007.

New angle on Victorian seismic transect

A magnetotelluric (MT) survey over the two most western lines of the 2006 central Victorian seismic transect will be calibrated with and provide confirmation of the seismic data and extend the interpretation to a depth of more than 100 kilometres. A parallel line 80 kilometres to the north will allow for extrapolation of major structures identified from the joint MT/seismic interpretation obtained to the south.

The survey, a joint venture between GeoScience Victoria, Monash University and the Korea Institute of Geosciences and Mineral Resources, is only the second ever use in Australia of state-of-the-art remote reference MT array methods to obtain resistivity data of the highest possible quality. Data collection is a low impact activity, with readings taken along road verges. The southern line has already been completed with processing and interpretation expected by December 2007.

The parallel line to the north will be completed in April 2008, with processing and interpretation expected by December 2008. Modelling and integration of the data interpretation with the 3D geology will lead to a better understanding of deep crustal structures and their relationship to major gold deposits in central Victoria.

Geochronology project

The timing and ore fluid geochemistry of Victoria's major gold-bearing systems are being recorded in a new project that GeoScience Victoria (GSV) recently launched in collaboration with the University of Melbourne's Earth Sciences Department. The project will involve establishing and documenting the timing (geochronology) and ore fluid geochemistry of gold bearing systems in Victoria's major gold fields. Geochronology and geochemistry are essential tools for understanding the age, origin and sequence of mineralising events and deformation in Victorian Palaeozoic rocks, which are critical for developing predictive models to enhance gold exploration in Victoria.

A scoping study to document current gold deposit geochronology in Victoria and the applicability of various methods is due for publication in July 2007. Other elements of the project include dating key central Victorian gold deposits and deformation events, using a recently developed pyrite dating method, and acquiring new noble gas/halogen geochemical data to provide constraints on the origin of gold-bearing fluids. At the end of the project, GSV will have new age data and noble gas/halogen geochemical data from which to reassess gold exploration models for Victoria, and to help develop protocols for evaluating new gold prospects.

A report on the final phase of the project is due for release in February 2009, with interim reports available in February, July and November 2008.

For more information contact: Peter O'Shea, Manager, Minerals Geoscience

GeoScience Victoria
Tel: 03 9658 4525
Email: peter.o'shea@dpi.vic.gov.au

$1.4 billion boost to offshore petroleum exploration

Australian Resources Minister Ian Macfarlane announced 19 new permits for petroleum exploration in Commonwealth waters, resulting in a multi-million dollar boost to offshore exploration investment.

The new permits in Commonwealth waters off Tasmania, Western Australia, Victoria and the Northern Territory will see an additional $1.410 billion invested in offshore exploration over the next 6 years. The programs comprise a $1.048 billion commitment together with options to invest another $362 million.

The successful applicants were announced in April/May this year and Table 1 lists the successful bidders and summarises their work programs.

As the Minister said: 'The annual release of offshore petroleum acreage is a key part of the Australian Government's strategy to encourage investment in petroleum exploration.' Australia continues to receive strong interest from both local and global petroleum explorers, especially in offshore Western Australia, where Hess Exploration Australia Pty Ltd will invest over $500 million.

Under the work program bidding system, applicants are required to nominate a guaranteed minimum 'dry hole' exploration program for each of the first 3 years of the permit term and a 'secondary' program for the remaining three years. Each component of the program must be completed in the designated year or earlier. Permits are awarded for an initial term of six years.

The record investment is a very good outcome for the government, which allocated additional funds to Geoscience Australia to investigate the potential for petroleum exploration so as to attract a more active program.

Table 1. Permit areas, operating companies and work programs

Permit area, number of bids	Operating Companies	Exploration programs
Permit WA-390-P (released as W06-11) in the Central Exmouth Plateau (Figure 1). Ten other bids	Hess Exploration Australia Pty Ltd	A guaranteed work program of geotechnical studies, 2000 km of 2D seismic data reprocessing, a new 3D seismic survey of 3135 km^2, and 16 exploration wells at an estimated cost of $500.9M The secondary work comprises geotechnical studies and 3135 km^2 of 3D seismic data reprocessing at an estimated cost of $2.8M.
Permit WA-391-P (released as W06-14) in the Barrow Sub-basin (Figure 1). One other bid	OMV Australia Pty Ltd	A guaranteed work program of geotechnical studies, 340 km^2 of 3D seismic data reprocessing and 800 km of 2D seismic data reprocessing at an estimated total cost of $3.3M. The secondary work comprises three exploration wells and a new 3D seismic survey at an estimated total cost of $52M.
Permit WA-392-P (released as W06-12) in the Central Exmouth Plateau (Figure 1). Four other bids	Chevron Australia Pty Ltd, Shell Development (Australia) Pty Ltd, and Mobil Australia Resources Company Pty Ltd	A guaranteed work program of geotechnical studies, 180 km of 2D seismic data reprocessing, a new 3D seismic survey of 1709 km^2, and one exploration well at an estimated total cost of $44.082M. The secondary work comprises geotechnical studies, and a new 2D seismic survey of 100 km at an estimated total cost of $0.56M. There were four other bids for this area.
Permit WA-393-P (released as W06-16) in the Barrow Sub-basin (Figure 2). Two other bids	Sweetpea Petroleum Pty Ltd	A guaranteed work program of geotechnical studies, a new 2D seismic survey of 500 km and one exploration well at an estimated total cost of $13M. The secondary work comprises geotechnical studies, and four exploration wells at an estimated total cost of $48.5M.
Permit WA-394-P (released as W06-18) in the Southern Exmouth Plateau (Figure 3). No other bids	Octanex NL and Strata Resources NL	A guaranteed work program of geotechnical studies and a new 2D seismic survey of 375 km at an estimated total cost of $0.7M. The secondary work comprises geotechnical studies and one exploration well at an estimated total cost of $20.6M.
Permit WA-395-P (released as W06-15) in the Barrow Sub-basin (Figure 1). One other bid	Holloman Corporation	A guaranteed work program of geotechnical studies, a new 3D seismic survey of 70 km^2, purchase of 3D seismic data, and two exploration wells at an estimated total cost of $29.7M. The secondary work comprises geotechnical studies and two exploration wells at an estimated total cost of $28.2M.
Permit T/44P (released as T06-4) in the Bass Basin (Figure 4). One other bid	Origin Energy Resources Limited	A guaranteed work program of geotechnical studies, a new 2D seismic survey of 275 km, a new 3D seismic survey of 235 km^2, 4000 km of 2D seismic data reprocessing, and one exploration well at an estimated total cost of $27M. The secondary work program comprises geotechnical studies, a new 3D seismic survey of 130 km^2, and one exploration well at an estimated total cost of $22.5M.
Permit T/45P (released as T06-2) in the Bass Basin (Figure 4). No other bid	Rawson Resources Ltd and Hardie Infrastructure Pty Ltd	A guaranteed work program of geotechnical studies, a new 3D seismic survey of 200 km^2 and two exploration wells, at an estimated cost of $22.3M. The secondary work program comprises geotechnical studies and one exploration well, at an estimated cost of $10.6M.
Permit T/46P (released as T06-1) in the Southern Platform, Gippsland Basin (Figure 5). No other bid	Great Artesian Oil and Gas Limited	The company proposed a guaranteed work program of geotechnical studies, reprocessing of 500 km of 2D seismic data and new 2D seismic surveying of 500 km, at a total estimated cost of $1.05M. The secondary work program comprises geotechnical studies, two exploration wells and a new 2D seismic survey of 500 km, at a total estimated cost of $8.2M.
Permit T/47P (released as T06-3) in the Bass Basin (Figure 5). Three other bids	Tap (Shelfal) Pty Ltd, SPC Production Company Limited and Jubilant Energy Limited	A guaranteed work program of geotechnical studies, a new 3D seismic survey of 506 km^2, a new 2D seismic survey of 511 km and two exploration wells at an estimated total cost of $33.35M. The secondary work program comprises geotechnical studies, a new 3D seismic survey of 205 km^2, and one exploration well at an estimated total cost of $14.6M.

(Continued)

Table 1 (Continued)		
Permit area, number of bids	**Operating Companies**	**Exploration programs**
Permit AC/P40 (released as AC06-1) in the Vulcan Sub-basin (Figure 7). One other bid	Coogee Resources (Ashmore Cartier) Pty Ltd	A guaranteed work program of geotechnical studies, 450 km^2 of 3D seismic data reprocessing, and two exploration wells at an estimated total cost of \$39.5M. The secondary work program comprises geotechnical studies and two exploration wells at an estimated total cost of \$51M.
Permit AC/P41 (released as AC06-2) in the Northern Browse Basin (Figure 8). Three other bids	Shell Development (Australia)Pty Ltd and Nexus Energy Limited.	A guaranteed work program of geotechnical studies, a new 3D seismic survey of 450 km^2, and three exploration wells at an estimated total cost of \$114.2M. The secondary work program consists of geotechnical studies at an estimated total cost of \$0.9 M.
Permit NT/P73 (released as NT06-5) in the North Eastern Bonaparte Basin (see Figure 6). One other bid	Alpha Oil & Natural Gas Pty Ltd	A guaranteed work program of geotechnical studies and a new 2D seismic survey of 2000 km at an estimated total cost of \$3.85M. The secondary work program comprises geotechnical studies and one exploration well at an estimated total cost of \$15.45M.
Permit VIC/P63 (released as V06-2) in the Gippsland Basin (Figure 9). No other bids	Great Artesian Oil and Gas Limited	A guaranteed work program of geotechnical studies, 150 km of 2D seismic data reprocessing and two new 2D seismic surveys of 250 km each at an estimated total cost \$1.05M. The secondary work program comprises geotechnical studies, a new of 2D seismic survey of 500 km and two exploration wells at an estimated total cost of \$8.2M.
Permit VIC/P64 (released as V06-3) in the Gippsland Basin (Figure 9). No other bids	Great Artesian Oil and Gas Limited	A guaranteed work program of geotechnical studies, 500 km of 2D seismic data reprocessing and two new 2D seismic surveys of 250 km each at an estimated total cost of \$1.05M. The secondary work program consists of geotechnical studies, a new 2D seismic survey of 500 km and two exploration wells at an estimated total cost of \$8.2M.
Permit VIC/P65 (released as V06-4) in the Gippsland Basin (Figure 9). No other bids	Eagle Bay Resources NL	A guaranteed work program of geotechnical studies, 50 km of 2D seismic data reprocessing, a new 3D seismic survey of 400 km^2 and one exploration well at an estimated total cost of \$18.85M. The secondary work program comprises geotechnical studies, a new 3D seismic survey of 200 km^2 and one exploration well at an estimated total cost of \$17.75M.
Permit WA-396-P (released as W06-8) in the Caswell Sub-basin, Browse Basin (Figure 6). No other bids	Woodside Energy Ltd	A guaranteed work program of geotechnical studies and a new 3D seismic survey of 400 km^2 at an estimated total cost of \$10.7M. The secondary work program comprises geotechnical studies, a new 3D seismic survey of 250 km and a new CSEM survey at an estimated total cost of \$9.4M.
Permit WA-397-P (released as W06-7) in the Caswell Sub-basin, Browse Basin (Figure 6). No other bids	Woodside Energy Ltd	A guaranteed work program of geotechnical studies, a new 3D seismic survey of 1,250 km^2 and one exploration well at an estimated total cost of \$69.4M. The secondary work program consists of geotechnical studies, a new CSEM survey and a new 3D seismic survey of 250 km^2 at an estimated total cost of \$9.4M.
Permit WA-398-P (released as W06-6) in the Caswell Sub-basin, Browse Basin (Figure 6). Three other bids	ConocoPhillips Australia Exploration Pty Ltd and Karoon Gas Browse Basin Pty Ltd	A guaranteed work program of geotechnical studies, a new 3D seismic survey of 1,400 km^2 and four exploration wells at an estimated total cost of \$114M. The secondary work program consists of geotechnical studies and two exploration wells at an estimated total cost of \$33M.

The Figures 1–9 show the locations of the newly granted leases.

Release of 34 offshore petroleum exploration leases in 2007 bidding cycle

On 18 April 2007, the Australian Government offered 34 new offshore areas as part of the regular annual release of offshore acreage.

These areas are located in six sedimentary basins, as shown in Figure 10, range from frontier to mature status, and offer opportunities for exploration companies of all sizes.

The release includes six Designated Frontier Areas, which are eligible for the frontier exploration tax incentive of 150% uplift for exploration expenditure.

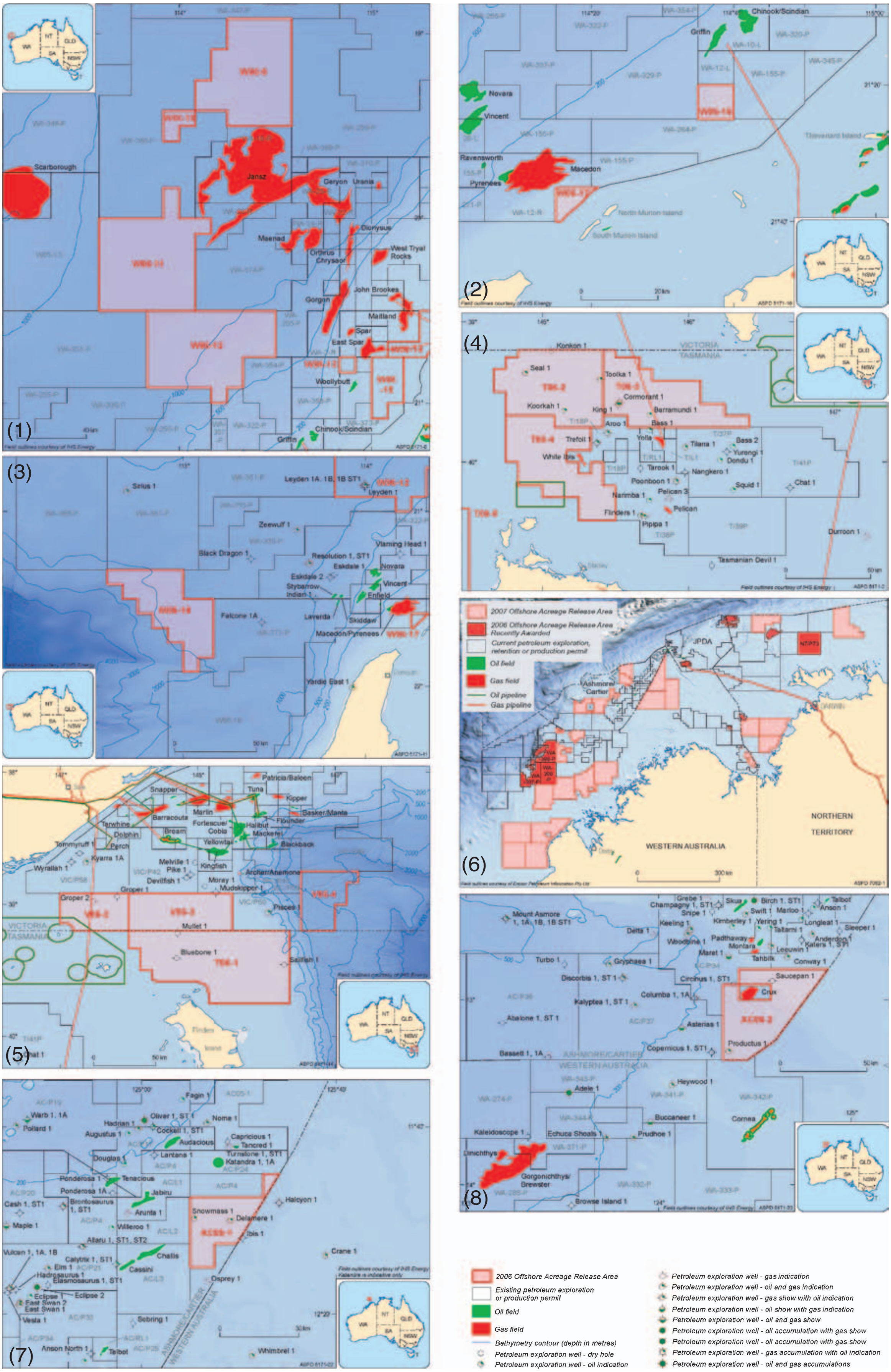
According to Minister Ian Macfarlane, ‘the take-up rate of acreage released each year has risen from just short of 50 percent in 2002/03 to 90 percent for the 2005 release. Borrowings of pre-competitive data from Geoscience Australia, used by explorers to define the best drill locations, have tripled between 2004 and 2006.’

All bids will be assessed under the work program bidding system and will be awarded for an initial term of six years.

UK awards 150 petroleum licences

In February 2007 the UK Government awarded 150 oil and gas exploration and production licences to 104 companies covering 246 blocks. However, the UK blocks, at 12′ in longitude × 10′ in latitude are comparatively small and have an area of only ~200 km^2 at latitudes higher than 60∞. Small blocks are the reward for having a mature and very prospective acreage in your region.

If Alistair Darling the Minister responsible is correct, then there are potentially more than 20 billion barrels of oil and gas still available, and at a consumption rate of less than 2 million barrels a day, that should be plenty to go on with. However, oil production peaked at about 2.9 million barrels per day in 1999 and has been steadily declining since then, so his estimates may be somewhat optimistic!



Figs. 1–8. The locations of the permits granted in 2007 for offshore petroleum exploration. The maps show the bathymetry, exploration wells and oil and gas fields and pipelines.

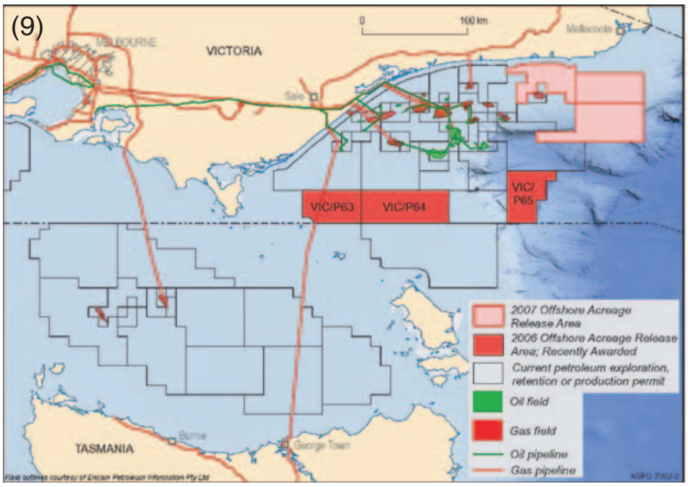


Fig. 9. The locations of the permits granted in 2007 for offshore petroleum exploration. The maps show the bathymetry, exploration wells and oil and gas fields and pipelines.

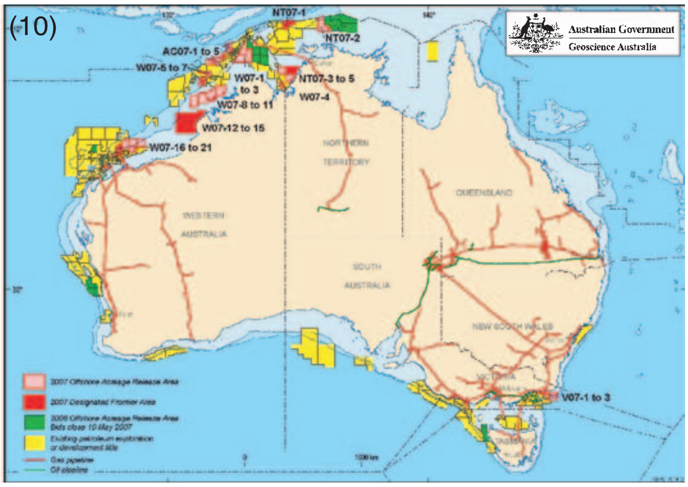


Fig. 10. Overview of the areas being released for petroleum exploration in 2007.

Table 2. Key information for the areas being released		
Basin State/Territory	**Geological notes**	**Areas Deadline for bids**
Eastern Money Shoal Basin Northern Territory	• Large under-explored Mesozoic basin. • Shallow water depths (70–220 m). • Shallow targets. • Palaeozoic and Mesozoic potential source rocks. • Numerous stratigraphic and structural plays. • Hydrocarbon shows/indications in nearby wells. • Large gas discoveries in adjacent Bonaparte Basin.	NT07-2 18 October 2007
Ashmore Platform, Bonaparte Basin Territory of Ashmore and Cartier Islands	• Nearby Puffin oil field in final development stages. • Numerous play types in potential Cretaceous, Jurassic and Triassic reservoirs. • Proprietary Vulcan Sub-basin MegaSurvey 3D seismic coverage available.	AC07-1, AC07-2, AC07-3, AC07-4 and AC07-5 18 October 2007
Londonderry High, Bonaparte Basin Northern Territory	• Under-explored, shallow water areas adjacent to significant hydrocarbon discoveries. • Evidence of oil and gas generation, migration and accumulation. • Potential Mesozoic petroleum system along the margin of the Londonderry High and Vulcan Sub-basin. • Tilted Permo-Triassic and Jurassic fault blocks with multiple reservoir facies. • Various styles of structural and stratigraphic traps.	W07-1, W07-2 and W07-3 18 October 2007
Petrel Sub-basin, Bonaparte Basin Northern Territory	• Under-explored, shallow water areas in a proven Palaeozoic oil and gas province. • Close to Petrel and Tern gas fields and the soon to be developed Blacktip gas field. • Area W07-4 close to Barnett and Turtle oil discoveries. • Various styles of structural and stratigraphic traps.	NT07-3, NT07-4 **NT07-5*** 17 April 2008
Petrel Sub-basin, Bonaparte Basin Western Australia	See above	W07-4 18 October 2007
Troubadour Terrace, Bonaparte Basin Northern Territory	• Surrounded by giant gas accumulations; Greater Sunrise, Evans Shoal and Abadi, and in proximity to the recent discoveries at Caldita and Barossa. Point LNG plant. • Close to Darwin operations base and the Wickham • Water depths less then 500 m. • Good quality Middle Jurassic reservoir. • Good quality regional seal.	**NT07-1*** 18 October 2007
Caswell Sub-basin, Browse Basin Western Australia	• Proven major hydrocarbon province, and adjacent to giant gas fields; Scott Reef, Brecknock, Brecknock South, and Brewster areas. • Early–Middle Jurassic and Early Cretaceous source rocks. • Good quality Early–Middle Jurassic reservoir. • Tilted Permo-Triassic to Jurassic horst blocks with Early Cretaceous seal. • Water depths between 200 and 500 m.	W07-5, W07-6 and W07-7 18 October 2007
Yampi-Leveque Shelf, Browse Basin Western Australia	• Under-explored areas adjacent to a proven Mesozoic oil and gas province. • Water depths less than 200 m. • Evidence of oil and gas migration. • Thick Early–Middle Jurassic and Early Cretaceous sediments with possible source potential.	W07-8, W07-9, W07-10 and W07-11 17 April 2008

(Continued)

Table 2 (Continued)

Basin **State/Territory**	**Geological notes**	**Areas** **Deadline for bids**
Canning Basin Western Australia	• Under-explored, shallow water frontier areas <500m water depth. • Offshore extension of proven onshore Palaeozoic oil and gas province, and potential Mesozoic petroleum systems. • Evidence of local oil and gas generation and migration. • Carboniferous, Permian, Triassic and Jurassic reservoir sands; potential Devonian clastic and carbonate reservoirs. • Potential Middle Triassic and latest Triassic-earliest Jurassic regional seals. • Potential stratigraphic pinchout traps.	**W07-12* to W07-15*** 17 April 2008
Exmouth Plateau, Carnarvon Basin Western Australia	• Frontier blocks in a range of water depths (<200 m to ~800 m). • Near to giant producing fields and near existinginfrastructure and an expanding gas market. • Traditional Triassic Mungaroo fault block plays, as at Goodwyn.	Areas W07-16 and W07-17* 18 October 2007
Beagle Sub-basin, Carnarvon Basin Western Australia	• Active petroleum system confirmed by Nebo 1 oil discovery. • Abundant Jurassic–Triassic horsts and intervening wrench-controlled troughs. • Basin-margin Permo-Carboniferous terraces and horsts. • Triassic–Jurassic fluvio-deltaic and Late Jurassic marine fan reservoirs. • Regional Early Cretaceous and Middle Triassic seals. • Proven local Early Jurassic source pod, but regional source distribution/quality risk.	W07-18, W07-19, W07-20 and W07-21 17 April 2008
Gippsland Basin Victoria	Located in a largely under-explored part of a major hydrocarbon province. • Proximal to at least two working petroleum systems. • Multiple sets of updated geoscientific data available.	18 October 2007 for V07-1 17 April 2008 for V07-2 and V07-3

Designated Frontier Tax Concession of 150% applies.

Jack Rayner and AGGSNA

John Rayner
Visiting Fellow,
Centre for the Public Awareness of Science
Australian National University
john.rayner@anu.edu.au

Introduction

The Aerial Geological and Geophysical Survey of Northern Australia (AGGSNA) was set up in 1935 following the passage of the "North Australia Survey Act" through the Commonwealth Parliament in December 1934 (Wilkinson 1996, p. 24). The survey was the brainchild of Sir Herbert Gepp, a mining metallurgist, industrialist and visionary. His concept was that the Survey would stimulate interest in mining in the more remote parts of Australia, north of the Tropic of Capricorn. The formation of the Survey was a first in that it pooled the financial and scientific resources of the Commonwealth, Queensland and West Australian governments. A ministerial committee was formed consisting of Sir Herbert Gepp, (as chairman) P.B.[1] Nye (as Executive Officer, and previously the Government Geologist of Tasmania), Dr W.G. (George) Woolnough (Commonwealth Geological Consultant), a representative of each government and my father Jack Rayner as geophysical consultant. At the time Jack was employed by the NSW Mines Department, and so divided his time between NSW and Northern Australia. The Commonwealth contributed £75,000 to the project while each of the state governments put in $37,500 (Wilkinson 1996, p. 25). In 1934, before the start of the Survey a reconnaissance flight was undertaken by members of the Committee in Kingsford Smith's "Southern Cross" to scout potential areas for investigation (Morrison 2005). Figure 1 is a map taken from a newspaper cutting at the time showing the proposed route.

The field headquarters for AGGSNA were set up in 1935 at Cloncurry. They comprised P.B. Nye and his office staff of four general staff and a drafting office of four, headed by A.C. Booth as senior draftsman. Cloncurry was described as the " *the home of heat, flies, goats and dust*" (Crespin 1967) and, as shown in Figure 2, life was a little slow.

Geological parties operated in Queensland, the Northern Territory, and Western Australia, led respectively by C.S. Honman, Paul Hossfeld, and K.J. Finucane (Aergusur Mosaic, No.1, October 1936). Jack's younger brother Ted Rayner[2] was a member of the Queensland party, along with Ben Dickinson, later Director of the SA Geological Survey. Alan Voisey, later professor of geology at New England and then Macquarie University, was in the NT party.

Two geophysical parties were established led by Bob Thyer and Eric Blazey, together with a dedicated Magnetic Survey party led by Lew Richardson, which did extensive work around Tennant Creek. Sepp Horvath of the Electrical Prospecting Company of Sweden (ABEM), was also contracted to the Survey with special responsibility for electrical methods (Electro-magnetic, self-polarisation and resistivity).

In addition:

> *"Tenders were called for the aerial photography work. The contract was won by the Royal Australian Air Force. The RAAF, seeking experience in this discipline, substantially undercut other contenders."*
> (Rayner 2007)

Figure 3, taken in 1936 during an inspection by Gepp and Stopford, the Queensland Minister for Mines, shows many of the protagonists. I am grateful to my uncle Ted, now well into his 90s, for being able to identify all but one of the people.

The Survey

Geophysical surveys were undertaken in a wide variety of localities ranging from Norseman in southern WA to Herberton in north Queensland. The map in Figure 4 shows the main geophysical field sites. Most of the sites were related to known mineral fields. Much of the emphasis of the Survey involved fairly small-scale investigations of likely mineral deposits, rather than regional geological or geophysical surveys. Gold was of particular interest because of its soaring price at the time as Britain came off the gold standard (Thyer 1963). Other minerals of interest included: copper, silver-lead, tin and coal. Magnetic, gravity, electrical and electromagnetic techniques were employed. I have not looked at all of the reports but have not been able to find any reference to seismic work.

Altogether about 42 geophysical reports were written, and most published. All of the geophysical reports were either written or part-authored by Jack and PB, although Lew Richardson and Bob Thyer were also significant contributors. In all, the Survey produced 12 half-yearly periodical reports, and many geological or geophysical reports numbered according to the state in which the work is carried out. Thus the inside cover of a typical report lists 64 reports for WA, 57 reports for NT and 55 reports for Queensland, a grand total of 189 reports. Of this total most were published although a number of others were written but never published while others, such as the later geophysical reports on Tennant Creek, were projected but never written.

Numerous visits were made to small prospects as in Figure 5, to determine their viability, and to assess the surrounding country for its potential for geophysical and geological investigation.

The Aergesur Mosaic

During 1936–37, the AGGSNA headquarters in Cloncurry produced a staff magazine,

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[1]Nye's first name was Percival, but he was always known as "PB", although I have heard Jack occasionally refer to him as "Perce".

[2]In the 1960's when Jack was the Director of the BMR and Ted was the NSW Government Geologist there were some interesting exchanges in Canberra at meetings between the Commonwealth and the States. Sometimes at the end of a tense day the brothers would retire to the Commonwealth Club for the evening and then return to the meeting the following day to report that an accommodation had been reached between the Commonwealth and NSW.

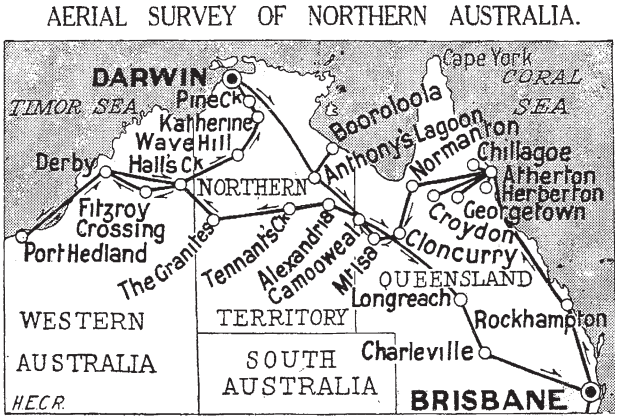

Fig. 1. Map of the proposed reconnaissance flight by the "Southern Cross" (Unknown newspaper clipping, 1934).

Fig. 2. View of central Cloncurry (family album).

Fig. 3. AGGSNA Staff, Cloncurry, 1936, as identified by Ted Rayner: from left to right: LC (Lionel) Ball, (Queensland Government Geologist), Ben Dickinson (later head of the SA Mines Department), Bob Thyer, Lew Richardson, Sepp Horvath (ABEM), Ted Rayner (Jack's younger brother), Eric Blazey, Sir Herbert Gepp, unidentified, Mrs Nye, Jack Rayner, James (Jimmy) Stopford (Queensland Minister for Mines), Fletcher Young (Queensland mining engineer), Flt Lt George Jones (RAAF), and PB Nye (Family album).

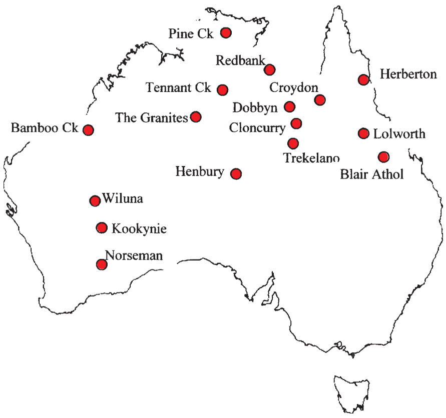

Fig. 4. Map of geophysical field sites.

"The Aergesur Mosaic". "Aergesur" (Aer[ial], ge[o], sur[vey]) was the registered telegraphic address of the Survey, while "Mosaic" referred to the aerial photographic work undertaken by the RAAF under contract to the Survey. The magazine described staff movements, news from the field parties and articles of general interest including one by P.B. Nye describing the water condenser constructed by PB and Sir Herbert Gepp, after their aircraft was forced down near Lake McKay (Aergesur Mosaic, **1**(6), Oct, 1937).

Issue number 1 is of particular interest as it lists the full staff of the Survey, and their positions as at October 1936, together with brief notes about the work of each field party at that time. It also included a cartoon by the senior draftsman, Alec (?) Booth, concerning a typical exchange between Jack and Lew (Figure 6).

The 4th issue gives a good idea of the tone of the magazine as under the heading:

> *"Geophysicists have "it"*
> *The Science with Sex Appeal"*

we read:

> *"Practically without warning Lew Richardson announced his impending marriage only a few short months ago and on 6th March, deliberately – and we assume gladly – took the fatal step. A little over a week before Lew was prosecuting anxious enquiries as to the type of tent his party was to be issued with for the current field season, but the editor was too dense to put two and two together. By the time the "Mosaic" comes out captivating and captivated (or should it be magnet and magnetised?) will have*

Fig. 5. Checking out a small prospect (family album).

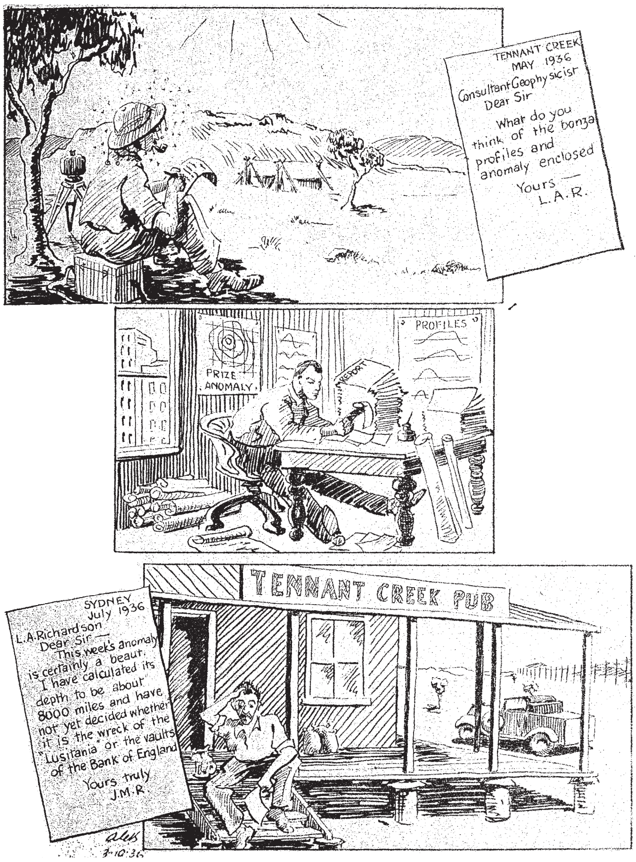

Fig. 6. Cartoon from the Aergesur Mosaic, Issue No.1, 1936.

> *tentatively tenanted a tent at Tennant Creek. The "Mosaic" wishes them all the best notwithstanding their anomalous position."*

Bob Thyer and Eric Blazey were also in the matrimonial business in the same issue as was Jack:

> *"But what of Jack Rayner? Who could possibly suspect anything fishy in his behaviour? Yet is seems that his periodical visits to Melbourne have been attended unofficially by some very successful angling or did he use a net? The following quotation from Kingsley's "Sands of Dee" seems particularly apt in Jack's case:*
>
> *"Was never salmon yet that shone more fair, Among the nets at sea."*
>
> *It was made fairly obvious that Jack's fishing was done to no little extent with a telephone line and hook and with ba(i)ted breath, that is, if the typiste's intuition was correct, and women seldom err in these matters. We don't know whether the day has yet been named, but whenever it is the projected partnership carries every good wish from the "Mosaic". The suggestion has been put forward that two lines of geophysicists with crossed compensators (or something equally, if not more, appropriate) outside the church door would lend a novel and original touch to the ceremony."*

All of the merriment at Jack's expense about fishing was because he was at the time courting his future wife, Phyllis (Phyl) Salmon, a young Melbourne lady. They subsequently married in Melbourne in July 1938, whereupon he brought his bride north to the Territory before they made their first home in Broken Hill.

Jack and Ted

Ted recalls several incidents involving himself and his brother:

> *"As I was also in AGGSNA, as a geologist ...I saw Jack a number of times on his visits there. [Once] I drove him to the Trekelano copper mine area, about 90 miles by road south of Cloncurry, ... A bad bump on the road caused Jack's suitcase to bounce from the back of the utility, springing open and scattering clothes and documents in the dust. Jack, like Queen Victoria, was not amused.*
>
> *Another memorable time, [was] when Phyllis came up to Cloncurry with Jack. They stayed at the Post office Hotel. It was a good hotel in those days... [as] it was the overnight stay for passengers of Qantas, with DH86 planes [see Figure 7] flying the Empire Route to London.*
>
> *Jack was scheduled to join up*

Fig. 7. DH 86 on the tarmac at Cloncurry (family album).

with Dr H. I. (Harald) Jensen[3] (Chief Geologist in the AGGSNA Queensland party), to inspect a copper prospect at Redbank near the Qld-NT border adjoining the Gulf of Carpentaria. Phyllis decided to join Jack in the adventure, and I was to be the driver. We set forth on the road from Cloncurry to Burketown on the Gulf, ...when well short of Burketown we broke down with wheel and axle damage.... We had adequate water and a few snack supplies. After nightfall Jack and Phyl stayed with the vehicle while I settled down on the track with a swag and torch. In the unlikely event of another vehicle travelling at night, we placed objects about 100 yards either side on the track. Eventually ... Jensen's ...field assistant, Tom McMillan came along. He was a first class mechanic ...and after he effected repairs we were able to go on to Burketown.

Next day, leaving Phyllis at the hotel, Jack and I, Jensen and Tom, drove to Redbank across the NT border ... on the Borraloola track.... On the way we called in at Doomadgee Mission, and Doc Jensen gave a short talk to the assembled aboriginal community. We inspected the copper showings at Redbank, guided by the lone occupant, an Englishman named Masterton; lone that is, except for his two aboriginal women who worked the mine for him[4].” (Rayner 2007)

Jack and Phyl

Phyl stayed in the Burketown pub. Family history has it that hessian bags that did not come down to the floor supplied the walls between the rooms. The first night as Phyl got ready for bed the cry went up: “Oi! Look at her legs”. After that she made sure that she changed while standing on the bed. One night she sensed that she was not alone and woke with a start only to find that a goat had wandered through her room. She was interested in the effect that she had in the dining room. It seems that when this smart Shelia from the south came in, all of the men staying in the pub went off to put on clean blue singlets. During her stay the town of about 50 souls closed for the day to take her for a picnic down by the local mangrove swamp, with stern instructions that she was not to go close to the water because of the crocodiles. Another evening there was a dance in her honour at the pub. In order to escape the attentions of the locals she found that the safest place to be was behind the counter pulling beers, taking some time, however, to get the knack of not overdoing the head.

Another family story concerns the Copenhagen vase. This was, and still is, a magnificent piece of smoky grey-blue Royal Copenhagen pottery, and was Jack and Phyl’s most treasured wedding gift. When Phyl arrived to join Jack in the territory she had with her a large round hatbox containing the vase. “Co-pee”, as it known then proceeded to travel around the Territory with them. Each night as they made camp, Co-pee would be brought out, sat on a packing case, and filled with pieces of smoke bush: a touch of feminine civilisation. Figure 8 shows a typical overnight camp, although the vase is not visible.

Jack and Phyl also made a number of air trips in the Territory. Arriving at an airstrip one day to be met by the legendary Eddie Conellan, they found that the aircraft could only accommodate the pilot and one passenger, so what to do with the bride posed something of a problem. Completely unfazed Eddie said: “Hop up on the scales love, and we’ll put you on the loading sheet as fresh meat.” As he packed her into the rear of the aircraft along with the mailbags he asked: “Do you want your legs up or down?” She then stayed like that for the next few hours as Eddie threw the aircraft around the sky so that Jack could get a good look at the geology.

Jack and Phyl also drove enormous distances. Phyl was a good driver and had driven her mother around most of the eastern states, as well as driving buses filled with girl guides to camps at Rosebud on the Mornington Peninsula. Jack was also a very good but careful driver and tended to offer advice when Phyl was driving them in the Territory, much to the annoyance of Phyl with her somewhat volatile personality. For example, once when approaching a muddy creek crossing he suggested that she should take it really slowly. Fed up, she accelerated through the creek and covered utility, equipment, and themselves completely with a layer of brown, dripping mud. Family history does not record what happened next. Figure 9, however, illustrates the sorts of difficulties that could occur.

A case study: Tennant Creek

Rather than trying to describe fairly superficially a number of the geophysical investigations, I thought that it would be more interesting to examine in some detail

[3]Jensen studied geology under Edgeworth David in 1898, and had been Director of Mines in the NT. He had several run-ins with politicians in both the NT and Queensland including the Queensland Premier “Red Ted” Theodore (Wilkinson 1996, p. 26).

[4]Jack told me that Masterton was one of the most well-read people that he ever met with the walls of the cave where he lived lined with books of English literature, history and the works of Greek and Roman writers.

Fig. 8. Overnight camp with Sepp Horvath and a mine in the background (family album).

Fig. 9. The perils of the track (family album).

just one of the major programs in order to illustrate how the Survey went about its geophysical work, and so I have chosen Tennant Creek as it is something of a classic.

One of the major successes of AGGSNA was the magnetic survey undertaken in the region around Tennant Creek by Lew Richardson, John Daly and others under the general direction of Jack as the consultant geophysicist to the Survey, with Lew responsible for the planning and supervision of the field work (Rayner and Nye 1936, Richardson *et al.* 1937, Daly 1957). As described by Jack writing in 1967:

> *"On this field the copper and gold are intimately associated with lenticular bodies of massive hematite derived from primary magnetite. The geophysical approach is direct for iron orebodies but indirect as far as copper and gold, the objects of the search are concerned. The principal exploration tools have been ground and airborne magnetic surveys in association with geological work and drilling campaigns. From the historical point of view, following the discovery by prospectors of some outcropping, gold-bearing iron orebodies, the geophysical program opened [in 1935] with intensive ground magnetic surveys in the vicinity of known orebodies and continued with ground surveys on a semi-regional scale [in 1936–37]."* (Rayner 1967)

The initial survey was conducted in 1935 by Lew Richardson, John Daly and a field assistant. Two vertical force magnetometers Nos 15977 and 15887, and one horizontal force magnetometer, no. 16165 manufactured by ER Watts & Son were employed. They were based on the Adolf Schmidt principle with a scale value ~30 gammas for the vertical force instruments and 14 gammas for the horizontal force instrument. The magnetometers no 15887 and 16165 are held in the National Historical Collection, with one shown in its present condition in Figure 10 (Shephard 2007).

An East–West baseline was laid out with traverses at right angles to it undertaken every 100 or 200 ft. with 50 or 100 ft between stations along the traverse. For the 42 working days of the first survey the party averaged 92 readings per day, covering an area of 27.5 acres per week. Work in the first season centred on the "Eldorado", Great Eastern" and "Rising Sun" areas (Rayner and Nye 1936). Later seasons covered the Peko-Golden Forty area, and a number of other areas around Tennant Creek (Richardson 1937, Daly 1957).

The method used to interpret the anomalies, originally suggested by Jack (Daly 1957), was to assume that the bodies causing the anomalies could be considered to a first approximation as spheres of magnetic material polarised by induction in the Earth's magnetic field. While recognising the limitations of these assumptions many of the theoretical profiles based on this approach fitted the field profiles remarkably well (Daly 1957). Daly concluded that:

> *"[The] testing so far performed[5] indicates that this method of interpretation will show the position of the body*

Fig. 10. Magnetometer number 15887 used at Tennant Creek, held today in the National Heritage Collection (courtesy Denis Shephard, National Museum of Australia).

[5]As of the mid 1950s.

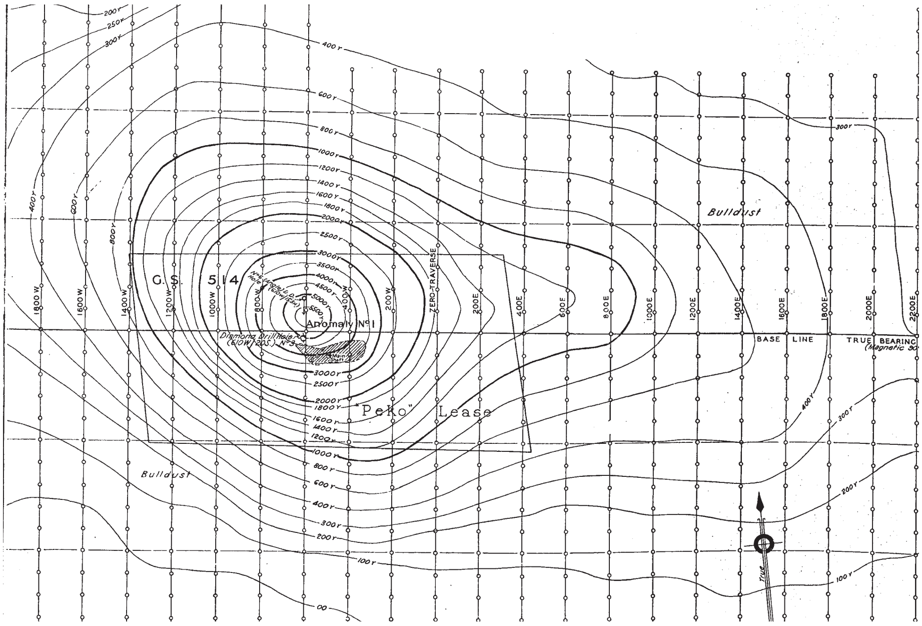

Fig. 11. Peko Anomaly No. 1, Tennant Creek (Daly 1957). The contour intervals are in gammas.

Fig. 12. Peko Mine, Tennant Creek, date unknown (National Library of Australia).

> *causing the anomaly with sufficient accuracy for siting an exploratory drill hole. It appears, however, that the observed results give no evidence of the dip of the body or, within reasonable limits, of its shape in horizontal section. In general, it appears that a reasonable estimate may be made of the depth extent of the body."*

By way of example, Figure 11, taken from the second Report, shows the large Peko Anomaly No. 1 based on the vertical magnetic intensity. The anomaly is associated with the Peko ore body that was not suspected at the time of the original survey. The anomaly was fitted by a sphere on traverse 600W centred at 70S at a depth of 580 ft. The radius of the sphere was 280 ft suggesting a vertical extent from 300 ft to 860 ft. The lack of a perfect fit between the calculated and actual profile was ascribed to a likely extension to the ore body at depth. Subsequent diamond drilling confirmed the existence of a large copper–gold ore body which in turn led to the establishment of a successful mine on the site as shown in Figure 12 (Daly 1957). As Jack concluded, later aeromagnetic surveys and further detailed surface mapping have:

> *"made it clear that [at Tennant Creek] the magnetic method has played a leading role in the discovery and development of several copper-gold orebodies which are now being exploited."* (Rayner 1967)

Conclusions

In later years talking with Jack, I can recall him saying that he regarded. The North Australia Survey as being of the utmost importance in the development of a systematic approach to geological and geophysical exploration in Australia. It was the first time that a large group (~60 people) had been assembled to work in this area, that techniques were developed for Australian conditions, that experience was gained over working in remote locations in northern Australia, and that a successful partnership was established between a Commonwealth organisation and a number of the state and territory mines departments. The lessons learned from the Survey were vital to the later success of the Bureau of Mineral Resources, Geology and Geophysics, established in 1946 with the Mineral Resources Survey of the war years providing critical links in terms of experience and personnel between the days of the North Australia Survey and the beginnings of the Bureau.

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Reviewed by Gary Fallon
gnfallon@consultgrs.com.au

Minerals: Their Constitution and Origin

Hans-Rudolf Wenk and Andrei Bulakh

Publisher: Cambridge University Press, 2004, 646 pp. (pbk)

RRP: $99.00, ISBN 0521529581

Just contemplating the title of this latest publication from Cambridge University Press, presents a daunting task, let alone undertaking a review. Wenk and Bulakh have a long established background in applied mineralogy and chemistry that has led to many published papers and books. The credibility of many of those mentioned in the Acknowledgment section indicates the breadth and depth of knowledge these authors have on the subject. Their writing style is authoritative, and relaxed, making the text easy to read and absorb. Each of the 35 chapters has approximately 15 or more black and white figures illustrating the author's ideas and observations. A further 9-page, colour-plate section is also included in the centre of the book. The figures cover the micro to macro scale and are schematic to specific photograph themes. They combine to indicate the breadth of mineralogical applications across the world and perhaps express the awe the authors hold for planet Earth.

Wenk and Bulakh have undertaken a very ambitious project of trying to condense over 500 years of mineralogical research into a single useful textbook. Their stated goal was to introduce concepts and look closely at the integration and application of mineralogy for undergraduate and graduate students. I believe they achieve this objective and for many topics leave the reader begging for more. They help the reader by supplying a 'Test your knowledge' and 'Further reading' section at the end of each chapter. The further reading sections are additional to the significant reference list supplied at the back of the book.

The book is divided into five main parts. The authors have started with an introduction to the fundamental concepts of mineralogy at the microscopic and atomic scale and then progress through the book to the applications of mineralogy at the macro and universal scale. Part 1, titled the 'Structural Features of Minerals', provides a brief description on the history of mineralogy and a more detailed description of the atomic composition, bonding, structure and behavior of minerals. This part introduces the fundamentals of mineralogy, with many illustrations on the micro and macro scale of minerals.

The second part of the book titled 'Physical investigations of minerals' focuses on the physics, methodology and equipment used to characterise and identify minerals. This part covers the optical and X-ray diffraction methods very comprehensively, perhaps to the expense of the physical properties where the mechanical properties are briefly covered and the electrical and radiogenic properties are not covered. The extensive use of equations would be very tempting in this chapter, however the authors have been well disciplined in only using what is appropriate and providing good descriptions or illustrations.

The third part of the book titled 'Variety of minerals and mineral forming processes' is the smallest part of the book. This part smoothly moves predominately from the microscopic and atomic scale into the hand specimen scale. It builds on many topics discussed in parts 1 and 2 and provides a brief outline on hand specimen description and an initial examination into the thermodynamic characteristics for mineral formation.

Part 4, entitled 'A systematic look at mineral groups', aims to provide a systematic treatment of mineral groups within the context of mineral forming environments. This is the largest portion of the book and the authors should be commended for the presentation of their ideas. It is arranged by breaking the mineral groups into the traditional rock forming mineral categories. Within this part the chemical, physical and applied characteristics of the mineral categories are discussed and illustrated. Approximately 100 minerals are discussed in detail and over 200 have their geological context outlined. The authors specifically discuss minerals formed by biogenic processes and the clay group. Comments and additional sections also discuss the impacts of weathering and metamorphic processes on the above mineral categories.

The fifth and final part of the book examines the application of mineralogy to mineral deposits, gemstones, and then briefly cements and human health. As each chapter has been the topic of many existing textbooks this part reinforces the introduction of concepts rather than providing extensive literature reviews on each topic. This part also discusses how minerals form in the solar system and their role in the evolution of Earth. Part 5 examines the common rocks and lithologies and discuses their mineral genesis, with a particular emphasis on their economic importance.

The book covers a tremendous range of topics and to mention them all in this review would be to produce a book! In examining all the topics there are a few notable omissions that would have added to the book's utility. Part 1 could have benefited with an additional section(s) on the stoichiometric composition and variations of minerals, Part 2 could be more comprehensive in the coverage of the physical properties of minerals, Part 3 on how minerals (similar and dissimilar) or crystals macro bond together to form lithology and Part 4 (or perhaps Part 5) on the economic importance of weathering processes.

Minerals: *Their Constitution and Origin* is designed as a textbook for undergraduate and graduate students in the fields of geology, materials and environmental science. The book bravely and successfully attempts to integrate a significant number of specialist fields over the micro to macro scale. This means this book would also be very suitable within the library of many in the earth science or related professions and even the more technically curious rock hounds and mineral collectors.

Copies can be ordered directly from Cambridge University Press, Tel: (03) 8671 1400 or from www.cambridge.edu.au