Preview

Australian Society of Exploration Geophysicists

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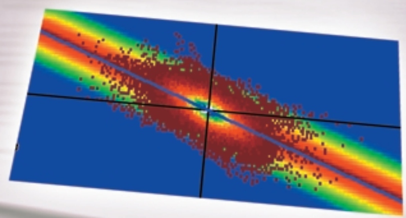
AVO Inversion

Direct Hydrocarbon Detection Made Easy

....Page 14



Software Advances

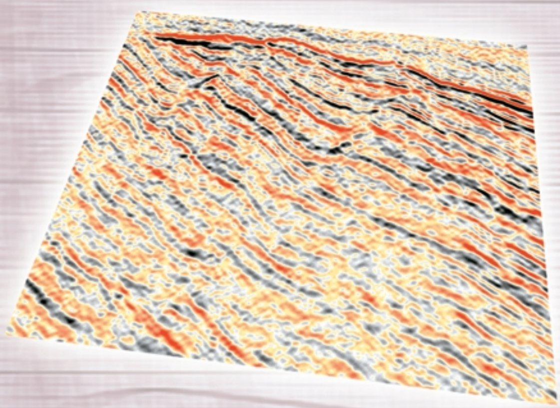
50 Years of Potential Field Modelling

....Page 16

4D Seismic Case Study

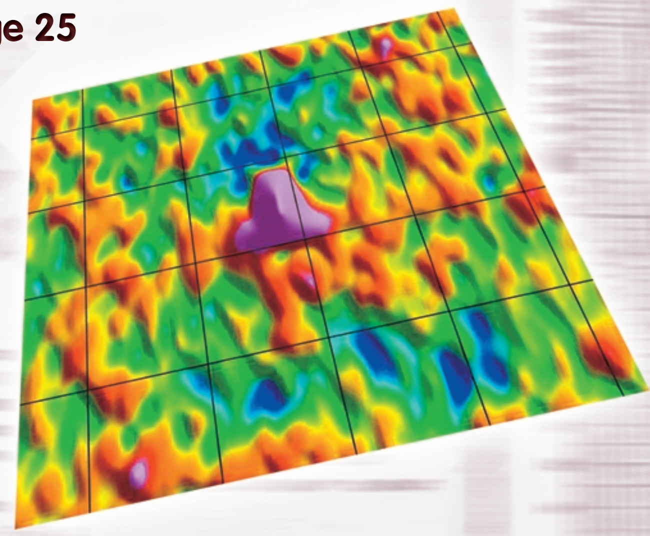
The Impact of Q Seismic Technology on 4D Seismic

....Page 23



Falcon™ Spreads Its Wings

....Page 25



Contents

Advertisers' Index

2002 Corporate Plus Members

MIM Exploration Pty Ltd
Velseis Pty Ltd

2002 Corporate Members

BHP Billiton Minerals Exploration
Chevron Australia Pty Ltd
Earth Resource Mapping
Encom Technology Pty Ltd
Fugro Airborne Surveys
Geosoft Australia Pty Ltd
Haines Surveys Pty Ltd
Normandy Exploration Ltd
Origin Energy Resources Ltd
Petrosys Pty Ltd
PGS Australia Pty. Ltd.
Primary Industries & Resources South Australia
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Veritas DGC
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The year of reviews

Cynical observers of politics are known to say: "If there is a really serious and difficult problem then initiate a review, particularly if you know what outcome you would like".

Well, we have any number of reviews underway at present and most of them are focussed on very important issues. However, I would not like to guess the outcomes, and I am not sure that anybody else would either, so it is up to us all to try and make as much of an impact as we can by being part of the process and putting in well reasoned submissions.

The cynics may say that this is a waste of time but you can't complain too much if the outcomes are not to your liking and you haven't made any input.

Let's just look at what is going on at present. To my knowledge the following are underway right now; there may even be more:

1. Resource exploration impediments

This inquiry is being carried out by the House of Representatives Standing Committee on Industry and Resources and is chaired by Geoffrey Prosser the MP for Forrest, WA

The committee has been asked to inquire into and report on any impediments to increasing investment in mineral and petroleum exploration in Australia by Ian Macfarlane, the Minister for Industry Tourism and Resources, including:

- An assessment of Australia's resource endowment and the rates at which it is being drawn down;
- The structure of the industry and role of small companies in resource exploration in Australia;
- Impediments to accessing capital, particularly by small companies;
- Access to land including Native Title and Cultural Heritage issues;
- Environmental and other approval processes, including across jurisdictions;
- Public provision of geoscientific data;
- Relationships with indigenous communities; and
- Contributions to regional development.

Obviously, the Committee has a very important task, and it is not difficult to identify the problems. However, solutions will be hard to find. Look at the following website for further information: http://www.aph.gov.au/house/committee/isr/index.htm.

2. National research priorities

As mentioned in the June Preview, the Minister for Education, Science and Training, Brendan Nelson, and the Minister for Science, Peter McGauran, have announced that it is the Government's intention to set national research priorities for government-funded research programs.

The priority setting is aimed at assisting and guiding research funding decisions across a range of government-funded research programs to achieve the best possible outcomes for Australia and Australians. The process of setting national research priorities also provides a significant opportunity for dialogue between the Government and the community on Australia's research strengths, opportunities and needs.

This issue is also very important. Obviously, we can't undertake research on everything we would like to, and it is not unreasonable to set priorities. However, how you do this is not all that easy.

My back-of-the-envelope high-level priorities are:

Wealth, Health, Wisdom and Sustainability

The Geosciences are used to produce wealth for the nation. They should also be used to enable our land and water systems to be sustainable, and contribute to our culture and understanding of the planet on which we live. So there is scope for including geoscience under the Wealth, Wisdom and Sustainability headings. However, at the next level down there are many good candidates. How about, Energy, Communications, Security, Preventative Health Care, and so on? All very important themes, but how do you translate these into a funding model?

Anyway the website is:
http://www.dest.gov.au/priorities/pubs/issues_paper/default.htm

It is worth a visit.

3. Higher Education Review

As was discussed in the last Preview, the Government is undertaking a comprehensive review of Australian higher education. The purpose of the review is to ensure that Australia's higher education institutions are best placed to contribute to the nation's future. Unfortunately, it does not seem that the government is prepared to invest any more public funds into the higher education system.

At present, three discussion papers have been produced:

- Higher Education at the Crossroads: an Overview Paper (26 April 2002),
- Striving for Quality: Learning, Teaching and Scholarship (21 June 2002), and
- Setting Firm foundations: Financing Australian Higher Education (25 July 2002).

These are accessible from the website:
http://www.dest.gov.au/crossroads/pubs.htm, and make interesting reading.

A crucial issue for the ASEG is really the funding model, and how it will affect science courses. At present, with the 'bums on seats' approach, the more expensive science courses are the ones that tend to be cut when Vice-Chancellors try to balance budgets. There is an opportunity now to put forward alternative models to change this situation, and the third discussion paper listed above proposes four models. I urge members to have a look at these and make an input to the review process, so that science courses are not continually subject to discrimination.

4. Business Commitment to Research and Development in Australia

This inquiry is being carried out by the newly established House of Representatives Standing Committee on Science and Innovation and is chaired by Gary Nairn the member for Eden Monaro.

International comparisons indicate that while the public sector in Australia supports R&D at an impressive level, business investment is less impressive. The committee will consider:

- The R&D drivers in small and medium sized business;
- The needs of fast-growing companies; and,
- The considerations by which major international corporations site R&D investment.

The committee will seek to address three questions:

- What would be the economic benefit for Australia from a greater private sector investment in R&D?
- What are the impediments to business investment in R&D?
- What steps need to be taken to better demonstrate to business the benefits of higher private sector investment in R & D?

Once again, a very important inquiry, particularly for members of the ASEG who provide high-tech services based on research results, and are short of venture capital.

The closing date for submissions to this inquiry is 30 August 2002. They can be sent by email to scin.reps@aph.gov.au, and the website for further information is:
http://www.aph.gov.au/house/committee/scin/r&d/index.htm

5. Strategic Plan for Earth Sciences in Australia

At the same time as all of the above are proceeding, the Australian Academy of Sciences' National Committee for Earth Sciences is developing a national strategic plan for the Earth Sciences in Australia. This is very important in the context of the prioritisation process mentioned above.

In summary, the main questions being addressed are:

- Where should we be focussing our research activities in the future?
- What funding mechanisms should be applied?
- What structural issues need to be addressed to move Australian Earth Science forward?

For those members who do not have a copy of the Background Issues Paper, I can provide a copy on request, and I strongly recommend that as many people as possible make a submission. These should sent to nr@science.org.au

6. WA State Ministerial Inquiry on Greenfields Exploration

Just when you thought that was enough, there is the WA State inquiry to identify strategies to increase resource exploration levels in 'Greenfields' areas of the State. David Howard has written about this in the WA Branch News so I will dwell no more on this inquiry.

These notes just give an indication of the frenetic activity that must be taking place within the Departments supporting these reviews, so spare a thought for the bureaucrats, and enjoy what's in this issue of *Preview*.

David Denham

David Denham

As members we observe the Society through a number of different glasses, not always rose tinted. We participate in it by reading the material, attending the conferences and meetings, being active in its functions, while being passionate about the profession and its future. However, when charged with its stewardship one revisits questions on its functions and its purpose. How do we coordinate through a group of volunteers the complex skills required to finance, manage and maintain a sophisticated professional Society? More importantly how do we manage this for the ***benefit of all our members***? If you don't want to wade through the details, go to the last paragraph!

This might be like teaching some of you to suck eggs, but I thought it appropriate to provide an overview of the functioning arms of the Society. If you want to know what these are: *Check out the website*, http://www.aseg.org.au/about.htm. What are our goals? Our activities? Our office bearers? Our Memorandum of Association? It says it all. We would like to see it evolve and, ***your interaction is essential to a dynamic Society***.

I will deal with the visible bits first. Preview is pulled together in every sense of the term by the ever-smiling David Denham; he is ready to include ***any material you may suggest***, of relevance to the profession. Exploration Geophysics provides the means to express our professional side; this immense task falls to the editor and his team. Both these publications are very important parts of the benefits to our members, and hence consume a good deal of energy to produce, maintain and manage. They are also the envy of other professional societies as they have established substantial reputations and an appreciative audience over time. Behind these visible manifestations of the Society sits the Publication Chairman. He has the considerable task, with his Committee, of managing finances, fees, policies, publication and advertising issues as well as interacting with the publisher and the Federal Committee. In addition, special publications are planned or are in the production process, including a potential ASEG/SEGJ joint issue, and the Geophysical Signatures of SA Mineral Deposits.

Communication with the world is managed through the web. We very much want to encourage the wider and more effective use of this medium, ***and urge you to forward suggestions*** and ideas to us as to how we could make this more attractive and interactive. In this respect I would like to draw your attention to the new Employment Section http://www.aseg.org.au/employment.htm, ***either to post or seek job opportunities.***

Then there is the premier event: the ASEG Conference. This Conference, held every 18 months, is run by a special Conference Committee from the State charged with its organisation. Although the conduct of the Conference is very much the domain of the local committee, it is ably guided by a comprehensive set of instructions developed and maintained by the Conference Advisory Committee. These guidelines compile the comments, reports and experience from previous conferences. The Adelaide Conference in February 2003, **"Growth Through Innovation"**, is ably organised by co-chairs Richard Hillis and Mike Hatch, and their committee is by all accounts looking to be very successful from both the technical content and attendance perspective. ***You are well advised to attend***.

The ongoing responsibility of the membership is handled through the Membership Standing Committee. This follows up on the many tasks of new membership applications, tracking existing members, updating the State Committees of changes, and generally maintaining the continuity of communication. We have recently approved the automatic and immediate award of Associate Membership for intending members, to speed up ***access to the benefits of the Society***. Transfer to active professional membership can then be achieved on receipt of the appropriate reference documentation. The day-to-day business and follow-up with membership and committees is handled by the Secretariat, which ensures continuity and management of the necessary background communication, accounting, audit coordination and other bureaucratic tasks.

Education is an important component of the Society's activities. This is accomplished through a variety of means, including the aptly named Education Committee. The latter has a role to identify initiatives that will project the role of geophysicists to audiences from school children and university graduates to the general public. It also aims to maintain professional standards through continuing education and distinguished instructor courses.

This Committee links with local initiatives developed by the State Committees and ***is the responsibility of all members.*** An important subset of this activity is the Research Foundation whose role is to attract high-calibre students into exploration geophysics through the dispersal of research grants. This function is carried out under an independent charter and is managed by ASEG members on an honorary basis, with financial and administrative support from the society to ensure that the funding is fully applied to research activities. Then there is the ASEG's Technical Standards Committee, which is responsible for implementing industry wide standards to aid in data transfer and data quality.

Each of the Standing Committees described above has an assigned representative on the Federal Committee, where we can review the major issues and make decisions based on their recommendations. There are also responsibilities for maintaining healthy finances of the Society, and more importantly to consider longer-term issues, so that the Society remains a dynamic and useful forum for professional geophysicists for now and into the future. It is important for us to maintain a balance across the disciplines we represent, and focus on key issues to complete tasks. The Constitution is under review as part of the strategic plan developed with the last executive. This includes a review of the roles and relationships of each of the active parts of the Society.

A very important group not yet mentioned is the Honours and Awards Committee. Members who are aware of the contributions of various individuals to our Society and its profession are encouraged ***to identify these contributions and make recommendations*** to the Chairman for consideration of awards. Candidates selected for awards

Continued on Page 6

Aims and Scope

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

Contents

The material published in *Preview* is neither the opinions nor the views of the ASEG unless expressly stated. The articles are the opinion of the writers only. The ASEG does not necessarily endorse the information printed. No responsibility is accepted for the accuracy of any of the opinions or information or claims contained in Preview and readers should rely on their own enquiries in making decisions affecting their own interests. Material published in Preview becomes the copyright of the Australian Society of Exploration Geophysicists.

Contributions

All contributions should be submitted to the Editor via email at denham@atrax.net.au. We reserve the right to edit all submissions; letters must contain your name and a contact address. Editorial style for technical articles should follow the guidelines outlined in *Exploration Geophysics* and on ASEG's website www.aseg.org.au. We encourage the use of colour in Preview but authors will be asked in most cases to pay a page charge of $440 per page (including GST for Australian authors) for the printing of colour figures. Reprints will not be provided but authors can obtain, on request, a digital file of their article, and are invited to discuss with the publisher, RESolutions Resource and Energy Services, purchase of multiple hard-copy reprints if required.

The text of all articles should be transmitted as a Word document. Tables, figures and illustrations should be transmitted as separate files, not embedded in the Word document. Raster images should be supplied as high resolution (300 dpi) tiff files wherever possible. Vector plots can be supplied using software packages such as Corel Draw or Illustrator. Illustrations produced in any other software packages should be printed to postscript files. Authors are encouraged to contact the publisher, RESolutions, for information to assist in meeting these requirements.

References

References should follow the author (date) system. When reference is made in the text to a work by three or more authors, the first name followed by et al. should be used on all occasions. References should be listed in alphabetical order at the end of the paper in the standard form:

Blackburn, G. J., 1981, Seismic static corrections in irregular or steeply dipping water-bottom environments: Exploration Geophysics 12, 93-100.

Abbreviations and units

SI units are preferred. Statistics and measurements should always be given in figures e.g. 10 mm, except where the number begins a sentence. When the number does not refer to a unit of measurement, it is spelt out, except where the number is greater than nine. Confusing mathematical notation, and particularly subscripts and superscripts, should be avoided; negative exponents or the use of a solidus (i.e. a sloping line separating bracketed numerator and denominator) are acceptable as long as they are used consistently. The words 'Figure' and 'Table' should be capitalised (first letter) and spelt in full, when referred to in the text.

Deadlines

Preview is published bi-monthly, February, April, June, August, October and December. The deadline for submission of all material to the Editor is the 15th of the month prior to issue date. Therefore, the deadline for editorial material for the **October 2002 edition** is **15th September 2002**.

Advertisers

Please contact the publisher, RESolutions Resource and Energy Services, (see details elsewhere in this issue) for advertising rates and information. The ASEG reserves the right to reject advertising, which is not in keeping with its publication standards.

Advertising copy deadline is the 22nd of the month prior to issue date. Therefore, the advertising copy deadline for the October 2002 edition is 22nd September 2002. A summary of the deadlines is shown below:

Preview Issue	Text & articles	Advertisements
100 Oct 2002*	**15 Sept 2002**	**22 Sept 2002**
101 Dec 2002	15 Nov 2002	22 Nov 2002
102 Feb 2003**	**13 Dec 2002**	**17 Jan 2002**
103 Apr 2003	15 Mar 2003	22 Mar 2003
104 Jun 2003	15 May 2003	22 May 2003

*** Centenary Edition***
**** Conference Edition, abstracts of papers to be submitted by 2 December 2002***

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Calendar of Events

2002

September 8-12
8th general annual meeting of the European Section of the Environmental and Engineering Society (EEGS-ES)
Venue: University of Aveiro, Portugal
Website: www.eegs-es.org/eegsb.htm

September 22-25
Applied Structural Geology for Mineral Exploration and Mining Symposium, Sponsor: Australian Institute of Geoscientists
Venue: WMC Conference Centre, WASM, Kalgoorlie, WA
Contacts: Julian Vearncombe at vearncom@iinet.net.au or Jocelyn Thomson at aigwa@iinet.net.au

October 6-11
SEG International Exposition and 72nd Annual Meeting, Salt Lake City, Utah, USA
Website: www.seg.org

October 20-23
West Australian Basins Symposium (WABSIII)
Burswood Convention Centre, Perth
Organised by PESA
Contact: Peter Baillie
Tel: 0417 178764
Email: peterb@tgsnopec.com.au

December 6-10
2002 AGU Fall Meeting, San Francisco, California, USA.
Contact: AGU Meetings,
Email: meetinginfo@agu.org;
Website: www.agu.org/meetings

2003

January 6-10
Deep seismic profiling of the continents and their margins (10th International Symposium), Taupo, New Zealand
Organised by Institute of Geological and Nuclear Sciences, Victoria University of Wellington and Geoscience Australia.
Website: http://www.gns.cri.nz/news/conferences/seismix2003/
Email: seismix2003@gns.cri.nz

January 20-23
International Conference On Soil and Groundwater Contamination and Cleanup in Arid Countries
Sultan Qaboos University, Muscat, Sultanate of Oman
Contact: Anvar Kacimov, Department of Soil & Water Sciences
Email: anvar@squ.edu.om, arkasimov@yahoo.com
Website: www.squ.edu.om

22-24 January
6th Society of Exploration Geophysicists of Japan's International Symposium on Imaging Technology
Themes: Solutions for Resource Exploration and Environmental Preservation
Organised by SEGJ and co-sponsored by the (SEG), (ASEG), (EAGE) and the Korean SEG
Venue: Nihon-Daigaku-Kaikan, Tokyo, Japan
Website: http://www.segj.org/committee/sympo/is6/index.html

February 16-19
Australian Society of Exploration Geophysicists
16th International Conference and Exhibition, Adelaide, SA
Theme: Growth through Innovation
Contact: Rob Bulfield
Tel: (08) 8227 0252
Email: rob@sapro.com.au
Website: www.aseg.org.au

April 7-11
Joint Meeting: European Geophysical Society (EGS) XXVIII General Assembly and the American Geophysical Union (AGU) Spring 2003 Meeting, Nice, FRANCE
Contact: EGS office
Email: egs@copernicus.org;
Website: www.copernicus.org/EGS

June 2-6
65th EAGE Conference and Exhibition, Norway.
Website: www.eage.nl

October 26-31
SEG International Exposition & 73rd Annual Meeting, Dallas, Texas, U.S.
Email: meetings@seg.org

Continued from Page 4

must be deserving of recognition from the entire Society for their contributions. This can only be done by acclamation from the membership.

The direct face-to-face interaction of the society membership takes place at the coalface of the various State Branches. Their technical and social functions promote discussions and address specific focus issues or just provide a local network on which members can rely for information and contacts.

What is the point of this discussion? At least, it provides a brief map of the different parts and how they function. It also describes some of the contributions needed to maintain the integrity of the Society. However, not everyone interacts with the Society in the same way. Many members do not have the time to devote to these activities, yet they are passionate, and have contributed in the past or want to contribute in the future in a constructive way without committing their time. I would suggest that ***your ideas, suggestions, and criticisms***, are the grist, which will allow us to ***direct our efforts for your benefit***.

So when you feel taken with an issue, have comments, or want to direct our attention, you can email secretary@aseg.org.au, for my attention, and we can collate and distribute these ideas to the appropriate people for feedback. ***Get the message! We all have a role to play!*** You never know, with sufficient volume, we may share it through a Preview Forum!

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Honorary Treasurer's Annual Report

The audited Financial Statements for the year ending December 31 2001 for the Australian Society of Exploration Geophysicists are presented.

The financial statements presented herein refer to the consolidated funds held and managed by the Society as a whole, including the state branches.

The society receives funds from membership subscriptions, corporate sponsorship, publications sales, subscriptions to publications, publications advertising, surpluses from conventions, meetings, and income from accumulated investments. The 2001 accounts include the 15th International Conference and Exhibition in Brisbane, Qld. These funds are used to promote, throughout Australia, the science and profession of geophysics. This was achieved during 2001 by funding the publication of *Exploration Geophysics* and *Preview* during the year, by paying capitation fees for the administration of state branches, by providing funds for the national administration of the society, by funding continuing education programs, by the provision of loans and grants for conventions and meetings, and for the ASEG Research Foundation.

The Profit and Loss account for the year shows a surplus of $233,530. The Balance Sheet indicates the retained surplus increased during the year from $380,727 at 31 December 2000 to $614,258 at 31 December 2001. The surplus was generated from an income of $1,097,179.

Apart from the conference, publications were the largest expense for the society, amounting to $257,728 ($278,042 in 2000). After income, this resulted in a loss from publications of $75,000 for the year. The use of CDs at the conference, as a publication medium, helped contain the publication expenses.

The society has budgeted for a loss in 2002 of $65,500. This loss is normal in a non-conference year.

During 2001 the society changed accountants in Brisbane, which has resulted in much more useful and timely reports enabling the Society to better manage and control its affairs.

The Society is in a sound financial position going into 2002 but careful planning and management are needed if it is to continue to survive, given the current state of both the oil and mineral industries.

R.M.S. White
Honorary Treasurer

Balance Sheet

As of December 2001

Assets	
Current Assets	
Cash On Hand	$179,092
Savings Funds	$209,005
Term Deposits	$154,892
Trade Debtors - Advertising	$53,618
Withholding Tax Paid	$3,073
Total Current Assets	$599,679
Other Assets	
Prepayments	-$6,757
Total Other Assets	-$6,757
Property & Equipment	
Equipment	$4,648
Total Property & Equipment	$4,648
Total Assets	**$597,570**
Liabilities	
Current Liabilities	
GST Liabilities	-$16,688
Total Current Liabilities	-$16,688
Total Liabilities	**$16,688**
Net Assets	**$614,258**
Equity	
Issued & Paid up Capital	$1,997
Retained Earnings	$378,731
Current Year Earnings	$233,530
Total Equity	**$614,258**

Queensland - by Kathlene Oliver

The Queensland Branch has held a number of well attended events during the last three months including a presentation by Fred Hilterman from the Geophysical Development Corporation who gave an interesting presentation entitled *Pore-Fluid and Lithology Predictions: Can we forecast any new advances?* The Branch is planning a number of other presentations before the end of the year. Members will be notified by email prior to meetings or can check the web site for further information.

There has been some confusion following our AGM about office bearers on the committee for this year. To clarify the elected positions are listed below:

- President - Werner Dutler, Werner.Dutler@santos.com
- Secretary - Kathlene Oliver, ksoliver@optusnet.com.au
- Treasurer - Peter Fullagar; p.fullagar@mailbox.uq.edu.au
- Members - Troy Peters, Natasha Hendricks, Fiona Duncan, and Michael Sharry.

Victoria - Ashley Grant

The AGM of the Victorian Branch was held on 30 April. Only a small number of members were present due to an unforseen conflict with the CSIRO Victoria Undercover conference in Benalla. The popularity of that event indicates a significant shift of geophysical expertise from mineral exploration ventures into environmental and engineering applications. This trend was further emphasised by our guest speaker for the June meeting. Professor Jim Macnae (now at RMIT University in Melbourne) provided a valuable pointer to potential applications in the title of his talk *EM at RMIT: Finding salt and plastic landmines*. Welcome to Melbourne Jim – are sheep cheaper than field hands?

Western Australia – by Kirsty Beckett and David Howard

The topic of the May technical talks was *NMR (Nuclear Magnetic Resonance) Geophysics*. This subject was more than adequately covered by Don Hunter and Andrew Duncan.

Refined and renamed MRI for the medical fraternity, NMR, uses the resonance frequency of hydrogen atoms to measure and model components of the body. This technology can be adapted for geological modelling, particularly in identifying the formation factor of materials, the porosity and permeability. However, the comparative fields used by MRI technology and the geological applications of NMR technology are vastly different. Artificial fields of 2 Tesla, generated in MRI scans, allow constant and variable field applications to measure minute changes in the subject. The ~58 000 nT generated by the Earth's magnetic field is considerably smaller, making measurements more difficult. However, the technology has the potential to measure proton resonance to depths of 100 m, which would serve to improve current aquifer models.

The challenge to refine this technology, undertake case studies and make NMR a new geophysical tool for the hydrogeologists tool kit is left to Don Hunter as the topic for his PhD for the next 3 years.

In June, Brian Evans from Curtin University of Technology and Greg Carlsen from the Department of Mineral and Petroleum Resources gave technical presentations on *Faults, Fractures, Seismic and the Yilgarn*. Brian Evans gave the results of research conducted by his student Robin Luo and demonstrated how the current industry practice of stacking multi-azimuth data into 15 degree azimuths is flawed due to the averaging effect of the linear trends utilised to extract information from visibly non-linear data. The methodology developed by Luo and Evans plots each data location independently, removing the biasing effect generated by the linear "averaged" trend. The trend can then be more realistically interpreted from visual presentations of the multi-azimuth data. A layer-stripping method is also being developed which aims to improve the mappability of different structural directions with depth.

Greg Carlsen upped the standard of PowerPoint presentations with a "singing and dancing" display. Greg displayed images of the latest major data acquisition by the Department of Mineral and Petroleum Resources, over 430 km of reflection seismic data extending from west of Laverton on the Yilgarn Craton to east of Yeo Lake in the Officer Basin. The data were acquired over known gold targets and potential petroleum interests and will be interpreted by the Department over the next few months.

Kirsty Beckett

ASEG (WA) submission to State Ministerial Inquiry on Greenfields Exploration

In April 2002, the Western Australian State Development Minister Clive Brown announced a review to identify strategies to increase resource exploration levels.

He prefaced his announcement with the statement that mining and petroleum development is the economic lifeblood of Western Australia, accounting for more than 70 per cent of exports, about half of private capital expenditure and around 30 per cent of Gross State Product. The resources sector generates nearly $27billion annually, and directly and indirectly employs about 165 000 Western Australians. In addition, the $1.2billion in royalties paid to the Government by resource companies helps fund WA schools, hospitals, roads and community safety.

Expressing concern that WA exploration expenditure in 2001 was less than $410 million compared with a peak of almost $1000 million in 1997 (with the likelihood of greenfields expenditure having decreased by a much larger proportion), he acknowledged the serious danger of not finding enough mines for the future and the challenge that this poses to WA given its reliance on the resource sector.

The Minister commissioned the Ministerial Inquiry with the recognition that the reduced level of investment in greenfields exploration is related to a range of factors, including downturns in demand and prices for minerals, land access, delays in approvals processes and financial

Continued on Page 10

ASEG 16th Conference & Exhibition
Growth Through Innovation

16-19 February 2003
Adelaide Convention Centre
www.aseg.org.au/conference/Adelaide/

The ASEG 2003 Conference and Exhibition is shaping up as a very exciting meeting. It's now time to put 16-19 February, Adelaide, in your forward planner for 2003. Here's why.

Conference Papers

We have just received more than 200 abstracts for the meeting. We are delighted that ASEG 2003 is the presentation forum of choice for so many of you. The technical papers committee chaired by Stewart Greenhalgh is busy going through these abstracts and formulating the program. As in Brisbane, authors of papers accepted for the Conference will be notified and requested to submit an extended abstract by 31 October. Extended abstracts will be published on the Conference CD. A selection of the top papers from the Conference will also be invited to submit full papers to Exploration Geophysics.

Conference Dinner

"A Scot and an American went to a cricket match ...". Sounds like the beginning of a bad joke, but both the Conference Co-chairs claim to be cricket fans. Where else then for the Conference Dinner than the magnificent Adelaide Oval, directly over the River Torrens from the Convention Centre. There's a rumour about drinks on the hill before dinner in the marquee behind the members' stand. The event promises to bowl you over (sorry!).

Adelaide Convention Centre

You may have visited the Adelaide Convention Centre for the recent Australian Geological Convention, or earlier this year for the APPEA Conference. If you've been there, you know that the newly re-developed centre makes a superb venue. Highlights being the short distance between the talks and the exhibition halls, the huge glassed atrium overlooking the River Torrens adjacent to the exhibition halls, and excellent audio-visual facilities. All this plus the Convention Centre's central location, an easy stroll from numerous hotels, restaurants, pubs ...

Sponsorship and Exhibition

The early commitment of our Platinum sponsor Santos and Gold sponsors Newmont Australia and Schlumberger/WesternGeco has put the Conference on a strong footing. Sponsorship and exhibition sales are going very well. The hard-working sponsorship and exhibition teams (i.e., the

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Continued from Page 9

issues related to levels of taxation and lack of incentives for such high risk investment.

The Inquiry, conducted by John Bowler MLA, Member for Eyre, sought submissions from major industry bodies, including the WA Chamber of Minerals and Energy, the Association of Mining and Exploration Companies (AMEC), the Amalgamated Prospectors' and Leaseholders' Association of WA, individual companies involved or interested in participating in mineral exploration in this State, community groups and individuals.

The Western Australian Branch of the ASEG held an extra ordinary meeting on the 12 June this year to discuss its submission to the Inquiry. Several factors were identified as key issues requiring redress in order to encourage greenfields exploration. These issues include:

- Improving access to large regional geophysical data sets of WA.
- Government production of more geophysical (integrated interpretation) mapping products.
- Tax incentives, grants or the like, for the re-education and preservation of geophysical intellectual property during down turns.

The full submission to the Inquiry was presented to John Bowler on June 26th in the company of representatives from AusIMM, AIG and GSA. It is available for perusal on the ASEG WA website at www.aseg.org.au.

A total of 36 submissions were made to the Inquiry; these are now being analyzed to help identify strategies to improve exploration expenditure levels. Mr Bowler has said that he expects to deliver a report on the findings of the submissions to Mr Brown in September 2002.

The findings will be considered along with the Fardon Report on funding for the Geological Survey of Western Australia (GSWA) that was tabled in Parliament by Mr Brown in February. The Fardon Report, compiled in late 2000 by Ross Fardon and representatives from the Association of Mining and Exploration companies and the WA Department of Treasury and Finance, recommended a substantial increase in State funding for the provision of pre-competitive information through increased appropriations to GSWA.

David Howard

entire Conference Committee!) are taking a brief respite from sponsorship and exhibition sales, while the papers committee draws up the Conference Program. Once the Program is prepared there will be a final round of sponsorship and exhibition opportunities. If you haven't yet arranged sponsorship or an exhibition booth then contact John Hughes (john.hughes@santos.com.au) or Mike Sexton (mike.sexton@newmont.com.au) for sponsorship opportunities and Doug Roberts (dcrgeo@tpg.com.au) or Chris Anderson (euroex@bigpond.com.au) for the exhibition.

Growth Through Innovation: Strong Petroleum Theme Promised

The Conference Theme is "Growth Through Innovation". As always the Conference will have a very strong minerals theme, and in 2003 there is a growing environment and groundwater program. Furthermore, with the help of our sponsors we are applying the Conference Theme to ensure an expanded petroleum focus at ASEG 2003.

In recent years there has been concern expressed by Petroleum Contractors and Operators that the ASEG Conference and Exhibition has not been meeting their expectations. It is the ASEG's firm belief that geophysics is extremely important to the Petroleum E&P industry and that the ASEG should provide a leading edge forum in which advanced technical geophysical issues are reviewed and debated by the oil community. To this end the Adelaide Conference Organising Committee has been working very hard to ensure that ASEG 2003 will be a "must attend" event for senior oil company geophysicists.

To achieve this we're planning innovative changes to the technical program such that there will be two petroleum-related Special Technical Forums each day. Each Forum will consist of a world class Keynote Speaker presenting on a particular theme, followed by two invited presentations from oil companies outlining their experiences and challenges in that same field. These talks will not necessarily be case histories, but will summarise what has worked, what has not, and what the authors see as the key challenges they would like to see the industry tackle in that particular field. The Forum will end with a panel discussion, the panel consisting of the three main speakers, the chairperson and potentially two senior/chief geophysicists who have experience in that same field. The papers will not necessarily be published (unless the companies/authors wish them to be) to ensure that they are as up-to-the-minute as possible and, hopefully, less encumbered by confidentiality issues. To-date the following have been arranged:

1. Seismic Amplitudes/AVO Interpretation

Fred Hilterman (SEG 2001 Distinguished Instructor) will be followed by Dennis Cooke, Santos' Chief Geophysicist and Klaas Koster, Woodside's Head of Quantitative Interpretation in this forum. Fred will also present an expanded version of his 2001 Distinguished Instructor Short Course on the Saturday/Sunday prior to the Conference/Exhibition.

2. The Drive for Better Bandwidth

Mark Egan (WesternGeco Chief Geophysicist) will head up this forum followed by a supporting paper covering onshore challenges. We are currently seeking a complementary offshore paper.

3. Global Geophysical Trends

Mike Bahorich (next year's SEG President and Apache Corporation's, Exec VP E&P Technology) and Yoram Shoham (Shell, VP External Technology Relations E&P, Applications and Research) will both be Keynote Speakers in this session.

4. Converted Wave/Azimuthal Seismic

Walt Lynn (current SEG President and PGS's Snr. VP, Technical Marketing) will lead off this forum. A paper on Cooper Basin full azimuthal seismic has been proposed as one of the supporting papers.

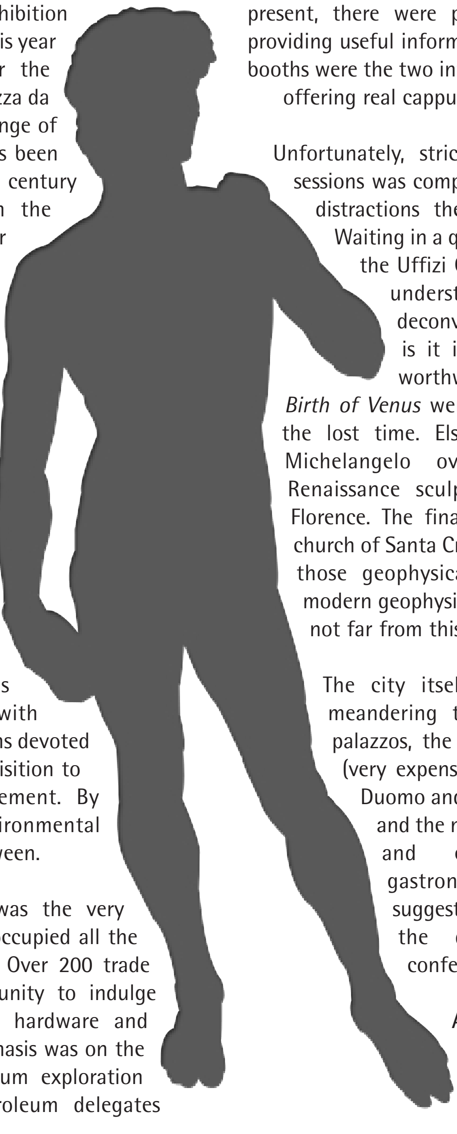
5. Structural Integrity - Depth Conversion/PSTM/PSDM

Helmut Jakubowicz (Veritas, Manager Research) will head up this forum and a range of supporting papers are being discussed including depth conversion issues on the NW Shelf and imaging issues in PNG.

These innovative special petroleum sessions have only been made possible because we have received so much early sponsorship support. Those in the oil patch that have been generous so far include Santos, WesternGeco/ Schlumberger, BHP Billiton, Veritas, Velseis, CGG, Beach Petroleum, Stuart Petroleum, PIRSA, OMV and Apache. We have also received great support from Shell, Geophysical Development Corporation, Apache, PGS, Veritas and WesternGeco in providing for the availability of the Keynote Speakers.

For more information on ASEG 2003 please visit our website www.aseg.org.au/conference/Adelaide or contact the Conference Co-chairs, Richard Hillis (rhillis@ncpgg.adelaide.edu.au) and Mike Hatch (zongeaus@ozemail.com.au), or the Conference Organiser, Rob Bulfield of SAPRO (aseg2003@aseg.org.au).

Notebook from Florence 2002



The 64th EAGE Conference & Exhibition took place from May 27th to 30th this year in Florence, Italy. The setting for the conference was the impressive Fortezza da Basso, a medieval fortress on the fringe of the main city area. The Fortezza has been re-built in a strange mix of 20th century contemporary architecture within the ancient walls of the city to cater especially for conferences and conventions.

The conference attracted over 1000 delegates from all corners of the Earth, although the Australian contingent was noticeably small. An exhaustive array of technical sessions within eight concurrent sessions was available for those who wished to witness at first hand the current developments in the technology and applications. In all about 350 oral papers and 250 poster papers were presented. The emphasis without question was on the seismic/petroleum area, with seven of the eight concurrent sessions devoted to topics ranging from seismic acquisition to reservoir monitoring and management. By contrast, the minerals/ environmental presentations were few and far between.

The main feature of the EAGE was the very impressive trade exhibition, which occupied all the floor space of two large pavilions. Over 200 trade booths provided an ample opportunity to indulge oneself in the latest geophysical hardware and software, but again the strong emphasis was on the seismic methodologies and petroleum exploration and production. To the non-petroleum delegates present, there were plenty of 'generic' trade displays providing useful information, but by far the most popular booths were the two internet cafes and the various booths offering real cappuccino and other local treats.

Unfortunately, strict attendance at the conference sessions was compromised by the pull of the various distractions the city of Florence has on offer. Waiting in a queue for two hours to gain entry to the Uffizi Gallery was hardly the best way to understand the latest theories on deconvolution, AVO or vector fidelity (or is it infidelity). However, the wait was worthwhile, and the beauty of Botticelli's *Birth of Venus* went some way to compensating for the lost time. Elsewhere, the awesome *David* by Michelangelo overshadowed the plethora of Renaissance sculptures that abound throughout Florence. The final resting place of Galileo, in the church of Santa Croce, provided a unique reminder to those geophysically inclined that the seeds of modern geophysical technology were probably sown not far from this place.

The city itself is a jewel – the lazy Arno meandering through medieval fortresses and palazzos, the Ponte Vecchio with its myriad of (very expensive) jewellery shops, the awesome Duomo and many other architectural delights, and the narrow cobbled streets, crazy people and enticing trattorias boasting gastronomic delights – all served to suggest that a visit to Florence without the distraction of a geophysical conference is a compellingly good idea.

Andrew Mutton
andrew.mutton@bigpond.com

Rock Adventures!

As geoscientists we make our living out of mapping rocks, cutting rocks, analysing rocks, drilling rocks, measuring rock properties etc. But how many of us take time out to really appreciate rocks!? This edition of Preview, Janelle Kuter and I share with you some websites that are sure to get you excited about rock adventures.

www.australianbouldering.com
Australian Bouldering

This site will guide you through Australian bouldering areas in NSW, Tasmania, Victoria and South Australia, and provide links to websites giving comprehensive information, maps and photos for each locality. You can also read about the grading system used for bouldering, read interviews with experienced boulderers and check out the latest bouldering news from around the country.

www.amonline.net.au/fossil_sites /index.htm
Fossil Sites of Australia

For all you fossil freaks, the Australian Museum Online provides information on five of the most important fossil sites in Australia (Riversleigh, Bluff Downs, Murgon, Lightning Ridge and Naracoorte). You'll learn what types of fossils are found at each site and the time period they represent in Australia's history. There are also links to scientific papers and other web resources containing information on Australia's fossil discoveries.

www.ropewerx.com.au
Blue Mountains Ropewerx

While this website is for an adventure tour company, you will also find a significant amount of general information on Abseiling, Canyoning and Rock Climbing, including details about some of the better spots for these activities in the Blue Mountains and Wollemi regions in NSW.

lisp.com.au/~daven/index.html
Dave Noble's Homepage

This is a personal website devoted to sharing Dave's caving, canyoning, climbing and white-water kayaking adventures in and around the Blue Mountains, NSW. Here you'll find some general information, recommended activity ethics, trip notes, and numerous links to other caving, climbing and canyoning web resources.

www.caves.org.au/index.html
Australian Speleological Federation

The ASF is the national caving body in Australia. Here you can find the contact details of your nearest caving club, and search for information about any of the 6500 caves and karst features documented in the National Karst Index Database. This site also provides standards and guidelines for cave naming, cave diving, cave safety, minimal impact caving, surveying and mapping, among other topics. In addition, there are links to other clubs and organisations, mailing lists, online publications and relevant government sites.

www.caveclan.org/index.html
Cave Clan Australia

If you're looking for something a little out of the ordinary ... consider the Cave Clan, a relatively small organisation that explores just about every type of artificial tunnel or chamber there is - including bridge rooms, gas pipelines, purification tanks, optic fibre tunnels, train tunnels, stormwater drains and cavities under cities. On this site you'll find contact details for the Cave Clan in your state capital, as well as details on the Il Draino Newsletter, safety tips for urban exploration, and a link to the Sydney Cave Clan Club site, where you can read a whole lot more about specific activities undertaken by club members.

www.climbing.com.au
Climbing Australia

An information-packed site giving comprehensive information on the science of climbing, contact details for Australian climbing clubs, and training advice for climbers. You can also read about Australia's climbing facts, including Australians on the 8000m Peaks, Mountaineering in Antarctica, and Australians on Everest. And if you're feeling game, read about the first-hand experiences of climbing Australia's 47 hardest climbing routes. Anyone for a climb!?

www.gold-net.com.au/fossicking/default.htm
Fossicking and the Law

A useful page for fossickers providing a link to the authority in each state of Australia that controls laws relating to fossicking. If you're looking for ideas on where to go fossicking, try www.ozbird.com/oz/subtopics/fossicking5 .html for locations in the Northern Territory, www.ozbird.com/oz/subtopics/fossicking6.html for locations in New England and the NW slopes of NSW, and cwpp.slq.qld.gov.au/afg/Fossicking.htm for locations in Queensland.

Natasha Hendrick

If you have any of your own favourite space sites you'd like to share with your fellow ASEG members, please contact me (natasha.hendrick @mim.com.au) and I'll include them in future editions of Preview. Enjoy your travels through space ...

Direct Hydrocarbon Detection Made Easy

Andy Furniss
Technical Business Development Manager
Paradigm Geophysical Asia Pacific
Email: AndyF@ParadigmGeo.com

Introduction

Post-stack inversion of seismic amplitude data for acoustic impedance (AI) is now commonplace in most seismic evaluation projects due to the ability of the technique under favourable conditions to predict reservoir properties, to identify reservoir lithologies and to discriminate between reservoir fluids. Unfortunately, many AI projects fail to deliver the required discrimination of fluid and lithologic properties because of the non-uniqueness of the solution and more fundamentally, because the input data lacks any angle-dependent information due to the stacking process. This angle dependent reflectivity data carries the seismic signature necessary to identify rock properties or discriminate between economic and uneconomic reservoir fluids.

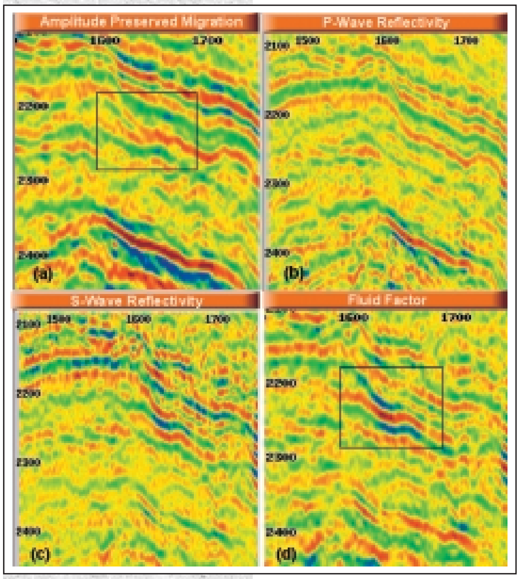


Fig. 1. (Above) Sample attribute sections from AVO inversion. Note presence of oil sands on Fluid Factor (d) that are not seen on conventional migrated data (a).

Fig. 2. (Right) AVO crossplots allow rapid identification of areas with gas or oil charge. Areas lying away from background trends are coloured blue and marked on the attribute sections indicating areas of gas and oil presence.

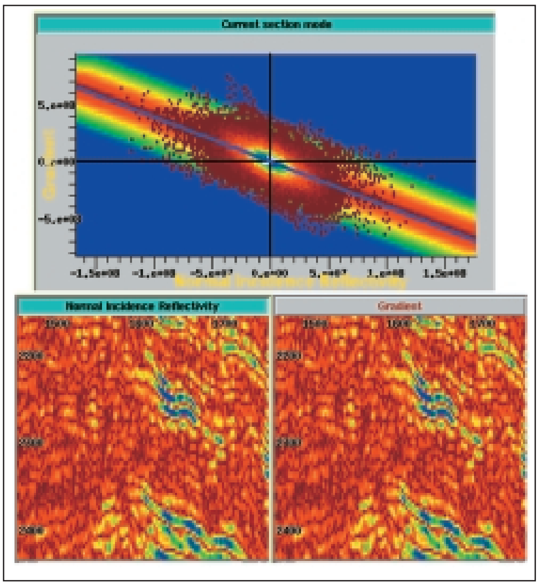
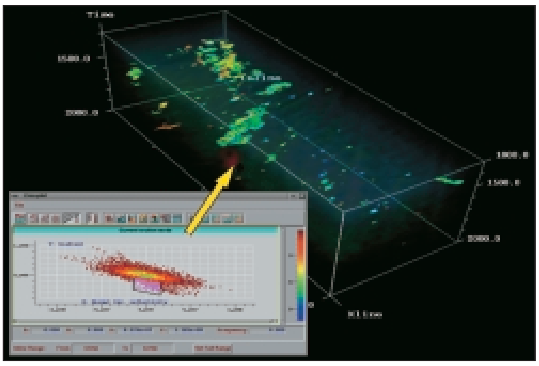


Fig. 3. (Below right) Linking AVO interpretation with volume visualisation techniques allows rapid reconnaissance of AVO anomalies. Here, a Class 2 AVO anomaly is directly extracted in a 3D volume by linking and marking the AVO crossplot.



Amplitude Variation with Offset (AVO) inversion is a pre-stack technique that is readily applied to seismic gathers but which is still largely under-utilised in the exploration community despite its ability to effectively discriminate between fluid and lithology effects. The process is inexpensive and rapid to apply during any seismic processing flow in time or depth, and provided that the input data (seismic gathers) have been processed and imaged with best amplitude preserving practices, the inversion process can yield attributes that have significant fluid and lithology discrimination qualities. AVO inversion methods vary, but the most useful are those that partition the amplitude response to estimates of P-wave, S-wave, and density reflectivities. These reflectivities can be combined to produce some very powerful Direct Hydrocarbon Indicators (e.g. Fluid Factor, Poisson's reflectivity). The different responses of these AVO attributes to changes in fluid type, saturation, and lithology allow us to more effectively distinguish hydrocarbon reservoirs from non-prospective zones. While the technique is more obviously suited to gas-charged clastic reservoirs due to their strong contrasts in Poisson's Ratio, there are many cases where oil reservoirs can be illuminated particularly where the oil has a high level of gas in solution.

Theory

Smith and Gidlow (1987) developed the ground-breaking methodology, now commonly used for transforming NMO corrected gathers into estimates of rock properties, by the use of weighted stacking. The method calculates AVO reflectivities by least squares fitting a curve that approximates the Zoeppritz equation to a crossplot of reflection amplitudes as a function of reflection angle for a given CMP. Inversion is performed using either a 2-term or 3-term approximation to the Zoeppritz equation. The most commonly used approximations are those derived by Shuey (1985) for 2-term inversion, and Aki and Richards (1980) for 3-term inversions.

A 2-term inversion effectively gives us just two AVO attributes, either AVO Intercept and AVO Gradient or Normal Incidence Reflectivity and Poisson Reflectivity. While the 2-term inversion is growing in popularity through the uptake of AVO crossplots as an interpretation tool, it is often overlooked that the Shuey approximation is invalid beyond about 30 degrees angle of incidence. A full 3-term inversion will solve for P-wave reflectivity, S-wave reflectivity and density reflectivity and will generally honour the Zoeppritz response accurately to about 50 degrees angle of incidence which is common in today's long-offset acquisition geometries. These attributes may then be combined or inverted (through a process of Elastic Inversion) to calculate more indicative hydrocarbon indicators such as Fluid Factor, Poisson Reflectivity or the Lamé parameters of Lambda-Rho ($\lambda\rho$) and Mu-Rho ($\mu\rho$) corresponding to the product of density and the elastic properties of incompressibility and rigidity respectively.

AVO Inversion in Practice

AVO inversion is equally applicable to both 2D and 3D seismic data in time or depth providing that sufficient care has been taken to preserve amplitudes during processing. A reliable velocity model is also a critical component of the AVO process as accurate angle information is a prerequisite for AVO inversion. The more accurate the angles, the better the partitioning of amplitudes to P-wave and S-wave reflectivities. In addition, both angle and ray path information can be incorporated in a variety of model-based amplitude corrections that are preferable and often more accurate than scalars derived from empirical equations.

The inversion process is then performed, completing in about the same time as a conventional stack. The resulting outputs are a series of AVO reflectivity sections or volumes that are determined by the Zoeppritz approximation used. Figure 1 shows the resulting reflectivity sections from a 3-term inversion. Note that the amplitude-preserved stack section (a) or P-wave reflectivity section (b) show no evidence of an anomaly at the marked location. This reservoir is an oil-bearing sand with relatively low acoustic impedance contrast with the surrounding shale and is therefore difficult to see on conventional stacked data, in part due to the cancellation of amplitudes by stacking traces of opposite polarity (Class 2P AVO). The relatively high amount of dissolved gas in the oil causes anomalous amplitudes on the S-wave reflectivity section (c) and its derivatives. A Fluid Factor section (d) clearly shows the strong definition of the oil sand due to the attribute's ability to distinguish fluid effects from impedance changes caused by lithology.

Fluid Factor is one of the most useful attributes derived from AVO inversion due its ability to make such distinctions and directly identify hydrocarbons. The Fluid Factor attribute is based on the deviation of given points from a background Mudrock Line that should be locally derived from full waveform P-wave and S-wave sonic logs. However, because Fluid Factor is identifying relative changes in the section, anomalies are often still visible with no constraint on V_P/V_S in the inversion.

Crossplot Interpretation

Crossplots have become the preferred method to interpret AVO data due to their ability to rapidly indicate areas of data that deviate from background values. Coupled with 3D volume visualisation techniques, they also provide a mechanism to quickly evaluate the spatial extent of AVO anomalies on multiple attribute volumes. Changes in Poisson's Ratio, caused by the presence of hydrocarbons, are mapped on the crossplots as data points that lie away from the background cluster and often lie on different trends to the non-prospective lithologies. For example, by crossplotting Normal Incidence Reflectivity against Gradient (Figure 2a) we can quickly mark the AVO attribute section according to distance from the background trend, which in this case would be representative of the local Mudrock Line. On these crossplots hydrocarbon-bearing sands, especially gas sands, tend to lie at the farthest distance from the background trend and are coloured blue accordingly. The marked sections (Figure 2b) make the distinction of oil-bearing sands immediately obvious to even an untrained eye. By further coupling these crossplot techniques with voxel-based interpretation systems, the marked anomalies can be immediately transformed into detected geobodies for determining the spatial extent and volumes of the hydrocarbon anomalies (Figure 3).

Summary

AVO inversion is a fast and inexpensive reservoir characterisation tool to directly determine the presence of hydrocarbons in 2D or 3D seismic data using hardware and software that runs on a typical desktop interpretation system. The technique often allows better discrimination between anomalies caused by lithology from those caused by hydrocarbons more easily and with less effort than AI inversion. Coupled with forward modelling and simple visual interpretation tools, AVO inversion provides the interpreter with a fast and easy method for screening seismic volumes for hydrocarbon potential in a cost-efficient and time-efficient process.

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Smith, G. C., and Gidlow, P. M., 1987, Weighted stacking for rock property estimation and detection of gas: Geophys. Prosp., **35**, 993-1014.

50 Years of Potential Field Modelling

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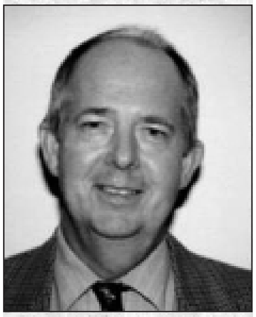


Introduction

The history of potential field modelling in Australian mineral exploration goes back many years but the most dramatic changes have taken place in the last 10 years. The changes over the next 10 years promise to be more spectacular as computer and software performance continue to improve. The author started his career in geophysics with a slide-rule, log tables and many pre-calculated interpretation charts. When first exposed to the power of computing in the mid-60's, the sensation was akin to stepping off a bicycle and sitting behind the wheel of a Porsche. Life has never been the same since.

This brief history of Australian potential field modelling has been prepared with a focus on the everyday tools available to the practising exploration geophysicist rather than advanced research and academic publications. Practical interpretation modelling is closely related to the computing resources available at the time, so it is appropriate to present a snapshot of the computing tools used by interpreters over the last 50 years.

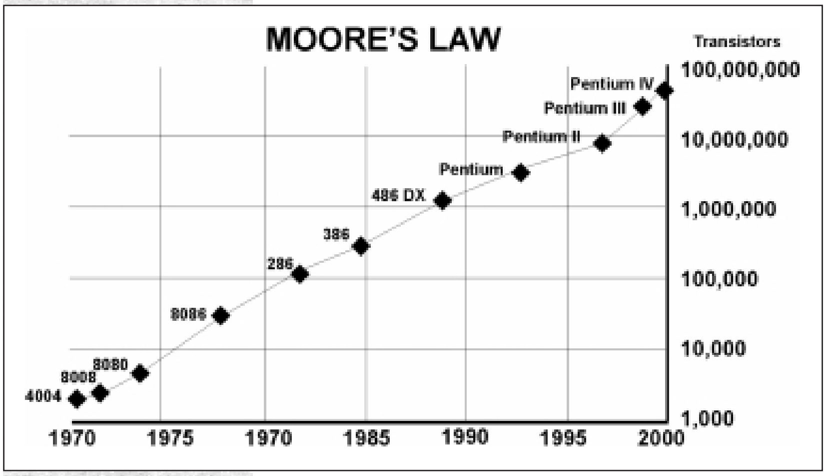


Fig. 1. Transistor density on Intel cpu chips from 1970 to 2000 (Graphic courtesy of Intel Corporation: www.intel.com).

Moore's Law

In 1970 Gordon Moore a co-founder of Intel Corporation predicted that the transistor capacity of an integrated circuit would double each year. In 1975 Moore revised his prediction to a doubling every 18 months. As can be seen in the graph below, his vision has proved close to reality.

Moore's Law provides a realistic way of predicting the rate of change in computing power that we can expect from our desktop computers and this, in turn, allows us to plan strategies that will utilise this increased capacity.

Transistor density as shown in this graph does not provide the complete story, because the execution speed of these computer chips has increased from around 1 MHz in 1980 to 2 GHz in 2002. Geophysical modelling is computationally intensive and historical benchmarks provide a better guide to performance changes over time. A useful set of benchmarks can be found at http://field.hypermart.net/CPU/cpu.htm. This site reveals that the computational performance improvement from the Intel 386 (1985) to the Intel Pentium 4 (2002) is approximately 1000. Extrapolation of this benchmark back to the first IBM PC suggests that the desktop computer performance has increased by a factor of approximately 10 000 in the last 20 years.

A Brief History of Modelling

Doug Morrison (2002) uncovered an old publication, which suggests the first magnetic modelling in Australia was performed by George Neumayer in 1861. Neumayer used quantitative methods to delineate the location, depth and size of a meteorite in outer Melbourne, Victoria and this is reported in his narrative on the Magnetic Survey of the Colony of Victoria.

1950 - 1980

In 1953, Lew Richardson worked with Bruce Kirkpatrick a senior lecturer in mathematics at the University of NSW to solve the mathematics to compute the magnetic response of ellipsoidal targets including demagnetization (Richardson, 2002). They needed a method for accurate drill targeting of the deep narrow copper-gold bearing magnetite-hematite deposits of Tenant Creek. When the results of a BMR aeromagnetic survey of Tennant Creek were released in 1956, Richardson applied the modelling method to a number of targets identified by the survey (Farrar, 1979). Contour maps were produced by lengthy hand computation of the response of theoretical bodies and compared with the survey results. This led to an early geophysical modelling success where the Warrego deposit was intersected within 4 feet of a target depth of 970 feet (Farrar, 1979).

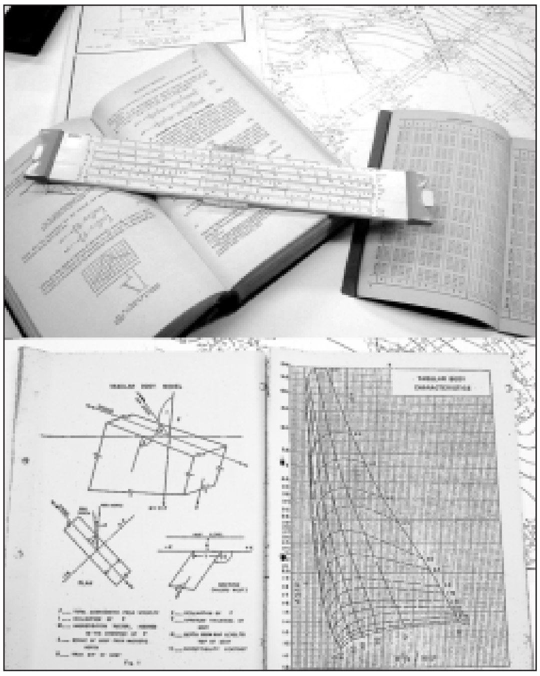


Fig. 2. Examples of tools used by geophysicists up until the mid to late '70s. (a) slide-rule and log tables, (b) nomograms of magnetic characteristic curves.

The method was computerised in 1965 using the CSA timesharing computer and by 1970; L. A. Richardson and Associates had installed a Wang computer to perform the modelling in-house. Richardson (2002) reports that the programming was done in Basic and a model contour map could be prepared with approximately two days computation that replaced a tedious manual process of a similar duration.

Thirty years ago, geophysicists wrote their own software. Computing environments were much simpler than they are today and programs typically contained several hundred to several thousand lines of code. Geophysicists used timeshare systems that were normally accessed from slow speed (10 characters per second) terminals. Towards the end of the '70s Digital Equipment Corporation released the PDP 11 minicomputer. This was a relatively affordable and powerful computer and its arrival sounded the death knell for the expensive timeshare services.

Interactive modelling was not available to most geophysicists during this time - most computer modelling involved the development of forward models with results being printed as tables or displayed as simple graphs on a pen plotter. For most geophysicists, modelling was still performed using charts and simple methods such as the direct approach developed by Peters (1949) or nomograms (Fig. 2).

1980 - 1990

In the early 80s both Hewlett Packard and Texas Instruments released programmable calculators. These rapidly became popular as computational aids and both the SEG (Ballantyne et al., 1981) and the ASEG (Emerson et al., 1985 and Clark et al., 1986) published a suite of geophysical programs for them.

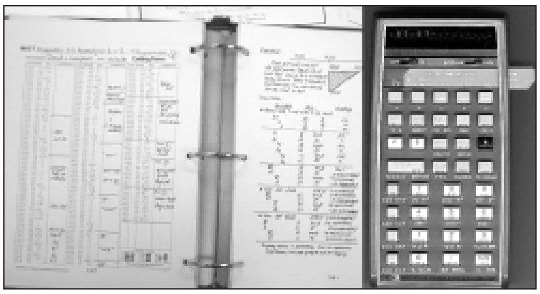


Fig. 3. SEG programs for the Texas Instruments 59 calculator and an image of the HP 67 hand held programmable calculator.

By 1981 desktop computing had become a reality. The Digital Equipment PDP 11 and VAX computers were the most popular corporate computers. Affordable monochrome graphics terminals appeared on the scene and to a lesser degree, colour terminals began to provide interactive capabilities for some exploration companies.

The early '80s heralded the start of the age of personal computers. Users had a choice of many different personal computers such as the Apple II, Osborne and Kaypro computers running CP/M and later the IBM PC running MS-DOS. Although most of these computers were limited in their capabilities, lower operating costs made them an attractive alternative to expensive timeshare facilities.

Fig. 4. Examples of early desktop PCs, HP85 (a), Apple II (b), Osborne (c) and the first IBM PC (d).

Computer technology had evolved to a stage where users could write their own programs and solve many of the operational needs of their exploration companies. Most software for magnetic and gravity modelling was developed internally within exploration companies but a new breed of service company was emerging – the specialist software developer.

By the mid-80's a number of low cost personal computer modelling programs were available on a number of desktop and mini-computers (Pratt & Doyle, 1984, MacLeod & Reeves, 1984). CP/M based computers had all but disappeared and the MS DOS based IBM PC had taken over as the personal computer of choice for most geophysicists.

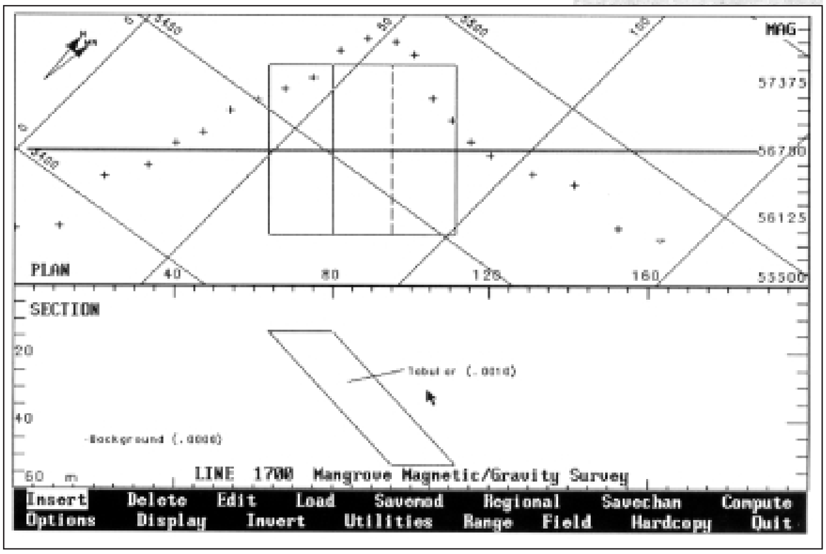
Early programs were relatively simple, but they did allow the interpreter to build arbitrary geological sections, compute a model response and compare it with field data without having to worry about expensive computer time or budgets. Most companies could afford to place a personal computer at the disposal of a geophysicist.

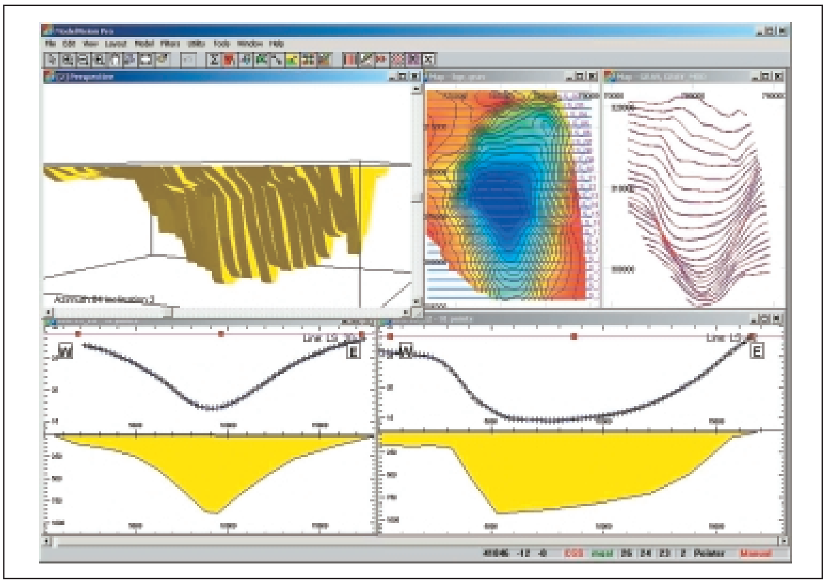
By the late '80s a large number of IBM PC compatible computers were available. The Apple Macintosh was very popular in educational institutions and with geologists, but its closed architecture and high price lessened its appeal to geophysicists.

1990 - 2000

By the early '90s personal computers were capable of performing significant work but the high ground for

Fig. 5. Example model display from the DOS based TOOLKIT modelling package (Pratt et al., 1989).





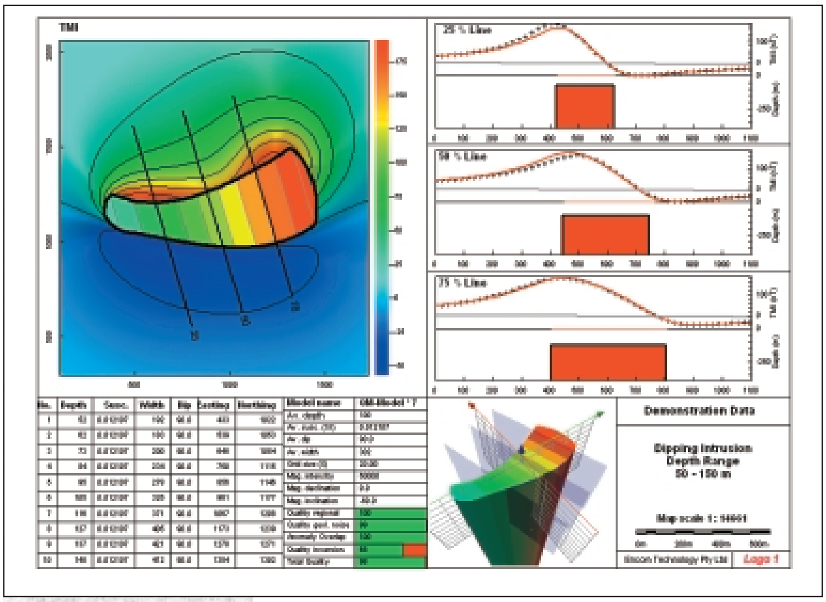


Fig. 6. (Top) Microsoft Windows 3.1 and Windows 95/98 example from ModelVision

Fig. 7. (Above) Example of an interactive object oriented application for magnetic modelling.

geophysical processing was held by Sun and Silicon Graphics workstations. These were expensive but provided higher performance, better graphics and a more robust operating environment than the PCs of the day. By the mid-90s, PCs had evolved to the stage where they were starting to compete favourably with the workstations. PCs were becoming ever more powerful and the introduction of the Windows 3.0 operating system provided an effective graphics environment for technical applications.

While the Windows operating system offered PC users a friendlier working environment, it posed significant challenges for software developers. The major effort in developing a program now involved the coding and testing of its user interface rather than the coding and testing of the underlying geophysical algorithms.

ModelVision was first released in 1994 as an early example of 3D magnetic and gravity modelling on the Microsoft Windows 3.1 operating system. Multiple graphics windows and direct operating system support for graphics printers represented the most significant benefits of this new operating system.

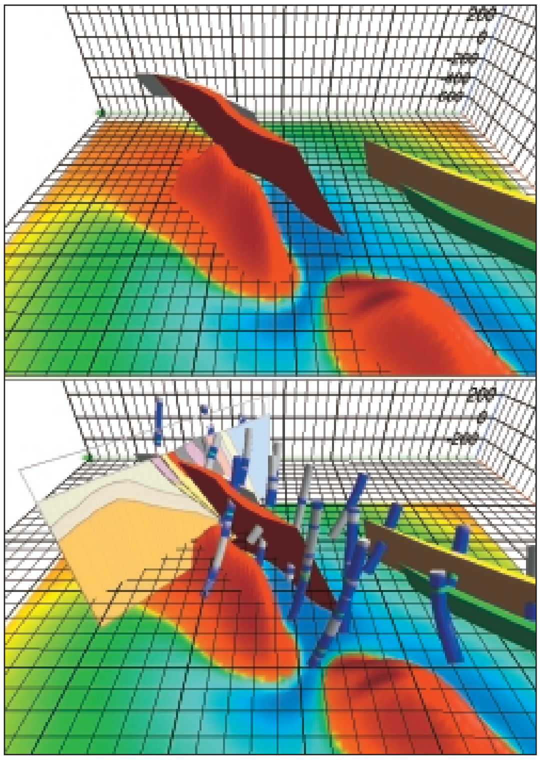


Fig. 8. Magnetic model and simulated magnetic field (a); magnetic model, drill holes and geological sections from the Discover for MapInfo GIS application (b).

Today

In 20 years, the personal computer has come a long way. Processor performance has increased 10 000 fold, programs are more powerful and less cumbersome and personal computers sit on every desk. Software professionals require far greater skills to develop programs than they ever did in the past.

Object-oriented programming techniques are used to build applications as a set of co-operating objects each of which is designed to perform a specific task. These objects can be reused in different applications thereby decreasing the overall cost of software engineering. Figure 7 from QuickMag (Pratt, et al., 2001), illustrates this style of program. The frames in this application are a set of co-operating objects. The magnetic model is also an object that knows how to render itself in each of the companion windows. In the map view, the object renders only the upper surface, while in the spreadsheet view it displays the physical properties of the model and in the 3D view it provides a dynamic view that can be manipulated using zoom and rotate tools. The scale bar is also an active object that can be used to control the scale of the main map.

Interactive modelling programs are more complex than procedural processing programs. With procedural programs data are read, processed and outputs generated with little if any input from the user. By comparison, during the running of an interactive application the user will interact with the data in many different ways. Interactive applications must cope with a wide range of user operations and cannot rely on a user performing these operations in a pre-ordered sequence. This means that interactive applications require a more robust and richer user interface that must be programmed to respond to a wide range of possible error conditions.

To further enrich the geophysical computing environment, Encom has been researching the use of expert systems to assist in the interpretation of magnetic anomalies. QuickMag utilises such a system to build complex three-dimensional geological models to help reduce the labour component of interactive modelling from hours to seconds. QuickMag replaces a time consuming set of manual steps that estimate the regional magnetic field, analyse anomaly interference, evaluate geological noise and invert the data based on a geological style selection.

This expert system method fits between full 3D applications like ModelVision (Pratt et al., 1994) and fast-automated methods like Werner deconvolution and Naudy. With sophisticated software like QuickMag, useful geological information that was often left uninterpreted can now be extracted quickly and cost effectively.

Where to from here?

Potential field modelling is part of an exploration decision support system that helps decide on drill hole locations. Most exploration companies now use GIS packages to hold the important geological information and thus it has become the primary tool for managing the decision to drill. It is important for geophysical interpreters to capture the geological outcomes of their interpretations so that they are compatible with the corporate GIS system.

Modern GIS systems such as MapInfo and ArcGIS provide development interfaces for communicating with companion applications. Specialist software modules can be developed and integrated into these products to enhance their usefulness to geoscience professionals.

In the near future you will be able to integrate geological sections, geological models, drill hole trajectories, assays, surfaces and other geophysical models in one seamless computing environment. Figure 8 illustrates the integration a 3D magnetic model with drill hole assay data, and geological sections generated in the Discover for MapInfo GIS application.

Within two years, you will be able to perform near real-time, solid geology interpretations of map regions using expert systems. Encom is undertaking research with support from an Australian Government grant on gravity studies of basins and continuous magnetic mapping of the basement.

In 5 years, our personal computers will be at least 10 times faster than they are today. More memory and larger and faster storage devices will further improve computer performance. This extra computing power will allow us perform real-time computing on more complex models.

The Internet has had a dramatic influence on the way we work, gather information, provide product support and distribute data. Little progress has been made, however, in utilising the Internet's potential for co-operative and complex computing. Our experience with most online interactive internet environments is frustrated by unpredictable delays and limitations of the user interface. Reliable, low cost, high bandwidth internet access from anywhere including field bases will help, but it is difficult to say when this will become a reality. Remote application servers for advanced modelling is a possibility, but the high cost of developing an effective Java based interface may relegate these tools to the top end of the market.

Thirty years ago, the modelling of even simple anomalies was an arduous task. 20 years ago the personal computer changed the way we work forever. Powerful computers, interactive software systems and integration of geological and geophysical data now provide an environment that allows us to apply realistic geological models to the interpretation of potential field data.

Acknowledgements

I would like to acknowledge the contribution by Bob Richardson on Tennant Creek and Doug Morrison for his contributions on some of the historical aspects of geophysical exploration in Australia.

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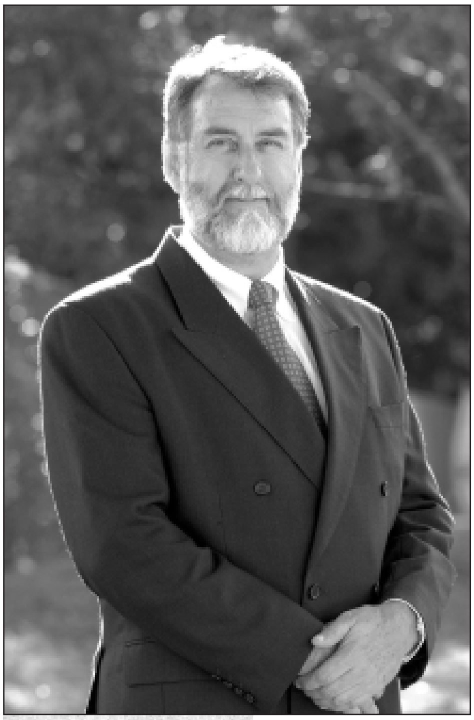
Ted Tyne appointed as Director, Geological Survey of NSW



Ted Tyne, Director of the Geological Survey of NSW.

Congratulations to ASEG member Ted Tyne, who in July this year was appointed to the position of Director of the Geological Survey of NSW, one of the three operational Divisions of the NSW Department of Mineral Resources.

In the announcement to the staff of the Department, the Director General of DMR, Alan Coutts, commented that the "appointment comes after an exhaustive recruitment process and is a measure of the high quality of internal applicants that competed for this position. Dr Tyne has worked in both the public and private sectors and brings to the position a balance of skills and experience that will be of immeasurable benefit as we face the many challenges ahead, including our relocation to Maitland."

Ted brings to the position extensive experience over the past 30 years in government, industry and academia, in particular, the application of geophysical surveying, geoscience computing and applied research to regional mapping and mineral exploration projects. Although he has had many years experience in New South Wales, he has also worked extensively throughout Australasia and on major exploration and government mapping projects in North and South America, southern Africa, northern Europe and Asia.

Ted returned to the Department from industry in 1999 as Assistant Director in charge of regional geological and geophysical mapping, but he had previously worked in the DMR as a Geophysicist and then Principal Geophysicist.

It's not often that a geophysicist is offered the opportunity (or privilege) to lead a Geological Survey. Ted commented to Preview that he has had the good fortune and privilege to work closely with and to learn from John Ringis and Steve Webster, the previous DMR Principal Geophysicists, as well as the three previous Directors of the Geological Survey, Toby Rose, Neville Markham and John Cramsie.

Ted has been a member of the ASEG since 1971 and was awarded the ASEG Service Certificate, for outstanding service to the ASEG in 2000.

New Members

We welcome the following new members to the ASEG. Membership was approved by the Federal Executive at its meetings on 29 May and 26 June 2002

Name	Organisation	State
Darren Patrick Andrews	University Tasmania	Tas
Andrew John Arnold	EDR Hydrosearch	WA
William John Ashby	Phillips Petroleum Ltd	WA
Partha Bhattacharya	FITT	India
Miroslav Brajanovski	Curtin University	WA
Sarah Clay	Adelaide University	SA
Brendan James Joseph Coleman	Normandy	SA
Anothony Murray Collings	University Tasmania	Tas
Jamie William Connell	Curtin University	WA
Timothy Brett Cotton	University Adelaide	SA
Timothy Brett Cox	Phillips Petroleum Ltd	WA
Andrew James Crawford		Tas
Luisa D'Andrea Depledge	University Tasmania	Tas
Jeromy Evan	Woodside Energy Ltd	WA
Tania Dhu	Adelaide University	SA
Cameron Geoffrey Dinning	Kuwait Oil Co.	WA
Selina Maria Donnelley	Adelaide University	SA
Greg Allan Dunlop	Grant Geophysical Inc.	USA
Reece Edward Foster		WA
Robert Michael Gill	Adelaide University	SA
Kate Elizabeth Godber	University Tasmania	Tas
Benn Raho Harrison Hansen	Curtin University	WA
Samuel George Howman	University of WA	WA
Amy Elizabeth Lockheed	Adelaide University	SA
Ryan John Metcalfe	Curtin University	WA
Trang Kim Nguyen	Curtin University	Vic
Nick Rawlinson	Monash University	ACT
Hannah Jane Ritson	Woodside Energy Ltd	WA
Moo Young Song	Chununam National Uni.	Korea
Jared Alan Townsend	Curtin University	WA
Andrew David Tyson	University Tasmania	Tas
Marko Vanderveen	Woodside Energy Ltd	WA
Jamie John Vecchio	WMC Resources	WA
Justin Vermelilen	Curtin University	WA
Andrew David Winch	Sydney University	WA
Ungsing Wong	Woodside Energy Ltd	WA

New South Wales

Major Release of new Geoscience Mapping and Information Products

More than 100 senior representatives from the mineral and petroleum exploration industries attended the largest release of new geoscience maps and information under the Government's *Exploration NSW* initiative, at an industry forum at Parliament House, Sydney. The forum also included a live demonstration of the new Internet application, MinView.

The release package comprised new geoscience maps, images, reports and CD-ROM data sets. The June 2002 *Preview* described some of the offerings now available to the resource industries. We are now able to expand on this information.

For those wanting a good summary of what is now available, a credit-card sized CD-ROM package was released at the forum. This provides summary information on each of the new maps and packages and appropriate links to further details on the Department of Mineral Resources web site (www.minerals.nsw.gov.au). The CD is extremely well presented and copies are available from the Department on request.

The new maps and packages, which cover many areas across the State, including Broken Hill, Cobar, Lake Cargelligo, Goulburn, Moree, Braidwood and the New England region are major geoscience project outputs for the Geological Survey of NSW. *Exploration NSW*, now into its third year, has contributed significantly to the production of these new geological and geophysical coverages designed to support and encourage explorers throughout the State. A summary of the main releases is given below.

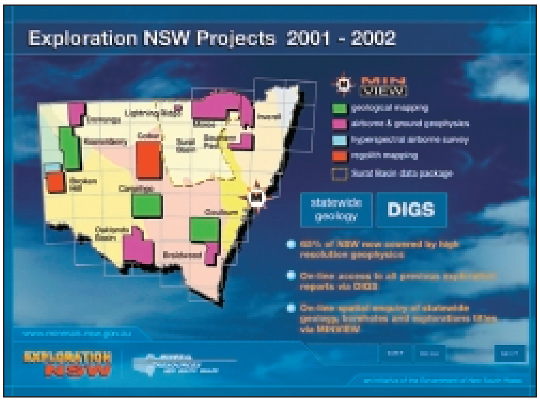


Fig. 1. (Above) Attendees inspect one of the displays in the NSW Parliament House.

Fig. 2. (Left) Information screen from the Exploration NSW Release CD-ROM showing the areas across the State covered by the new maps and products

Broken Hill Region

Broken Hill continues to be a major focus of *Exploration NSW* and the Broken Hill Exploration Initiative. The release of new products and the application of new techniques include:

- 4000 km^2 hyperspectral survey that covers most of the outcrop and subcrop areas on the Broken Hill Block. The HyMap system provided 3 m spatial resolution, 126 spectral channels and high image quality. Mineral abundance maps are expected to map stratigraphic units, regolith, alteration zones, sulphate, hydroxyl-bearing minerals, iron oxides and green and dry vegetation (see June *Preview*).
- A review of the Broken Hill copper-gold potential was completed by modelling specific aeromagnetic targets with the best available geological information. This resulted in new exploration concepts and identified about a dozen new exploration targets.
- A new Broken Hill geoscience package on CD ROM that includes geological maps at 1:25 000 scale, airborne magnetic and radiometric collected by Geoscience Australia (mostly at 100 m interline spacing), gravity, hyperspectral imaginary and previous exploration data that includes geochemical data from 54 000 auger holes, 40 000 RAB drill holes, 2000 diamond and percussion drill holes, 9500 stream sediment sample points, 2000 rock analyses and 8200 rock descriptions.
- New geology maps in the Koonenberry Region over the Nuchea and Wonnaminta areas were produced by using the new aeromagnetic data. These maps indicate a number of unrecorded prospects and shafts that were associated with volcanic units and gossaniferous ironstones. Geological/geophysical mapping also revealed the extent of faulting and tectonic disruption of the upper crustal rocks in this area. The historic Wonnaminta Copper Mines and some copper-gold occurrences at Koonenberry Gap are associated with the regional Koonenberry Fault and branching cross faults. Recent exploration has confirmed that many of these faults have elevated gold values. Traces of copper carbonates are commonly found associated with the tholeiitic volcanics and tuff components within the Ponto Group phyllites west of the Koonenberry Fault. On the Wonnaminta sheet and adjacent to the Bancannia Trough, strong magnetic anomalies at shallow depth have revealed the presence of many small exposures of gossanous ironstone, slates, sandstones and basic volcanic rocks between the sand dunes.

Cobar

Over the Cobar East area a comprehensive report has been released on the shallow drilling, regolith studies and geochemical results as part of the Department's participation in the production of CRCLEME, regolith maps of the area.

Lake Cargelligo

New geology maps for the Lake Cargelligo region reveal detailed structural mapping of the extensive Ordovician turbidite sequence, which identified complex faulting and some controlling gold mineralisation. Over 50 newly discovered graptolite localities have enabled correlation with the very prospective Ordovician sequences in Victoria and have defined better the internal stratigraphy of the region.

Goulburn and Braidwood

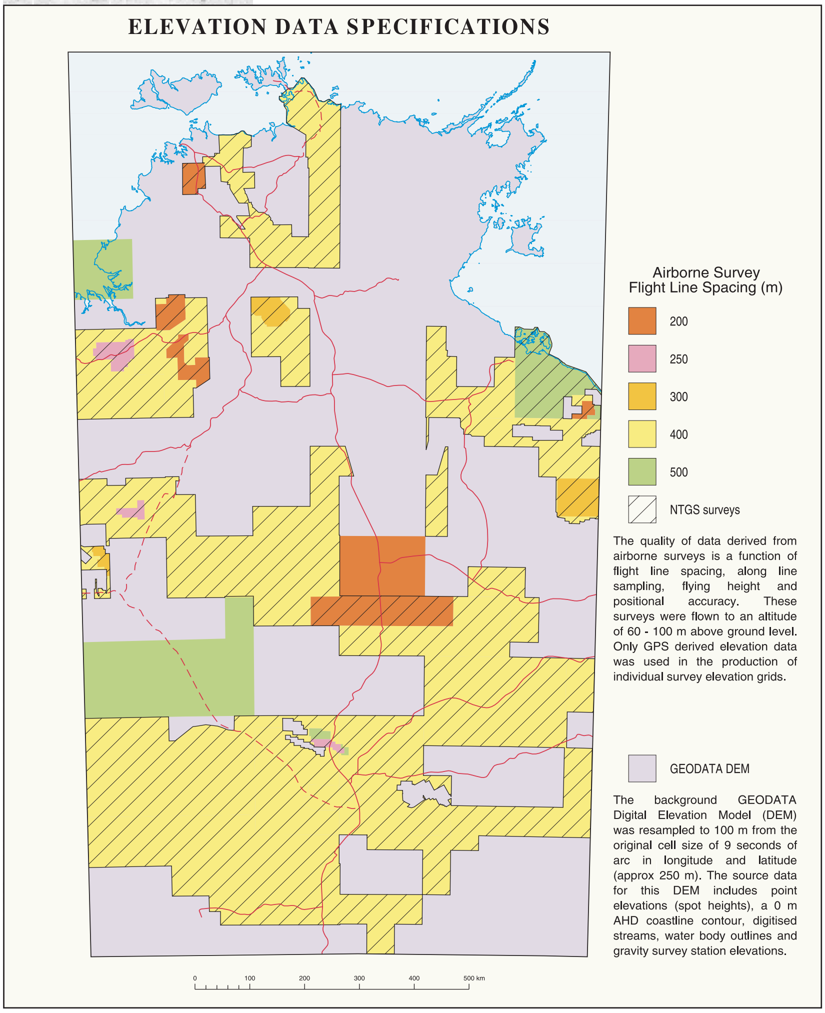
New geology maps of the Crookwell, Boorowa and Gunning 1:100 000 map sheets have been released. These indicate several new areas of volcanics considered to have very good potential for gold and base metal discoveries.

The release of the new Braidwood airborne magnetic and radiometric data collected at a 250 m interline spacing highlighted large extensions of Late Silurian felsic volcanic rocks that host the important Captains Flat and Woodlawn ore bodies.

New England

The forum also announced the release of the major GIS package covering the Southern Peel area immediately north of Tamworth. The autorun menu interface and drive-independent ArcView and Mapinfo files accesses 241 mineral occurrences; 3420 stream sediment samples, 55 drill holes, 198 whole rock analyses, 10 mineralised grab sample assays, and 411 petrological samples. This information will provide new opportunities for slate belt gold, silver, base metals, tin, sapphire and diamond exploration.

Metadata map showing the quality and coverage of the elevation data used to compile the NTGS Elevation Map.



Interpretation of new aeromagnetic and radiometric data has demonstrated the value of high-resolution geophysics in a granite-dominated part of the New England region. It has resulted in a greatly improved understanding of the structure, lithological distribution, subdivision of intrusives and controls on mineralisation of the region. Radiometric data provide a valuable tool for interpreting the surface geology, for identifying previously unrecognised geological units and relationships, and for distinguishing some pluton zonations and phases.

Latest Geophysics

Since the May release, the Oaklands Basin and the Inverell airborne geophysical surveys have been completed. The latest information on new geoscience information releases is available on the Department's web site.

MinView internet data viewer
A highlight of the forum was the unveiling of the new MinView Internet data viewer, which provides on-line viewing and querying of the State's geological and exploration titles information. The MinView application uses the latest technology including XML, Java, J2EE (Java 2 Platform, Enterprise Edition), ArcIMS and JavaScript to provide a fast and easy to use solution to the Web delivery of mineral resources information.

The application also uses Tomcat application server technology to provide users with the ability to link current geological and exploration titles information displayed on screen to the associated exploration reports held in the Department's DIGS database. The MinView application can be accessed from the Departments homepage at: www.minerals.nsw.gov.au

NTGS

New Elevation Map of the Northern Territory

NTGS has released the 2002 Elevation Map of the Northern Territory, which was produced by Roger Clifton. This is a companion to the 2002 Magnetic and Geological Maps of the Northern Territory and is available in both digital (ER Mapper ERS, ALG & ECW, and MapInfo TAB formats on CDROM) and hardcopy (1:2.5M scale) formats.

The Elevation Map of the Northern Territory has been gridded to 100 m and comprises all datasets as indicated on the Figure.

Approximately 60% of the coverage is composed of the GEODATA 9' Digital Elevation Model from Geoscience Australia (250 m grid equivalent). The remaining 40% comprises GPS-derived elevation data from 23 NTGS and Geoscience Australia airborne surveys flown since 1993 (200-500 m line spacing).

Also included on the CDROM is a spatial index outlining full specifications of all component airborne datasets. The digital product is provided in GDA94 MGA53 and the hardcopy version is in an Albers Equal Area projection.
The image can be viewed on the NTGS website: http://www.dme.nt.gov.au/ntgs/ecw/NT_magnetics.htm

The Impact of Q Seismic Technology on 4D Seismic - a case study from the Magnus Field

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Summary

Improving signal bandwidth and repeatability of seismic data are key requirements for reservoir monitoring surveys. This paper details how the recently developed Q-Marine system has impacted these requirements through a case study over the Magnus Field in the UK sector of the North Sea. The key objectives of the Magnus survey were to improve seismic resolution of the reservoir and to provide a repeatable 4D baseline survey. The 2001 survey provides a backward-looking comparison with the 1992 Magnus survey and a baseline time-lapse survey for the Magnus Enhanced Oil Recovery (EOR) scheme.

Introduction

The Magnus Oil Field is located 160 km NE of the Shetland Islands in Blocks 211/12a and 211/7a and is the most northerly producing field in the UK sector of the North Sea. The water depth in the Magnus area is 186 m. The reservoir lies at a depth of approximately 3000 m subsea and comprises Upper Jurassic submarine fan sandstones in an eastwards dipping fault block. The reservoir is enveloped by the hydrocarbon source rock, the organic rich mudstones of the Kimmeridge Clay Formation. The Magnus Platform currently produces over 50 000 barrels of oil a day.

The Magnus EOR scheme involves injecting a limited volume of miscible injectant and displacing the injectant with water as a drive fluid, known as a water alternating gas (WAG) scheme.

The key interpretation requirements for EOR planning, and hence objectives for the new survey were:

- To improve vertical resolution to enable mapping of thin beds within the reservoir section.
- To improve lateral resolution to facilitate mapping of flow barriers.
- To maximize the 'repeatability' of the baseline seismic data for confident 4D interpretation.

Acquisition and processing

The survey was acquired; between May and June 2001; by the Geco Topaz with the Western Pacific being used for the platform undershoot. The source for the survey was a single source (3 strings) air gun array towed at a depth of 6 m. The survey was conducted with 6 x 4.5km single sensor streamers towed at a depth of 7 m. The cell size was 6.25 m for the inlines by 25 m for the crosslines. This was re-binned in processing to 12.5 m x 12.5 m. The Health, Safety and Environmental performance was excellent with zero Lost Time Injuries (LTIs). The footprint and shooting direction of the 2001 acquisition were the same as for the 1992 survey.

Pre-survey modeling determined that a bandwidth increase of 40% over the heritage survey was needed to meet the requirements for increased resolution. VSP data confirmed that, with an appropriately designed survey, this level of bandwidth improvement should be achievable. Source and streamer depths were 6m and 7m respectively compared with 7m and 10m for the heritage data to push the ghost notches to higher frequencies to enable wider bandwidth recovery. The relatively shallow streamer tow depth could have potentially increased weather related downtime dramatically due to excessive streamer noise level, however, data adaptive beam forming (Ozbek, 2000) applied to the single sensor data gave an improved noise attenuation of around 4dB compared to linear array forming, and facilitated timely completion of the survey.

To avoid errors introduced by statistical deconvolution techniques, and to ensure that a repeatable source signature was achieved for every shot, a deterministic designature approach was employed. Far field signatures were synthesized on a shot by shot basis from near field hydrophone measurements (Lunde *et al*., 1995, Ziolkowski *et al*., 1982, Parkes *et al*., 1984).

A key requirement for repeatability of the seismic image is to minimize both positional uncertainty and positional variations between repeat surveys (Williams and Goodchild, 1998, Morice *et al*., 2000). Positional fidelity was optimized through use of a full streamer acoustic network, with GPS positioning at front end and tail-buoy. Survey wide full streamer average positional uncertainty is shown in the table below.

	95% error ellipse Semi-Major Axis (m)		
Offset (m)	**Minimum**	**Average**	**Maximum**
1125	2.1	2.9	3.5
2250	2.2	3.3	4.1
3375	1.9	2.7	3.3

In order to maximize the repeatability of the seismic coverage, streamer steering was employed to ensure constant streamer separation throughout the survey. Streamer steering was effected by modified depth controllers (Q-Fins), which, through independent control of each 'wing', could generate a lateral force sufficient to steer up to around 3° against natural feather.

To calibrate the survey 'repeatability', one boat line from the survey was over-shot to provide data from which a no-production baseline repeatability noise floor could be established. The vessel and streamers were steered to minimize differences in surface positions of sources and streamers. Streamer separation was maintained within 4 m of the nominal 50 m separation over the repeat lines. The two lines were processed to migration independently through the same processing sequence, including noise adaptive beam forming and deterministic designature. No cross-equalisation was performed since the objective of the experiment was to ascertain the underlying repeatability of the dataset.

Fig.1. (Below) Central frequency over reservoir zone.

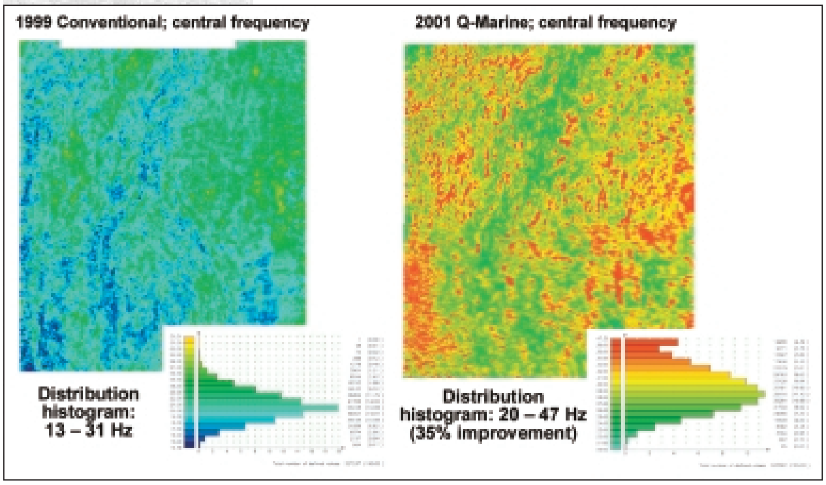
Fig. 2. (Middle) 3D migration comparison.

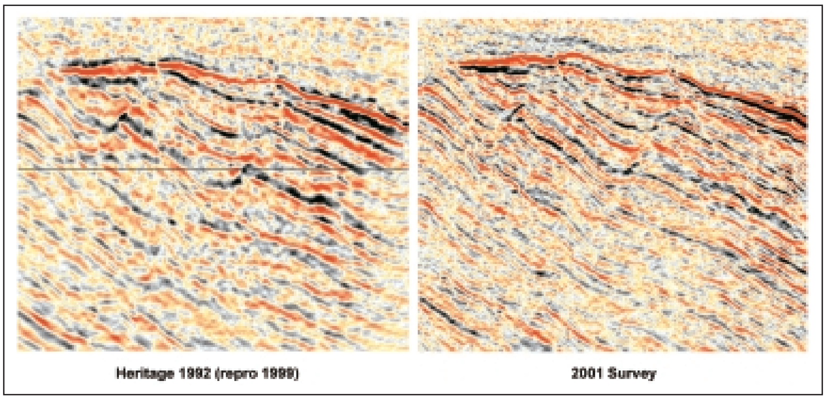
Fig. 3. (Bottom) Repeatability calibration; overshot profile.

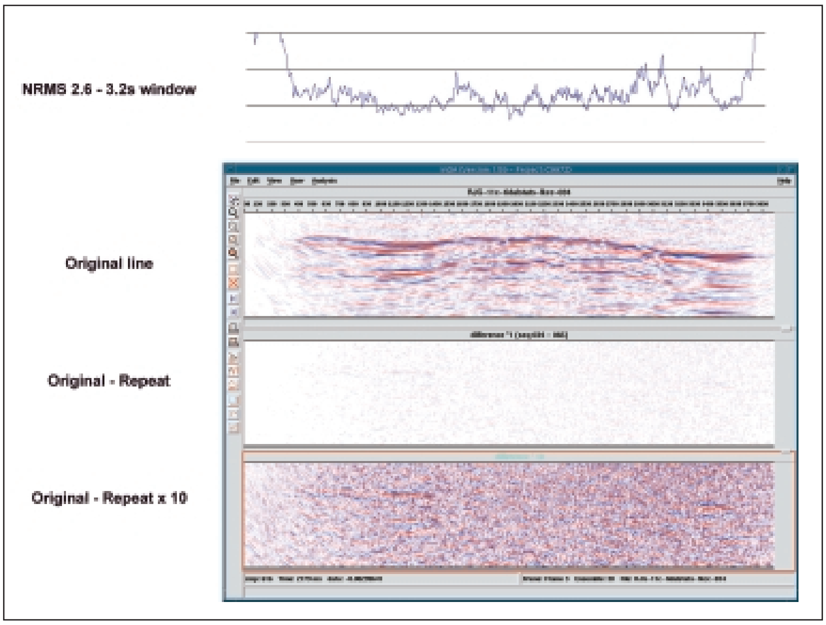
Results

The survey-wide increase in central frequency measured over the reservoir achieved in the new survey is illustrated in Figure 1. In addition to this improved bandwidth, excellent well ties were achieved without residual wavelet shaping, indicating good phase stability in the dataset. Figure 2 shows seismic cross sections over the field from the heritage and the Q survey, with clear improvements in resolution and fault delineation within the reservoir zone.

The results of the repeatability experiment are illustrated in Figure 3. The average NRMS difference of around 15% is more than a factor of two better than the expected values for towed streamer acquisition based on experience from previous analogous 4D datasets. The level of ' repeatability noise' is seen to be more than 20dB down on the signal strength; inline with the needs of reservoir monitoring which require in general a noise floor below 20db.







Conclusions

The objectives of the Q survey over the Magnus field were to improve temporal and lateral resolution, for a more reliable interpretation of fine scale features in the reservoir zone, and to provide a highly repeatable baseline dataset for future 4D work. Analysis from the final processed datasets indicates that both of these objectives have been largely met with the new Q survey.

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Acknowledgements

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Falcon™ Spreads Its Wings

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Introduction

An article appeared in Preview (Issue 86) in June 2000 which described Falcon™, BHP Billiton's airborne gravity gradiometer (AGG) system and the BHP Billiton funded project which led to the development and deployment of two systems known as Einstein and Newton. The technological achievement of BHP Billiton's Falcon™ team has already been recognised through several prestigious scientific awards including the CSIRO Medal for Research Achievement 2000, the ASEG's Graeme Sands Award 2001 and recently the Clunies Ross Science and Technology Award 2002.

Since the first survey by Einstein in October 1999 the two systems have flown in four continents over a variety of geological terranes, for a range of exploration targets. Falcon™ has demonstrated its ability to acquire high-resolution gravity data from the air in a highly productive and reliable mode. The data acquired to date have changed our way of thinking about the application of gravity as an exploration and mapping tool.

In April 2001 BHP Billiton approved the manufacture of two further systems, confirming its confidence in the technology. The first of these two new systems, Galileo, was completed and airborne tested in the US during the first half of 2002 and will be deployed in Australia and Asia from June 2002.

This article briefly summarises Falcon™'s performance and explains the rationale behind the BHP Billiton business model for deployment of the technology. In Australia this will be achieved predominantly through its alliance partner, Gravity Capital Limited (GCap).

The AGGs are mounted in Cessna Grand Caravans together with typical high-resolution aeromagnetic and optional radiometric systems. Also on board is a LASER scanner, which continuously measures the aircraft to ground distance, mapping the terrain with high precision. This combination of geophysical data has been shown to add considerably to our understanding of geology and also provide a powerful new way to identify and prioritise exploration targets.

Analogy of Falcon™, to a magnetic compass

Some technical specifications of the Lockheed Martin Gravity Gradiometers on which Falcon™ is based are in the public domain and have been described in a number of papers published by BHP Billiton and Lockheed Martin

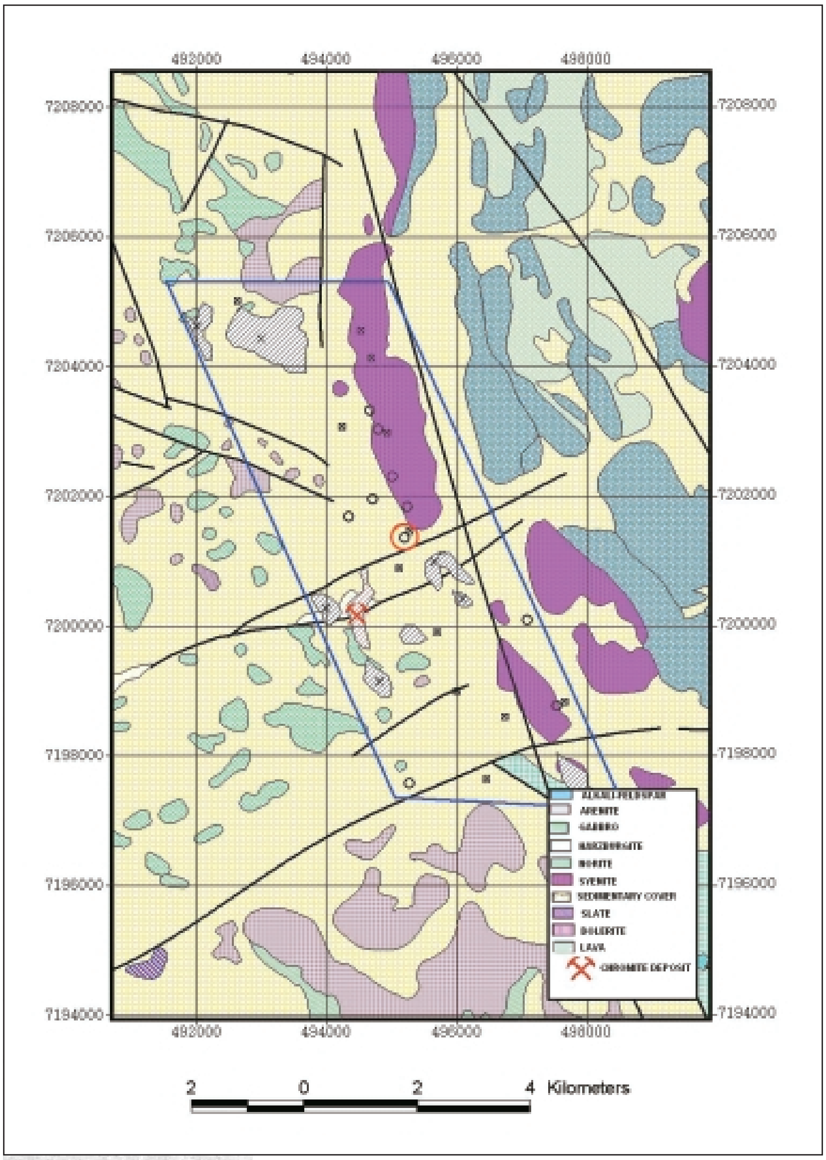

Fig. 1. Geological map of the Palmietfontein survey area. The location of the Palmietfontein pipe is indicated by the red circle and the survey boundary by the blue outline. The coordinates are UTM Zone 35S/WGS84.

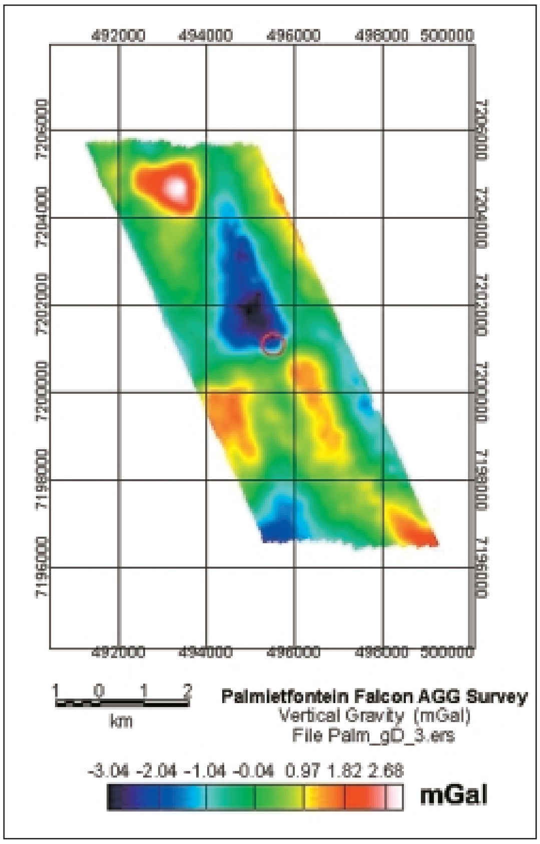

Fig. 2. Palmietfontein gD. The location of the pipe is indicated by the red circle and the coordinates are UTM Zone 35S/WGS84.

staff (for example Hofmeyer and Affleck 1994, Lee 2001, Talwani et al. 2001).

A useful analogy compares the Falcon™ AGG to a compass in the horizontal plane. As the compass moves past a magnetic body the compass needle will deflect in the direction of that body. The rate of deflection is related to the strength of the magnetic source.

The Falcon™ AGG can be considered as a mass-detecting equivalent of the compass, however, the gravity signal strengths associated with geological density contrasts are orders of magnitude weaker than magnetic signal strengths of geological magnetic susceptibility contrasts. This demonstrates the level of technical sophistication and precision required of this instrument. Sophisticated data processing is employed to distinguish the gravity gradient signals from the noise created by the motion of the system in the aircraft.

Review of the performance of the instruments

The Falcon™ Operations team within BHP Billiton has gained valuable experience around productivity and performance of the systems over the past 2 years for a wide range of operating conditions, survey specifications and ore deposit types.

The two Falcon™ systems have now completed over 280 000 line-km of production survey flying in Australia, USA, Canada, Mexico, Chile, Peru, South Africa, Zambia and Botswana. The main focus of the application of Falcon™ in mineral exploration has been diamondiferous kimberlites, which accounts for approximately 60% of production to date. Exploration surveys have also been flown for iron ore, iron oxide copper gold (IOCG) and various classes of base metal deposits.

In common with other airborne geophysical systems, productivity is variable and controlled by such factors as weather conditions, proximity of survey to operating base and payload of the aircraft. The load is increased when crystal packs are included for optional radiometric data acquisition. Under optimal conditions, with two flights per day, Falcon™ has acquired more than 10 000 line-km of data per week and on average approximately 2500 line-km per week.

A significant technical challenge in operating Falcon™ is the minimisation of ground clearance in order to maximise signal strength. In rugged terrain, a regional digital elevation model (DEM) is required to plan the line direction and drape surface for the survey. Due to the load of the AGG system in the aircraft, the drape flown will be higher than standard airborne magnetic surveys in rugged terrain and is ultimately controlled by safety considerations. The typical nominal clearance is 100-120m and careful survey design has allowed Falcon™ to operate in surprisingly

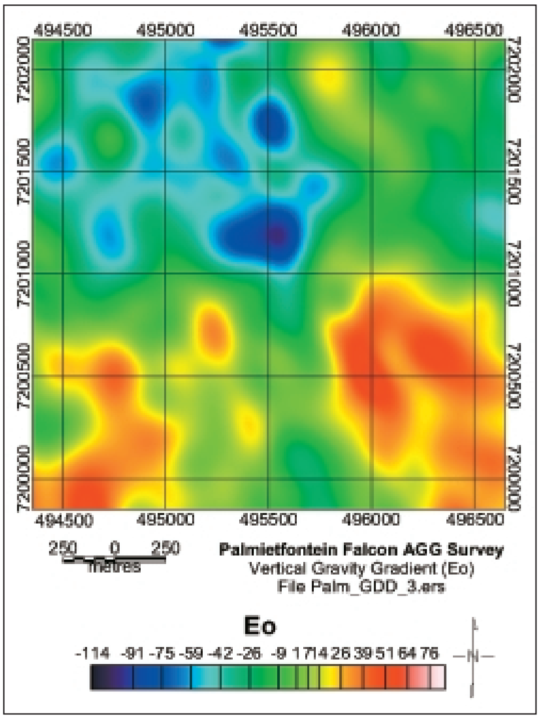

Fig. 3. A close-up of the Palmietfontein GDD anomaly. The location of the pipe is indicated by the red circle and the coordinates are UTM Zone 35S/WGS84.

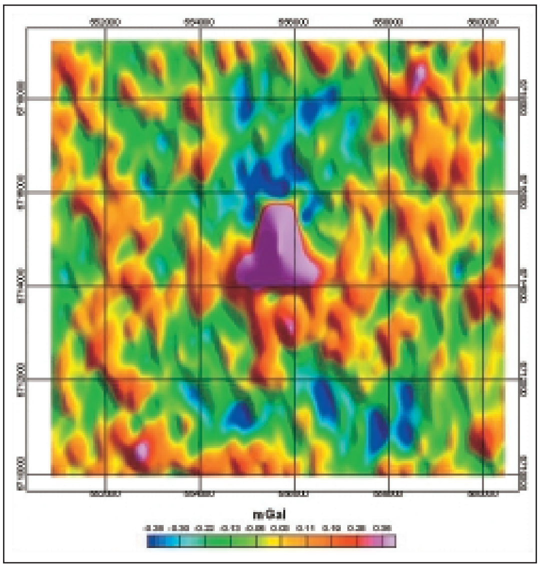

Fig. 4. IOCG Model gD. The data were calculated by modelling the curvature gradient components in Modelvision, adding synthetic Falcon™ noise and transforming to gD and GDD using BHP Billiton proprietary methods.

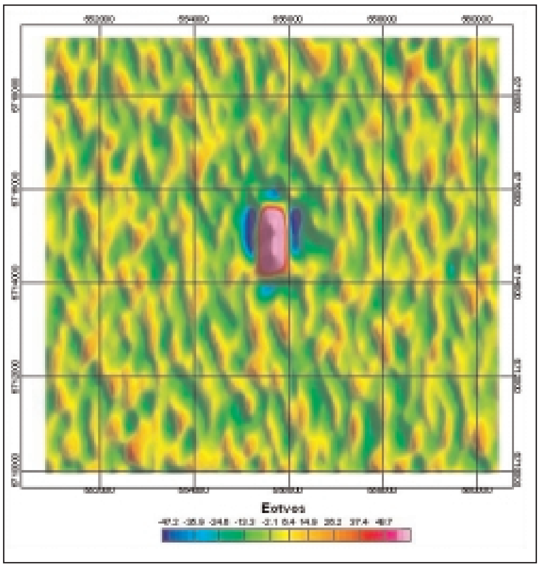

Fig. 5. IOCG Model GDD The data were calculated by modelling the curvature gradient components in Modelvision, adding synthetic Falcon™ noise and transforming to gD and GDD using BHP Billiton proprietary methods.

rugged terrain more effectively than would be possible with a ground based survey.

Within the last 12 months, the Falcon™ system performance has been tested and proven at altitudes between 3000 and 4000 m in the Chilean and Peruvian Andes. Technical challenges are currently being overcome to allow Falcon™ to operate in densely vegetated terrain.

Aside from ground clearance, the second most important impact on signal to noise ratio is turbulence experienced by the aircraft. In practice, the conditions in which Falcon™ is flown are closely monitored and controlled during acquisition. Surveying is discontinued if turbulence exceeds a specified threshold and this restriction rarely has a significant effect on productivity.

Palmietfontein Kimberlite – A new case study

The Palmietfontein survey was flown by Einstein after arrival in South Africa in April 2001 as a test case study.

The Palmietfontein pipe is located approximately 150 km northwest of Johannesburg on the western edge of the Pilanesberg Intrusive Complex (Figure 1). It intrudes rocks of the Bushveld Complex at its contact with the Pilanesberg syenites and lies under shallow cover. The dominant northwest fabric of the area is well mapped in both the vertical gravity (gD) and the vertical gravity gradient (GDD) shown in Figures 2 and 3 respectively.

The Palmietfontein pipe is expressed by a closed GDD anomaly of -50Eo and a possible gD anomaly. Many kimberlites have previously been detected with Falcon™ but prior to the Palmietfontein survey, all were located in the Northwest Territories, Canada.

IOCG Deposit modelling

The role of gravity in IOCG exploration has been highlighted by the recent Prominent Hill discovery in South Australia. A hypothetical IOCG body (with dimensions 1250 m x 500 m x 200 m) has been modelled to demonstrate the applicability of Falcon™. Other assumptions include, a depth of 50 m to top of the body, a density contrast with the host of 0.6 t/m3, a line spacing of 400 m and a flying height above ground of 100 m.

This model predicts anomalies at Falcon™ flying height of ~5µm/s2 (0.5 mGal) and 80 Eo both of which are clearly detectable above the 2µm/s2 (0.2mGal) and 5-8Eo noise levels observed in typical Falcon™ data. The data are presented in Figures 4 and 5.

The BHP Billiton Deployment Model for Falcon™

A variety of studies such as that by Ken Witherly (2000) have demonstrated that significant technical breakthroughs can lead to an in increase in the discovery rate of relevant ore deposits. This study in particular, In Australia:

- GCap identifies favourable areas to survey and forms JVs
- BHP Billiton provides FalconTM data over GCap areas and identifies targets
- GCap follows up targets
- BHP Billiton may buy GCap's equity on definition of a A$100M inferred value resource

Table 1. The BHP Billiton/GCap basic deal structure.

Witherly (2000), examined the impact that breakthroughs in electromagnetic technology have had on massive sulphide exploration. Significantly though, with a couple of notable exceptions, many of the developers of new technology fail to capture the material benefits through new discoveries.

BHP Billiton has a philosophy that has been developed to broaden its range of mineral exploration options by accessing a larger diversity of ideas and applications. One example is the recent agreement between BHP Billiton and GCap described in more detail below.

The Gravity Capital BHP Billiton Agreement

On 13 December 2001, BHP Billiton and Grenfell Resources Limited signed an alliance agreement that gave Grenfell access to FalconTM data obtained from surveys flown by BHP Billiton over mineral properties in Australia in which Grenfell has negotiated an interest. As a term of the agreement, BHP Billiton retains the right to buy the Grenfell share of any new discovery made. Grenfell's rights under this agreement have since been assigned to GCap.

The basic deal structure is shown in Table 1.

The performance of the Falcon™ airborne gravity gradiometer technology has exceeded expectations. Its success has led BHP Billiton to approve the manufacture of two new systems to both improve the global spread of Falcon™ and to continue to develop the technology to broaden it's application. In parallel, BHP Billiton continues to evolve the business model for Falcon™. The recent agreement with GCap provides BHP Billiton with a unique opportunity to market its technology while gaining access to survey data over a large area of mineral properties.

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ASEG Foundation: project results

The ASEG Research Foundation has been supporting students for studies in all facets of Applied Geophysics at the BSc (Honours), MSc, and PhD (or equivalent) levels for 12 years. Members may not be fully aware of the research outputs from these projects, so we will be giving some of the results in this and subsequent Previews. In this issue we give results from students at The Universities of Adelaide and Sydney, and the Australian National University

Fig. 1. Geophysical surveying over the sands of Muweilah, UAE

Ryz Evangelista: High-resolution Geophysical Investigations at the Muweilah Archaeological Site, United Arab Emirates (UAE).

Host Institution:	University of Sydney
Supervisors:	Iain Mason and Peter Magee (Bryn Mawr College, USA)
Industry Mentor:	Eric Wedepohl, Subsurface Imaging
Contact:	ryzzo_e@hotmail.com

Project Summary

Ground-penetrating radar (GPR) was used to characterise an Iron Age II (1100-600 BC) archaeological site in the United Arab Emirates (UAE). The settlement at Muweilah is the only Iron Age Arabian site so far discovered; it consists of complex interlocking mud-brick (pisé), and stone and mud-brick walls (one of which encloses the whole settlement). Structures with several rooms, for domestic and political purposes have also been recognised.

GPR was used, along with magnetics, electromagnetics and radiometrics, to facilitate the imaging of this complex site by surveying three unknown areas with varying thicknesses of sand overburden. One area was completely ground-truthed after the surveys, the second area was surveyed to benchmark previous magnetic gradiometry surveys, and the third area was chosen as this was where previous gradiometry could not penetrate the sand overburden.

Archaeological features were identified to a depth of several metres including planar features such as floors, linear features such as walls, and isolated hyperbolae representing archaeological activity, corner reflectors or other point scatterers. Surveying conditions were favourable with sand cover allowing good radar penetration and strong reflections from targets. The feature of this project is the use of 3D GPR migration slices at 10 cm vertical spacings, in a manner, which mirrors the excavation methodology employed by archaeologists.

Although much of the interpretations are still subject to ground-truthing, limited excavations have been extremely encouraging. GPR is capable of imaging the complex elements at Muweilah and its use will aid the ongoing excavations by indicating areas of inferred cultural or geological activity, thus avoiding costly and unnecessary excavations and also helping with the conservation of the site.

The project was supported by Roger Henderson, formerly of Geo Instruments.

Chris Leslie: Using shallow seismic techniques to determine structure in the regolith.

Host Institutions:	Australian National University and Geoscience Australia
Supervisor:	Eva Papp and Tony Eggleton
Mentors:	Leonie Jones, Geoscience Australia

Project Summary

Seismic methods were used to determine structure and depths in the regolith near West Wyalong, NSW. The area is known for gold-bearing "deep leads" and thus geological interpretations were to assist in further studies to determine possible mineralisation migration paths resulting from ground-water movement.

Two paleochannels were chosen as targets for the project but at that time only the spatial definition of the paleochannels was apparent from aerial magnetic images. Two reflection seismic survey lines, using a Minivibe seismic truck, were subsequently shot orthogonal to the flow direction of the paleochannels. The expectations were that the surveys would provide structural detail on the channel profiles and possibly other regolith structure.

As the paleochannel depths were unknown but possibly shallow, the seismic acquisition parameters were designed to enhance shallow features. Shot spacing was as tight as 1 m and vibroseis frequencies were as high as 500 Hz. Notorious with such shallow seismic work is interference of useful reflection and refraction data by coherent noise such as ground roll. Filtering out dominant noise frequencies, followed by spectrum equalisation and J/K filtering, proved to be effective in enhancing useful data in the shot records. Reflection events in the 50 to 100 m depth range consequently became more apparent.

Refraction first-break picks from the shot records, and values calculated during reflection static processing, were used to determine very shallow layers. Beneath one of the lines the refraction layer shape suggests an apparent typical paleochannel profile with cut-bank asymmetry at about 2 to 9 m deep and about 200 m wide. Drill chips from shallow holes drilled over that line contained a significant amount of maghemite-rich nodules at corresponding depths. The drill chip constraints provide further evidence that the refraction layer represents a paleochannel on the assumption that the nodules provided a refractive density contrast.

The reflection seismic sections over both lines indicate deeper paleosurfaces at 50 to 200 m depth and constrained by borehole data as the interface between unconsolidated material and underlying solid sandstone. The interpretation is of a profile of an ancient and eroded landscape that has since been filled with transported material. The apparent dip directions may help in determining local ground-water movement.

The project demonstrated that reflection seismic methods were useful in assisting to determine structure in the regolith. The refraction component of the data, inherent in the shot records, enabled interpretation of very shallow structures, while the processed seismic sections enabled deeper structural interpretations.

A pertinent outcome of the project in terms of shallow seismic methods was that resolution was critically dependent on appropriate acquisition parameters such as geophone spacing, vibroseis energy and output frequencies.

Chris Leslie, Email: chris_leslie@telstra.com

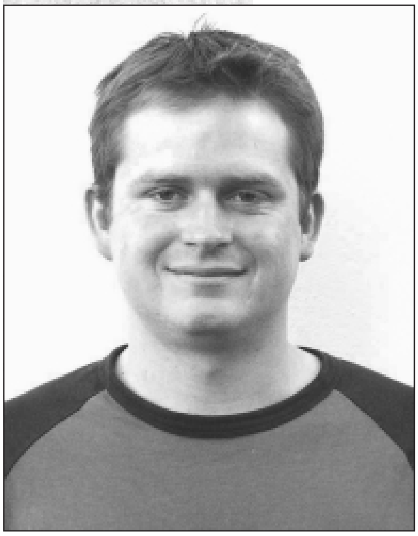
Peter van Ruth: Overpressure in Australian Basins (Cooper and Carnarvon Basins)

Host Institution: National Centre for Petroleum Geology and Geophysics, University of Adelaide.
Supervisor: Richard Hillis
Contact: pvanruth@ncpgg.adelaide.edu.au

Project Summary

Knowledge of abnormal fluid pressure (overpressure) is an important aspect of petroleum exploration with respect to drilling hazard, and as a potential control on open natural fractures and fluid flow. Fluid pressure is balanced while drilling by varying drilling mud weight. It is important to use a mud weight in the 'window' between pore pressure and fracture pressure to prevent blowouts (during underbalanced drilling), and prevent mud loss and formation damage (during overbalanced drilling). In overpressured formations, the 'window' is narrow and knowledge of the pore pressure is vital for safe and efficient drilling. The project focuses on overpressure in two Australian basins: the Cooper and Carnarvon Basins. The former is an 'older' onshore basin and the latter a 'younger' offshore basin. Overpressure has been encountered in both basins and is a hazard for ongoing petroleum exploration and development. The aims of this project are to:

Peter van Ruth



- Provide an improved model of the distribution of overpressure within permeable sediments (e.g. sandstones) using direct pressure measurements and mud weights;
- Quantify wireline log and physical characteristics of the overpressured sediments;
- Identify the origin of overpressure in each basin, and;
- Provide a basis from which overpressure can be detected prior to drilling using seismic velocity data.

Direct pore pressure measurements and mud weight data have identified overpressure in the Nappamerri Trough region of the Cooper Basin, and extensive overpressured strata in the Carnarvon Basin.

A wireline log analysis of the Cooper and Carnarvon Basins has focussed on empirically determining pore pressure in low permeability lithologies (e.g. shales) using the Eaton and equivalent depth methods. There is a complex acoustic velocity-depth relationship in the Cooper Basin that cannot be simply explained by variations in pore pressure and compaction. A detailed sonic log analysis incorporating uplift and other wireline logs was needed to gain pore pressure estimates that accurately reflect direct pressure measurements and mud weights. There is a 30–45 μs/m sonic anomaly associated with the overpressured seiments that may be detectable using seismic velocity data.

In the Carnarvon Basin pore pressure estimates in thin shale sequences, derived from sonic logs, accurately reflect direct pressure measurements in adjacent sandstones. However, log-derived pore pressure estimates were far in excess of mud weights in thick shale sequences. It is unclear whether the sonic log-derived pressure estimates in these thick shale sequences accurately reflect pore pressure (i.e. the formations were drilled underbalanced) or whether the sonic anomaly is unrelated to pore pressure. The variation in sonic anomaly associated with the overpressured sediments would need to be considered in the pre-drill seismic detection of overpressure in the Carnarvon Basin.

The origin of overpressure in the Cooper Basin and Carnarvon Basin has been investigated using a combination of wireline log analysis and basin history analysis. Wireline log analysis involves comparing the physical properties, especially porosity, of the normally pressured and overpressured sediments (e.g. porosity-effective stress analysis). Additionally, the burial, thermal and tectonic histories of each basin have been studied to identify the timing and mechanism of overpressure generation. The Cooper Basin has not been subjected to significant sedimentation since the Late Cretaceous (90 Ma), and reached maximum paleotemperature before 75 Ma. Hence, the origin of overpressure in the Cooper Basin is not easily explained by the commonly cited burial or temperature driven processes, and is most likely related to an increase in horizontal stress acting since the Late Cretaceous. The origin of overpressure in the Carnarvon Basin is predominantly disequilibrium compaction related to Tertiary burial, with minor contributions from hydrocarbon generation and lateral transfer.

Predictive Mineral Discovery Cooperative Research Centre

*Overview of the pmd*CRC .(pmdcrc.com.au)*

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Australia's CRC Program

The Cooperative Research Centres (CRC) Program established in May 1990 seeks to bring together researchers and research groups from universities, government research laboratories, and the private sector, into long-term cooperative relationships. The active involvement of industry in the CRCs is a crucial aspect of the CRC Program and ensures that the long-term research conducted will have strategic relevance and that research outputs are used to produce outcomes of benefit to Australia.
The Predictive Mineral Discovery CRC

The *pmd**CRC was one of only 7 new centres granted funding in the latest round. It formally commenced operation in July 2001 and was conceived by industry in partnership with the research community to focus geological research on issues that are of critical importance to ore discovery. There is considerable supporting data to demonstrate that over the past decade discovery of large high value deposits has dramatically declined in spite of the record levels of exploration expenditure over the same period.

The purpose of the *pmd**CRC is to focus on research that will contribute towards a major shift in exploration practice and will therefore provide the means to target ore deposits faster and at lower costs than achieved through current practice. Two important points will contribute to the ability of this CRC to make a measurable impact. Firstly, to be predictive, we need to be far better than we are today at understanding the critical controls on ore formation in the context of the entire mineralising system. Secondly, in order to exploit a superior understanding of ore formation processes we must have a four dimensional view of the geology of a target area – an accurate reconstruction of the nature and timing of events which made the geology that we see at the surface, a three dimensional picture of what that geology now looks like at depth and of what the geology looked like at the time of ore formation. Through this combined understanding of the architecture of mineralised systems and the processes that formed them, informed and efficient use of the increasing variety and quality of exploration data and technologies can be used to develop new targeting tools that must ultimately gain wide industry acceptance.

Of great importance is the requirement to be relevant to the industry at all scales of operation and therefore research in this Centre aims to answer questions:

1. Why are some geological provinces well mineralised and what are the predictive signatures we can draw from the terrane and apply to terrane selection elsewhere?
2. Within particular provinces, how do we target mineralised systems or belts that have potential to contain "giant ore deposits"?
3. Having identified a mineralised system, how do we predict that an anomalous or altered zone contains a deposit and what are the predictive tools for targeting?
4. Within ore environments or deposits, what are the controls on high-grade ore shoots and how do we predict them?

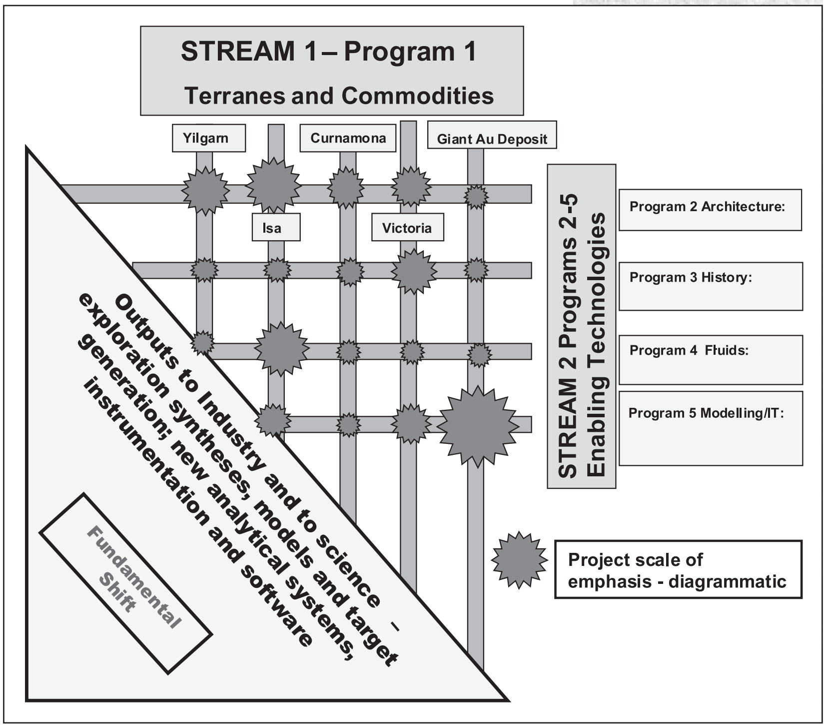
Perhaps, most importantly, we must convert this understanding into insightful judgements with minimal data for use by explorers who are so commonly faced with small parts of the puzzle, yet expected to make decisions that carry high price tags.

Current Research Program Design

This CRC will develop a true *systems approach* to exploration utilising quantitative computational modelling as the platform for data synthesis, analysis and improvement in ore system and target prediction. This approach is designed to complement and extend the capabilities of the empirical approach to prospectivity analysis.

The research programs are structured into two streams that are designed to enhance integration and linkage amongst the research programs.

The Projects in **Stream 1** are concerned with specific geographic terranes or research issues that are of priority to the mineral exploration community or that have been selected as data-rich "laboratories". The current terranes are the Yilgarn, Curnamona, Isa Inlier and Western Lachlan in Victoria. The Projects in **Stream 2** are of an "enabling technologies" nature in that they are concerned with developing and applying technologies and concepts to answer the problems identified in the Stream 1 Projects. The integration of Programs is depicted in the figure below.



Applications within specific regions and commodities will drive advances in modelling, visualisation and communications and will provide the building blocks for quantitative modelling. The wide resource base and funding arrangements in the centre will provide a unique opportunity to develop a series of fully integrated projects incorporating 3D geology, fluid studies, innovative geochronology and computational modelling to solve key mineral exploration issues and lead to practical exploration tools that focus on improving targeting techniques for superior deposits.

Core Participants

Eight collaborative research partners form the Core Participants of the *pmd**CRC and comprise Geoscience Australia, Canberra; the Universities of Melbourne, and Monash, in the Victorian Institute for Earth & Planetary Sciences, Melbourne; the Centre for Global Metallogeny, University of Western Australia, Perth; Economic Geology Research Unit, James Cook University, Townsville; CSIRO, Exploration and Mining, Perth & Sydney and AMIRA International, Melbourne.

Supporting Participants and Sponsors of the CRC

A broad group of industry participants and government organisations are also supporting the pmd*CRC.

Barrick Gold
AngloGold Ltd
Mount Isa Mines
Placer Dome Asia Pacific
BHP-Billiton
Mining Project Investors Pty Ltd
WMC Rsources Limited
Rio Tinto
Sons of Gwalia
Fractal Graphics Pty Ltd
Geological Survey of Victoria
Geological Survey of Western Australia
Queensland Department of Natural Resources and Mines
NSW Department of Mineral Resources
Western Australian State Dept of Commerce & Trade.
Minerals Council of Australia.
SUN Microsystems Australia Pty Ltd.

Mineral Exploration levels now lowest since 1978/79, Petroleum also falls

Minerals

Figures released in June 2002 by the Australian Bureau of Statistics showed a continuation of the steady downward trend evident over the last few years.

The trend estimate for total mineral exploration expenditure decreased in the March quarter of 2002 by 2% from the previous quarter and was 9% lower than the trend estimate of $172m for the March quarter 2001.

The actual money spent amounted to only $130m, and you have to go back to 1978/79 before encountering levels as low as this. Figure 1 shows the raw numbers compiled by the ABS. It is not a pretty sight.

The actual expenditure reported for the March quarter 2002 decreased by a massive 24% ($41m) to $130m. This is 10% lower than the March quarter 2001 and was mainly due to a 23% ($31m) decrease in expenditure reported on 'all other' or 'green field' areas. The majority of the decrease on 'all other areas' occurred in Western Australia, down 26% ($22m) and Queensland, down 28% ($5m).

Overall, Western Australia was the main contributor to the March quarter 2002 decrease, down $26m, followed by Queensland down $8m, and the Northern Territory down $6m.

However, the total Western Australian expenditure of $78m is still more than half of the $130m total.

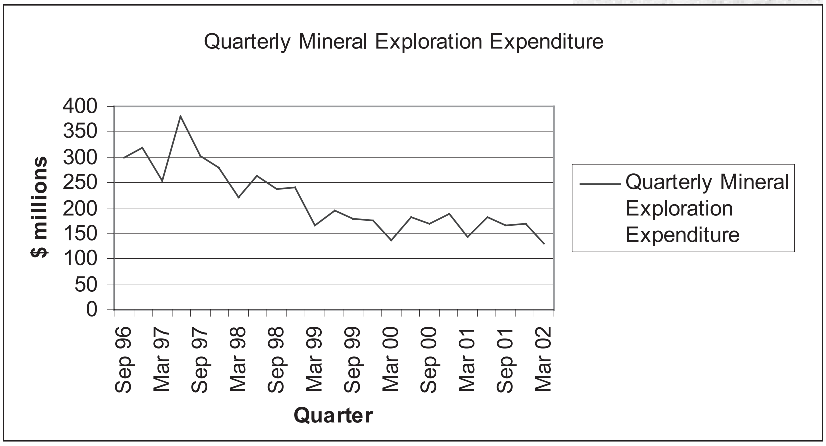
Between the December and March quarters, exploration expenditure for gold decreased by $10m (12%), nickel and cobalt by $7m (41%) and diamonds by $5m (47%). The majority of the decrease for gold, nickel, cobalt and diamonds occurred in Western Australia. Exploration expenditure for selected base metals (copper, silver, lead-zinc, nickel and cobalt) also decreased, by 32% ($12m) to $25m.

The trend estimate for metres drilled fell slightly (0.2%, or 3 km) between the December quarter 2001 and the March quarter 2002. The March quarter 2002 figure of 1300 km was 14% lower than the March quarter 2001, with the main fall being in the 'green field' areas - not a good sign.

Petroleum

Reported expenditure on petroleum exploration in the March quarter 2002 was $202m, 25% ($66m) lower than the December quarter 2001, and 34% ($102m) lower than the March quarter 2001.

The decrease occurred as a result of a 38% ($58m) drop in offshore drilling expenditure. Between December quarter 2001 and March quarter 2002, expenditure for petroleum exploration on 'all other areas' decreased by 26% ($65m), and exploration on 'production leases' decreased by 6% ($1m).



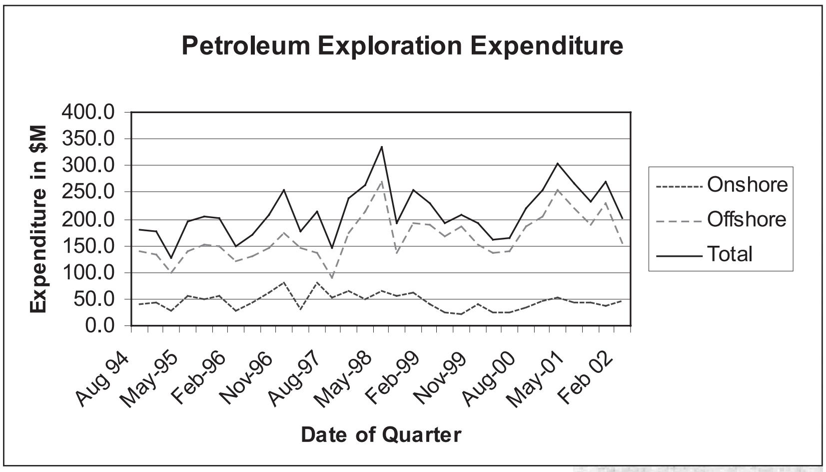


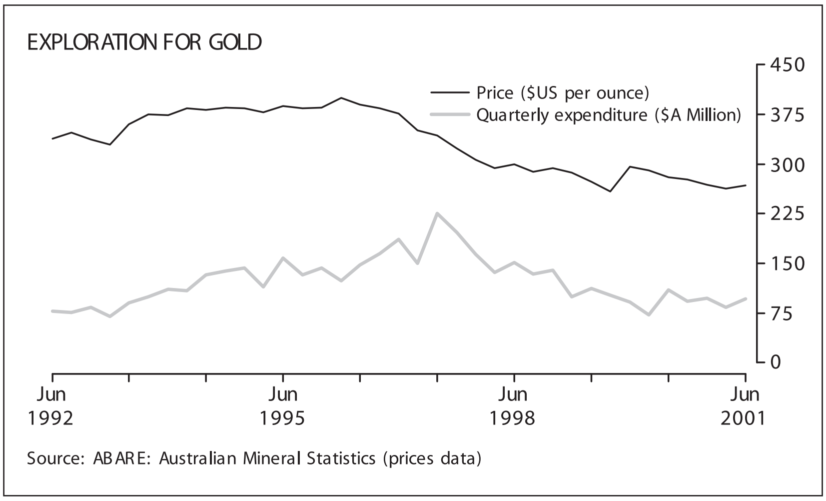
Fig. 1. (Top) Quarterly mineral exploration expenditure from 1996 to 2002 (compiled from ABS publications).

Fig. 2. (Above) Petroleum exploration expenditure from 1994-2002, from ABS statistics (not corrected for inflation).

Regional data for petroleum exploration expenditure are available for Victoria, Queensland, Western Australia, the Northern Territory/Ashmore and Cartier Islands and the Joint Petroleum Development Area formerly known as the Zone of Cooperation Area A. These regions, when combined, contributed 96% to total exploration expenditure in the March quarter 2002.

Of the published regions, Western Australia was the main contributor, with a reported $120m expenditure on exploration, a decrease of 16% ($22m) from the December quarter 2001. Northern Territory/Ashmore and Cartier Islands reported a fall in exploration expenditure of 49% ($38m) to $39m.

Figure 2 shows the Petroleum expenditure over an eight-year period. It is clear that the long-term trends indicate a slight increase in dollars invested, but when inflation is taken into account the increases are quite small.



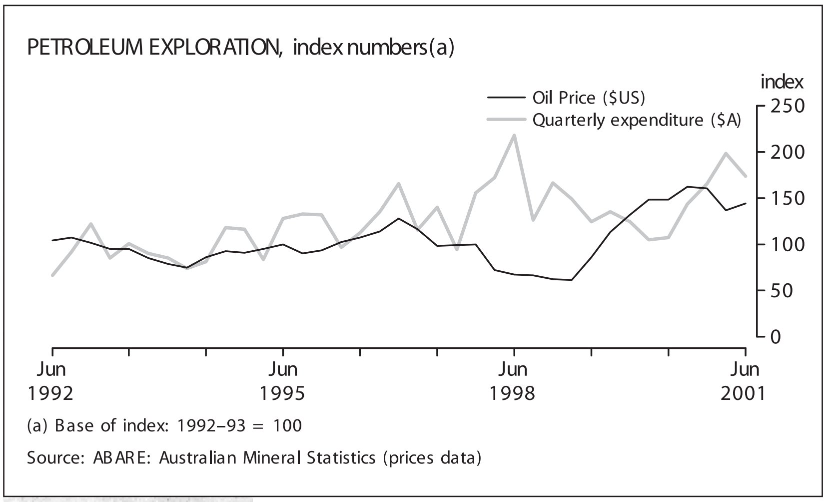


Fig. 3. (Top) Relationship between the gold price and gold exploration expenditure.

Fig.4. (Above) Relationship between the oil price and petroleum exploration expenditure.

Decade of Australian Exploration Expenditure: 1991/2 to 2000/01

The ABS also included an interesting albeit simplistic analysis of Australian Exploration spending over the last ten years, and tried to make sense of the longer-term trends. I will not describe the results of this analysis, but two graphs relating commodity price to exploration expenditure are of interest. These are for gold and petroleum, and are shown below.

The gold expenditure is clearly related to the price of gold, with a lag of a few months, but the petroleum expenditure exhibits no such simple pattern. An interesting commentary, but how these results can be used to plan future activity is not clear.

Big increase in Mining Industry R&D expenditure during 2000-2001

The latest figures from the Australian Bureau of Statistics show that, after four years of decline, business expenditure on R&D has increased by 18% to the highest expenditure levels ever recorded. BERD as a percentage of Australia's Gross Domestic Product (GDP) increased to 0.72% in 2000/01, still significantly lower than the high of 0.87% in 1995/96. However Australia's BERD/GDP ratio is still relatively low when compared with other OECD countries. For example in Canada, the ratio is 1.10% and in France it is 1.37% and in Finland it is a huge 2.35%.

All the major industry sectors recorded an increase in R&D expenditure in 2000/01, with the mining industry recording a 57% increase in expenditure to $456m, reversing the falls of the preceding three years. This was in spite of the number of businesses reporting falling from 100 in the previous year to 89.

A big surprise is the huge increase in person years allocated to research. These increased from 749 to 1169 between from1999/2000 to 2000/2001. Given the state of the exploration industry it would be of interest to know how these numbers were compiled, and what part of the industry is expanding so rapidly.

Full details are in Research and Experimental Development, Businesses, Australia, ABS., (Cat. No. 8104.0).