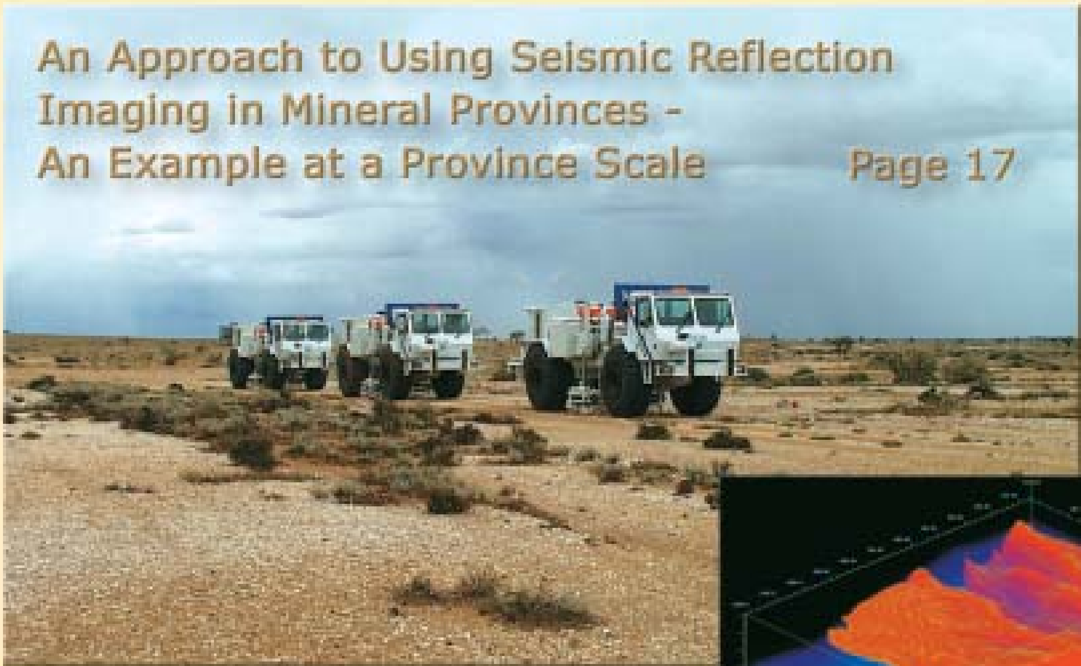
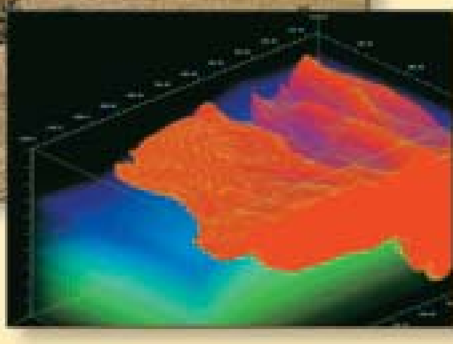
Preview

Australian Society of Exploration Geophysicists

ABN 71 000 876 040 ISSN 1443-2471 October 2000 Issue No.88

Seismic Focus Part 3





Contents

Advertiser's Index

2000 Corporate Plus Members

MIM Exploration Pty Ltd
Velseis Pty Ltd

2000 Corporate Members

Anglo America Technical Services - AATS
Ashton Mining WA Pty Ltd
BHP Minerals Discovery Group
Chevron Australia Pty Ltd
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Silicon Graphics International
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Veritas DGC
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Woodside Energy Ltd
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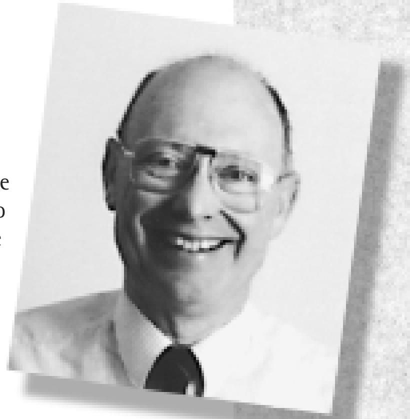

This issue of Preview was assembled in the glare of *Sydney 2000*, and I would like to thank all those contributors who produced their outputs in-spite of the distractions of the Olympics. As one who sampled the atmosphere of athletics in Stadium Australia, I have nothing but admiration for the Sydney organising committee, and you can see what it did to the President's Piece.

While all this was proceeding, Robin Batterham the government's Chief Scientist was touring the country selling his report 'The Chance to Change' and the report of the Innovation Summit Implementation Group; *'Innovation - Unlocking the future'*. My reading of the situation is that Dr Batterham believes that, if he can get significant groundswell support across the country, then he has an excellent chance of persuading the government that it should significantly increase its investment in science, engineering and technology. He hopes to have a submission on both reports before Cabinet in late October, with an innovation action plan to be announced at the Prime Minister's Science, Engineering and Innovation Council, scheduled for early November this year.

Eristicus has more to say on this important issue in this edition of Preview.

Interestingly, I am led to believe there is a view in Treasury that the declining A$ against the US$ is largely due to our poor IT investment strategies and that something has to be done to fix this otherwise we really will go down the tube. So we may get some action in this sector.

The Euro is in a similar pickle because of its dependence on manufacturing industries. We live in a very strange world at the moment. When I left UK in 1964 it manufactured cars, aeroplanes, motorcycles, ships, sewing machines and any number of useful products, but the pound was weak and the country was essentially bankrupt. Now the UK doesn't seem to make anything very much, but the pound is strong and the country (at least in the south east) is very wealthy – what a paradox.

Now back to this edition of Preview. It contains the last of the 'Geophysics in the Surveys' articles with AGSO's contribution and also the third and final article from Veritas, this time on seismic interpretation. We also have a Geoff Pettifer special on the groundwater of Bundaberg, so there are some very interesting articles.

In the next issue we plan to have several contributions on borehole geophysics and a Brian Minty challenge on how we should be processing our γ-ray data.

Until then, happy reading.

David Denham

Citius, altius, fortius

Unless you have been ensconced in a far-away field location for the last year or so, you are probably aware that Australia is currently in the throes of Olympic fever. Emotions are running high, with the search for gold, silver and bronze reminiscent of the heady days of the gold rush in the 1850's in many parts of Australia. As in the days of the gold rush and other commodity booms, media attention and venture capital are focused on the riches to be made, as Olympics fever dominates our daily lives.

'Citius, altius, fortius' is a Latin phrase meaning 'swifter, higher, stronger', and is the official motto of the Olympic Games. The words were borrowed by Games founder, the French aristocrat Baron de Coubertin, from Father Henri Martin Dideon of Paris, soon after the first modern Games in Athens in 1896. Dideon was headmaster of Arcueil College, and used the phrase to describe the athletic achievements of students at the school. He had previously been at the Albert Le Grand school, where the Latin words were carved in stone above the main entrance.

How does this relate to geophysics? It seems to me that the themes 'swifter, higher, stronger' are geophysical in nature. 'Swifter' applies to our geophysical surveys, our computing power, and the speed of change of geophysical technologies and of our industry. 'Higher' applies to the need for continued education and training, and the requirements put on us in an increasingly global and competitive marketplace. 'Stronger' is what our profession and Society must become to fulfill the potential of contributing to the welfare and wealth of our nation.

One might also take note of the Olympic Creed, "The most important thing in the Olympic Games is not to win but to take part, just as the most important thing in life is not the triumph, but the struggle. The essential thing is not to have conquered, but to have fought well." There have been many permutations of this basic message throughout Games history, though this is the current creed, which appeared on the scoreboard during the Opening Ceremony in Sydney on September 15th.

There are many reminders of the 'struggle' presented by the geosciences - exploration itself is a constant search for the truth, in terms of earth structure and composition, through remote sensing of physical fields. Yet it is this very struggle that excites the intellectual passion and enthusiasm that drives our profession.

The ultimate triumph is the discovery, the successful drill hole, targeted on geophysical interpretation, intuition and know-how. However, just as few athletes are destined to win medals, few geophysicists are destined to discover a new oil field or orebody. Exploration is a high-risk venture, and most geophysicists are part of large integrated teams working for companies with long-term goals and strategies. Just being part of the game, contributing one's geophysical knowledge and skills to the best of one's ability to achieve a 'personal best', is a reward in itself.

Your society, the ASEG, assists in many ways to bridge the gap between struggle and triumph. Through its journals and conferences, networks and outreach programs, the

ASEG plays a key role in our profession. The ASEG Executive has decided to keep membership dues unchanged for the coming year, and will investigate mechanisms for further expanding services to members. Please pass any comments or ideas you may have on to your State Branch or any members of the Federal Executive.

Brian Spies
President

I would like to remind all members of the immediate deadline in submitting an Expression of Interest to give a presentation and/or poster at the Brisbane Conference in August next year. An expression of interest simply involves a working title, and guidelines for the submission are detailed elsewhere in this Preview.

Membership Renewals for 2001 are now in the post and to save extra administration costs I strongly encourage members to promptly pay their dues. As detailed in the President's Piece, the Executive is very mindful in not having a fee increase in 2001. Members will be pleased to learn that over the past 12 months both Preview and Exploration Geophysics are now delivered 'on-time' and the Executive feels that these publications give a refreshing and professional value-for-money.

To help gauge the current needs and future requirements of members, the Executive, with the assistance of the State Branches, will distribute a questionnaire, which is currently planned to arrive with your Renewal Notice. For the improvement of the Society, I encourage all members to spend five minutes in completing this form.

As part of the total revenue to the ASEG, the Executive has been discussing with RESolutions, our publisher, on a better marketing strategy for the ASEG. The Executive has also discussed with the Publications Committee the possibility of having a Buyers Guide that would be modelled on the North American Geophysical Directory. Initially it may form part of the 2001 Membership Directory.

Recently, the Executive formed a sub-committee to review our 40-page constitution. There has not been a major review of the constitution since our inception in 1970 and it requires amendment to better reflect how the society now operates. As part of this review, the committee is reviewing other society constitutions (AusIMM, SEG, EAGE, Royal Society, CPA) to initiate deliberations and produce a modern and more workable constitution. Recommendations by the committee are expected to be formalised for approval at the 2001 ASEG AGM.

The ASEG booth at the 70th SEG Conference in Calgary, Canada was a real success. With nearly 8000 delegates, there was a lot of interest in Australia and the ASEG. In particular, many new exhibitors and SEG members expressed strong interest in attending the Brisbane Conference. Besides seeking new members, new advertisers and new corporate members, I made a point of thanking many of the larger North American based contractors who routinely are major sponsors at our ASEG conferences and support many of our publications. Liaison with other geophysical societies and expanding our membership outside Australia will be so important for the future growth of our society. At the Global Affairs Committee meeting and special luncheon, I promoted the ASEG and with assistance by Andrea Rutley, all delegates were formally invited to the Brisbane Conference. The Calgary Conference gave Brian Spies and myself an opportunity to further our liaison with SEG Japan and the Korean SEG. Also our colleagues in Indonesia (HAGI) and New Zealand (NZGS) wish to expand links with the ASEG and plan to at least advertise each other's major events. We also have the promise that Sally Zinke, the recently appointed SEG President, plans to attend the Brisbane Conference and to be our guest at the ASEG Council Meeting.

From the recent SEG Conference and from discussions at several of the SEG committee meetings, it will become increasing important for the ASEG to look global but at the same time keep its relevance to our ever-changing profession.

David Robson
Secretary

Print Post Approved – PP3272687 / 0052.

Preview is published six times per year by the Australian Society of Exploration Geophysicists and is provided free to all members and subscribers of the ASEG, which is a non-profit company formed to promote the science of exploration geophysics in Australia. This publication remains the legal property of the copyright owner (ASEG).

Contents

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Material published in *Preview* aims to contain new topical advances in geophysical techniques, easy-to-read reviews of interest to our members, opinions of members, and matters of general interest to our membership.

All contributions should be submitted to the Editor via email at pdenham@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 $400 per page 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.

Deadlines for contributions to Preview for 2000/2001

Preview is published bi-monthly, February, April, June, August, October and December. The deadlines for submission of all material to the Editor is as follows:

Preview Issue	Text & articles	Advertisements
89 Dec 2000	15 Nov 2000	22 Nov 2000
90 Feb 2001	15 Jan 2001	22 Jan 2001
91 Apr 2001	15 Mar 2001	22 Mar 2001
92 Jun 2001	15 May 2001	22 May 2001
93 Aug 2001*	**29 Jun 2001**	**13 Jul 2001**
*** (Conf Edition)**		
94 Oct 2001	15 Sept 2001	22 Sept 2001

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 the issue date. Therefore, the advertising copy deadline for the December 2000 edition is the 22nd of November.

What's Next in Exploration Geophysics

The next issue of Exploration Geophysics (Volume 31 (4)) is scheduled for publication in December 2000. The papers listed are likely to be included in this Volume.

Advertising in Exploration Geophysics is welcome. Please contact RESolutions Resource & Energy Services for more details.

Tel: (08) 9446 3039
Email: paul@oilfield.com.au

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- A sequence stratigraphic analysis of the Late Permian succession in the Dural area, central Sydney Basin, New South Wales — P. A. Arditto
- The cause and effects of multilayer-generated guided waves — D. M. Leslie & B. Evans
- Transmission Seismic Imaging of the Subsurface Using Simulated Evolution Techniques — S. K. Nath & S. Chakraborty
- Acoustic Structure and Seismic Velocities in the Carnarvon Basin, Australian North West Shelf: towards an integrated study — T. Fomin, A. Goncharov, P. Symonds & C. Collins
- A later arrival- based inversion scheme to recover diffractors and reflectors — T. Gruber & S. Greenhalgh

Airborne Geophysics

- Quality control of gridded aeromagnetic data — S. Billings & D. Richards
- HEM data processing - a practical overview — N. C. Valleau
- Bathymetry and sea floor mapping via one dimensional inversion and conductivity depth imaging of AEM — J. Vrbancich, P. Fullagar & J. Macnae

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- Wavelet based inversion of gravity data — F. Boschetti, P. Hornby & F. G. Horowitz
- The Hilbert Transform - a tool to interpret potential field anomalies — N. Sundararajan, Y. Srinivas & T. Laxminarayana Rao
- Electric potential arising from a point source near a cylinder in layered earth structures: design criteria for a modified marine heat flow probe — J. Yang & R. N. Edwards

Mine-scale Geophysics

- Detailed orebody mapping using borehole radar — G. Turner, I. Mason, J. Hargreaves & A. Wellington

Published for ASEG by:

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Events for 2000-2002

2000

November 16-19
CODES SRC and the Society of Economic Geologists
University of Tasmania, Hobart
Theme: ***Volcanic Environments and Massive Sulfide Deposits***
Contact: Conference Design Pty Ltd
PO Box 342, Sandy Bay, Tasmania 7006
Email: volcanic@cdesign.com.au

December 15-19
American Geophysical Union,
2000 Fall Meeting, San Francisco, California, U.S.A.
Website: http://www.agu.org

2001

January 24-26
The Society of Exploration Geophysicists of Japan, 5th International Symposium, Tokyo, Japan
Theme: ***Subsurface imaging technology and Underground Heterogeneity***
Website: http://segjsvc.geosys.t.u-tokyo.ac.jp/segj/meeting/
Email: segj5th@segjsvc.geosys.t.u-tokyo.ac.jp

March 4-7
The Annual Meeting of The Environmental and Engineering Geophysical Society
Doubletree Hotel, Denver Colorado, U.S.A.
Theme: ***Geophysics: Reducing Risk in Environmental and Geotechnical Engineering***
Email: lcramer@expomasters.com
Website: http://www.sageep.com/

May 29-June 3
American Geophysical Union, 2001 Spring Meeting, Boston, Mass., U.S.A.
Website: http://www.agu.org

June 11-15
63rd EAGE Conference & Technical Exhibition, Amsterdam, The Netherlands
Website: http://www.eage.nl

August 5-8
Australian Society of Exploration Geophysicists
15th International Conference and Exhibition
Brisbane, Queensland
Theme: *A Geophysical Odyssey*
Theme: '2001: A Geophysical Odyssey'
Website: http://www.aseg.org.au
Event Manager: Jacki Mole
Tel: +61 7 3858 5579
Email: aseg2001@im.com.au

September 2-6
7th Environmental & Engineering Geophysical Society, European Section, Birmingham, U.K.
Theme: ***Better and faster solutions***
Email: conference@geolsoc.org.wk
Website: www.geolsoc.org.uk/eegs2001/

September 9-14
SEG International Exposition & 71st Annual Meeting, San Antonio, Texas, U.S.A.
Website: http://www.seg.org

September 24-28
4th International Archaean Symposium,
University of Western Australia, Perth
Convenor: Susan Ho
Tel: +61 8 9332 7350
Email: susanho@geol.uwa.edu.au

2002

May 27-30
64th EAGE Conference & Technical & Exhibition, Florence, Italy
Website: http://www.eage.nl

September 22-27
SEG International Exposition & 72nd Annual Meeting, Las Vegas, Nevada, U.S.A.
Website: http://www.seg.org

New South Wales - by Alan Willmore

The NSW Branch held its annual dinner at the Different Drummer restaurant, Glebe, on the 28th July. Once again a core group of members enjoyed the food, company and a few too many bottles of red while looking at the spectacular city skyline.

During August the Branch held a joint meeting with SMEDG (Sydney Mineral Exploration Discussion Group). The presentation was by Glenn Jones (NSW Land Information Centre) on the topic *'The Change of Australia's Geodetic Datum'*, with a focus on the transition in datums from AGD66 to GDA94. Glenn proved to be an excellent presenter, making what could be a rather dry topic very interesting.

Some of our interstate brethren might not have realised that the Olympics were held in Sydney during September. The NSW Branch decided not to hold a meeting during the Olympic period, and thus avoid the rush of people to attend the meeting and ease SOCOG's fears the Games might not be a success otherwise.

Ken Witherly gave a presentation on the 17th October - *'A Comparative Study of Modern Airborne EM Systems'* Ken's talk focused on the Ontario Government's Treasure Hunt program, where seven airborne EM systems have been flown over the same patch of ground and more than 100 000 line-km of new data have been acquired.

The annual student night will be held on the 15th November. Students from Sydney, New South Wales and Macquarie universities will present on current research projects. The committee looks forward to a good turnout by the NSW members in the coming months.

Northern Territory - by Gary Humphreys

The September technical meeting was held at the Darwin RSL on 22nd September. Peter Hausknecht from Fugro Airborne Surveys gave a detailed introduction to the OARS airborne spectral mapping system. This system gives highly-discriminated broadband spectral data at the same time as recording the more traditional magnetic and radiometric surveys. All this for a small extra cost over mag/rad flying. The system has wide-ranging applications including mineral alteration mapping, soil/vegetation mapping and hydrological studies.

This allowed us to invite a number of interested scientists from outside the Society's normal reach, and invitations were sent to the Geological Society of Australia (GSA) and the NT chapter of the International Association of Hydrogeologists. A good indication of the degree of interest was a turn-out of 18 of whom seven were ASEG members (and this is a majority of the NT membership).

The PACRIM2 airborne radar and thermal system flew an area around Rum Jungle the week before. Roger Clifton from the NT Geological Survey was closely involved. Roger reports that: "NASA test flies its instruments by flying them in a DC8 before launching them on a space platform. Once mounted, the equipped plane is available for research flights. In this case the PACRIM2 mission is visiting the countries of the Pacific Rim, serving various research interests, including mineral exploration. On 15th September the DC8 flew over Rum Jungle, collecting AIRSAR and MASTER data for the NTGS and later the public domain.

Thermal infra red image, band 45, seen in real-time over Rum Jungle; a subset of the swath width of 12 km, scanned in 10 seconds of flight, i.e. about 2 km square.
The vegetation in the creeks is visibly cooler than the more exposed ground.

The AIRSAR system collects a massive coherent set of radar returns over each 60 x 10 km strip - two of which cover Rum Jungle. Understandably, inverting this incredible stack can only be done back at JPL. They will then send us a very precise elevation model (within a metre of AHD) and several polarimetric grids will be available in February or March next year.

The MASTER scanner includes several bands in the thermal IR, which I hope will be made to yield discrimination of silicates for exploration use. If successful, the MASTER data on Rum Jungle will provide prototype examples of what the ASTER (without the M!) data can do for explorers in the NT and elsewhere. The equivalent space-acquired ASTER data are expected to be made available from the Terra satellite, cheap or free, sometime around Christmas 2001.

As it was, the flight collected the radar data at 8230 m without a hitch. Heavy smoke haze degraded the MASTER data, but I still hope that the thermal bands will penetrate the haze sufficiently to test the silicate discrimination. NASA generously turned the plane around and flew the MASTER data again, at the lower altitude of 3960 m.

The MASTER data are easier to process and will be available about November, but we must expect some research will be required to make the MASTER data talk turkey for explorers - if they can!"

From the above, the NT Branch is showing its commitment to the widespread applications of geophysics in fields other than traditional mineral exploration. Expect more exciting news in future Previews.

South Australia - by Michael Hatch

South Australia continues to be a hive of local ASEG activity, with plenty happening through to the end of the year.

On the 9th August, our Branch hosted the 4th talk in the Millennium series. This talk was titled, *'Energy for our Future'*. It was presented by Andrew Stock, General Manager, Major Industry and Power, Origin Energy, and was well attended and very interesting.

We also participated in Resources Week 2000. This was a weeklong celebration of the mining industry in South Australia, and ran from the 6th through to the 12th August. Richard Hillis (Branch President, and Professor at the NCPGG) also gave one of the keynote addresses.

In September we held our annual Industry Night on the 26th. This year we had speakers from Beach Petroleum, Schlumberger, PIRSA, and Zonge Engineering.

On the 17th October we had Dennis Cooke of Santos who gave a presentation titled, 'What is the best seismic attribute for quantitative seismic reservoir characterisation?'

On the 2nd of November, Dr. Tim Flannery of the South Australian Museum, gave the next talk in the Millennium Series. This one was hosted by PESA, and titled, 'Extinctions, Past and Future'.

On a lighter note, we have our annual Melbourne Cup Luncheon coming up on the 7th of November. And then on the 12th of November PESA SPE and ASEG will be getting together for a Family Day in Belair.

Looking even further into the future, on the 6th December Don Henry of the Australian Conservation Foundation will give the final Millennium Series Lecture, this one hosted by SPE. His talk will be titled, 'Environmental Challenges in the New Millennium'.

And yes, we did manage to battle our way through this year's wine selections, coming up with a couple of very reasonably priced winners for your enjoyment. For this year's red we chose the Woodstock Five Feet, and for the white we chose the Hamilton Ayliffes Orchard Sauvignon Blanc. Look for your order form in this issue of Preview.

Much to look forward to here in SA over the next few months. See you at the meetings.

Queensland – by Kathlene Oliver

The Queensland Branch continues to focus on the upcoming 15th Geophysical Conference and Exhibition which is to be held between August 5th and 8th 2001 at the Brisbane Convention and Exhibition Centre. Further details can be obtained from the ASEG web site.

Recent attendances at our technical meetings have been the best in a number of months, which we hope to see continue. At the beginning of August the Queensland Branch hosted a very successful evening of technical presentations. Two papers were presented, *'Drilling-constrained 3D Gravity Interpretation'*, by Peter Fullager and *'3D Seismic Surveys applied to map detailed geological features in coal seams'*, by Binzhong Zhou.

The Christmas dinner has been booked for the 14th December and will be held at the Turkish Coffee House. Members will receive updated information closer to the day. We hope to see as many of our members at the dinner as possible.

In October we held a joint meeting with AIG and AusIMM. The presentation was by Gary Fallon and titled, *'The Use of 3D Seismic as a Primary Underground Coal Resource Definition Tool'*. Members are advised to check the web page regularly for updated information and upcoming social and technical events.

The Queensland Branch is investigating the possibility of holding a beer tasting evening and other social events. If anyone has ideas for social outings please contact either Troy Peters or Kathlene Oliver with your suggestions.

Western Australia – by Mark Russell

Technical Meetings:
CELTIC CLUB, 48 Ord Street, West Perth
(5:30pm drinks and food, 6:00pm meeting commences)
ASEG members admission free; Non-members admission $10.00

August Technical Meeting
Wednesday, August 16th, 2000

- *'Magnetic Exploration from the Ground-Up'*
  by Phil Schmidt of CSIRO
- *'Anisotropy in the South Sydney Basin'*
  by Milovan Urosevic of Curtin University

September Technical Meeting
Wednesday, September 20th, 2000

- *'Seismic Volume Visualization and Interpretation using Multiple Volume Rendering Techniques'*
  by Tony Marsh, Paradigm Geophysical
- *'Faults: Sealing or Non-Sealing?'*
  by Richard Hillis, (NCPGG) & (APCRC)

Call for nominations, GIBB MAITLAND medal
The Gibb Maitland Medal recognises the achievements of individuals who have made substantial contributions to geoscience in Western Australia. Nominations for this annual award close 30th November. Visit ASEG WA Website for appropriate links.

If your company would like to present a paper and/or sponsor at ASEG WA meetings please contact:
Kevin Dodds (9464 5005) or Guy Holmes (9321 1788) about speakers and sponsorship possibilities

For information on upcoming events, check our website http://www.aseg.org.au/wa

Golf Day
Details for the PESA/ASEG 2000 Golf Classic are on the WA website. www.aseg.org.au/wa/golf/
Meadow Springs 24th November 2000
Contact: Robert Iasky
Email: r.iasky@dme.wa.gov.au

Employment Service
Our employment service is running on the WA web site. This service is available to WA members to facilitate initial contact between employers and those seeking employment. To see who is available right now, or to register, go to the employment section of the website.

Web: http://www.aseg.org.au/wa
Correspondence to: ASEG-WA Secretary C/- PO Box 1679 WEST PERTH WA 6872
President: Jim Dirstein Tel: 9382 4307
Vice Pres: John McDonald Tel: 9266 7194
Secretary: Kevin Dodds Tel: 9464 5005 Fax: 9472 7444
Email: Kevin.Dodds@per.dpr.csiro.au
Treasurer: John Watt Tel: 9222 3154

Honorary Treasurer's Report

Balance Sheet as at 31st December 1999

	1999	1998
CURRENT ASSETS		
Cash	347 380.36	332 007.25
Receivables	62 083.38	141 793.26
Inventories	600.00	640.00
TOTAL CURRENT ASSETS	410 063.74	474 440.51
NON-CURRENT ASSETS		
Property plant and equipment	6 041.00	7 605.00
TOTAL NON-CURRENT ASSETS	6 041.00	7 605.00
TOTAL ASSETS	**416 104.74**	**482 045.51**
CURRENT LIABILITIES		
Accounts Payable	49 134.83	111 836.01
TOTAL CURRENT LIABILITIES	49 134.83	111 836.01
TOTAL LIABILITIES	**49 134.83**	**111 836.01**
NET ASSETS	**366 969.91**	**370 209.50**
EQUITY		
Issued Capital	1 997.00	1 997.00
Retained Profits	364 972.91	368 212.50
TOTAL EQUITY	**366 969.91**	**370 209.50**

The financial statements for the year ended 31st December 1999 for the Australian Society of Exploration Geophysicists are presented. In summary, 1999 was a year of consolidation for the Society. A number of steps taken by the previous Federal Executive, particularly to rein in costs and to increase revenues in the area of publications, were pursued and a number of new initiatives were taken. As a result, a small deficit is reported for 1999, in spite of the year being a non-conference year.

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

These funds are used to promote, throughout Australia, the science of geophysics by paying for national administration, capitation fees for the administration of state branches, publication of Exploration Geophysics four times during the year, publication of Preview six times in the year, continuing education programs, and the provision of loans and grants for conventions, meetings and the ASEG Research Foundation.

The balance sheet indicates the retained profits reduced marginally from $368 212.50 at 31st December 1998 to $364 972.91 at 31st December 1999. The profit and loss account shows that the income of the Society was $255 506.66 ($416 953.23 in 1998) and the expenditure was $258 746.25 ($484 534.22 in 1998).

The main reasons for the differences between the 1998 and 1999 accounts relate to 1999 being a non-conference year and the ensuing effect this has on both conference profit figures and on recovery for publications costs.

The largest contribution to operating income is from advertising revenue for the publications ($97 509.34) followed by membership income of $75 029.00. Conference revenue was $25 225.38, made up of adjustments related to the 1998 Hobart and AEM conferences. State Branch income, other than from capitation, was $46 300.38.

Publications were the largest expense of the Society, amounting to $91 530.94, with secretariat and accounting expenses amounting to $68 475.49 and the Society's contribution to the Research Foundation at a reduced level of $25 000. State Branch expenditure was $67 713.23.

Membership income in 1999 was generated from 1073 individual members.

G. Butt
Honorary Treasurer
17th September 2000

Consolidated Profit and Loss Account for the year ended 31st December 1999

	1999	1998
TOTAL INCOME	255 506.66	416 953.23
TOTAL EXPENDITURE	258 746.25	484 534.22
OPERATING SURPLUS (DEFICIT) before income tax	(3 239.59)	(67 580.99)
Income Tax (credit) attributable to operating surplus (deficit)	0.00	0.00
OPERATING SURPLUS (DEFICIT) after income tax	**(3 239.59)**	**(67 580.99)**
Retained profits at the beginning of the financial year	368 212.50	435 793.49
Total available for appropriation	364 972.91	368 212.50
RETAINED PROFITS AT THE END OF THE PERIOD	**364 972.91**	**368 212.50**

ASEG 2001 A Geophysical Odyssey

Fugro Airborne Surveys Gold Sponsor for ASEG 2001

With less than 12 months remaining, preparations are increasing for the ASEG 2001 Conference. All the organising sub-committees have been actively undertaking tasks towards the conference preparation.

The Conference Organising Committee (COC) is pleased to announce Fugro Airborne Surveys as one of the Gold Sponsors, with several strong offers of sponsorship for Silver and Bronze levels. We thank these companies for their support. Information packages on Silver and Bronze level sponsorship will be sent to companies and finalised over the coming few months. Any companies interested in either of these levels of sponsorship, or additional sponsorship opportunities, are asked to contact Sonia Higgs at Intermedia, via the ASEG 2001 Conference web site (www.aseg.org.au) or by e-mail at aseg2001@im.com.au.

The conference web page is continually being updated and I encourage you all to visit it. This site has all the information about the conference and is planned to have links to accommodation sites and tourism information for Brisbane and Queensland.

Currently Expressions of Interest are being sought for the presentation of papers at the conference. Information on how to submit an Expression of Interest, and also an Extended Abstract Kit, are available at the Conference web site. The technical papers sub-committee has already received significant support from potential authors, and would like to continue the level of interest in presenting papers by encouraging us all to consider the following presentation themes:

- Integrated Hydrocarbon Case Histories
- Non-traditional Geophysical Applications
- New-field Discoveries
- Integrated Case Histories in Basemetals, Gold, Diamonds - Discovery, Mapping, Innovative use of Geophysics
- Reservoir Characterisation, Production Geophysics
- Government Initiatives
- Multiple Suppression, Migration, Depth Conversion
- Near Surface Geophysics
- Multicomponent and Vector Seismic Techniques
- In-mine Geophysics
- Innovations in Seismic Acquisition
- 3D Geophysical Processing, Visualisation, Interpretation
- Advanced and Novel Signal Processing Techniques
- Innovative Airborne Geophysics
- Petroleum Exploration from Space
- Downhole, Hole-to-Surface Geophysics
- Coal Geophysics
- Theoretical Geophysics
- Geostatistics in Geophysics

The ASEG 2001 Conference is being actively promoted within Australia and overseas. The SEG has requested information updates and posters for display within the SEG travelling booth, as it attends functions during the year. From 22nd - 24th October 2000, the Bowen Basin Symposium will be held in Rockhampton. There will be a strong presence at the conference by ASEG members who will be promoting all aspects of the conference.

Given the commitment of all members on the COC, and the support of the ASEG members, the ASEG 2001 Conference will be a resounding success.

ASEG at Calgary SEG Meeting

The ASEG was well represented at the SEG's 70th Annual Meeting and International Exposition, which were held from 6-11th August in Calgary, Canada.

We have included two snapshots of our members at work in Calgary, and would like to thank Ken Witherly, Dave Robson and Brian Spies for providing the pictures.

The SEG Appreciation Reception (previously known as the President's Reception). Pictured (from left to right) are: Professor Deseng Li, Chief Geologist, China National Petroleum Company, who spoke at the SE Asia/ Australia luncheon, Qichang Zhu, Professor Li's wife, David Zinke (husband of Sally Zinke), David Robson, ASEG Honorary Secretary, Sally Zinke, SEG incoming President, Brian Spies, ASEG President, Bill Barkhouse, outgoing SEG President, and Anne Geyer (wife of Bill Barkhouse) .

The backdrop is a painting of the Canadian Rockies, an hour or two west of Calgary by car.

ASEG Booth with Dave Robson and one of the thousands of happy SEG delegates who visited the booth.

Written by:

Natasha Hendrick

Promoting Geophysics

As geophysicists it is important that we contribute to the promotion of our own profession. Schools, universities and community organisations are always willing to have scientists visit and share experiences about their work. This month Web Waves provides sources of information that can help you prepare presentations on how geology and geophysics contribute to society, technical methods used in everyday geophysics, and information on careers in geoscience.

Remember to make your presentation suitable for the age group you are visiting, use visual aids to make the presentation interesting, and be open to answering questions from inquisitive students. Most importantly spread the word about our fun and exciting profession of geophysics!

AGSO - Education Resource
www.agso.gov.au/education

AGSO has a number of on-line resources aimed at increasing awareness of the importance of geology and geophysics in Australia. The Minerals Down Under fact sheets and interactive quiz includes information on Gold, Copper, Silver, Iron, and Mineral Sands, as well as a section on Exploration Techniques. Geophysical techniques covered on this site include radiometrics, magnetic surveys, gravity and electrical techniques. AGSO also has an on-line, interactive remote sensing image processing activity. In addition a number of educational resources can be purchased via the web.

APPEA - Australia's Petroleum Industry
www.appea.com.au/education2/home.html

APPEA provides an interactive web page designed to teach school students about Australia's petroleum industry. On-line topic sheets are available including marine exploration and production. In addition a number of resource publications (books and CD-ROMs) can be purchased.

SEG - PowerPoint Presentations
students.seg.org/k-12slides/

SEG provides two Microsoft PowerPoint slide sets (free of charge), making it extremely quick and easy to prepare a presentation for your local school. Content is focused on exploration geophysics and the petroleum industry, and is suitable for upper primary and secondary school students.

Introduction to Exploration Geophysics
138.67.1.32/fs_home/tboyd/GP311/

Supported by the SEG, this on-line educational kit is aimed at promoting applications of exploration geophysics to upper secondary and university students, and earth-science educators. The site is divided into four modules: gravity, magnetics, DC resistivity and refraction seismic. Each module consists of lecture notes and an interactive case study. The focus is on learning by doing, and participants follow a sequence of decisions based on real-world problems to acquire, process and interpret a test dataset.

Geoscience Classroom Demonstrations
www.geol.binghamton.edu/faculty/barker/demos.html

Jeffrey Barker provides 15 comprehensive classroom demonstrations, useful for introducing geology and geophysics at upper secondary and university level. Topics include seismic waves, seismic reflection, rigidity and velocity, the magnetic field, and earthquake location.

WA - The Chamber of Minerals and Energy
www.mineralswa.asn.au/cme/frameset.cgi/5

The Western Australian Chamber of Minerals and Energy provides a series of fact sheets covering the history of mining in WA, mining methods and techniques, and mineral exploration (including details on gravimetric, magnetic, electrical and seismic methods).

USGS - Solid Earth Geophysics
pasadena.wr.usgs.gov/eqhaz/4kids/

A renovated, bright and colourful web page from the US Geological Survey provides fun and educational activities and information on solid earth geophysics. Kids can read cool earthquake facts, find out how to become a geophysicist, and learn about the science of seismology. Adults can find out more about seismic waves, earthquakes and plate tectonics. The site also includes a comprehensive list of related web-sites.

AIG - Careers in Geosciences
www.aigweb.org/career/

The American Geological Institute provides useful information on careers in geosciences aimed at secondary school and university students. A brochure is available on-line covering the 'who', 'what' and 'where' of geoscience careers. There is also an insightful article on managing your energy career, and answers to FAQ on choosing a career in geoscience - information that will certainly help you put a meaningful student presentation together.

If you have any favourite sites (not necessarily geophysical) that you would like to share with our members please email me, Natasha (natasha@geoph.uq.edu.au). An ASEG Favourites list will be published in the next edition of Preview.

Batterham and Miles Report on Science in Australia

The main question in Canberra on science, engineering and technology (SET) policy at the moment is - how will the Government respond to the Batterham and Miles Reports, on the future of science in Australia?

Batterham

The Chief Scientist, Robin Batterham, carried out the first. Back in 1999 (it really does seem like the last century now) he was asked to assess the SET capabilities of Australia to ensure it can meet the needs of Australians in the 21st century. In August 2000 he presented his findings to Minister Minchin in a report titled ***'The Chance to Change'*** and identified several key themes for the future. These were that science, engineering and technology underpins our future as a thriving, cultured and responsible community, and that innovation is the only way forward. He argued that we must invest to change our ***Culture***, to create an environment to generate ***Ideas***, and to improve the ***Commercialisation*** of our science. Otherwise, we will get left behind as our competitors continue to invest more and more into SET, while we are investing less and less.

Under these headings the major recommendations are as follows:

Culture

- Provide 200 HECS scholarships for students undertaking combined science/education qualifications and 300 for students of the enabling sciences -maths/ physics/chemistry;
- Increase the number of Australian Postdoctoral Fellows - doubling would be appropriate;
- Redesign and expand R&D Start Graduate.

Ideas

- Over five years, significantly increase funding for the Australian research Council's competitive grants and related infrastructure activities, consistent with the commitments already made for increased funding of health and medical research;
- Expand the funding for university research infra-structure (RIBG);
- Commonwealth fund 50% of the cost of creating new major research facilities on a competitive basis in conjunction with the States/territories, universities and commercial interests; and
- Libraries - develop a pilot scheme to test a national site licence concept between higher education institutions and publishers in an attempt to keep the price of journals down.

Commercialisation

- Expand the CRC program to encourage greater Small & Medium Enterprise access and to facilitate stronger networks between the Science, Engineering and Technology base and industry, nationally and internationally;
- Establish a small number of Innovation Centres to provide universities and government funded agencies with support in commercialising research;
- Establish a pre-seed capital fund for universities, Innovation Centres and government funded research agencies, such as CSIRO, RDCs (Rural Research Development Corporations) and CRCs; and
- Universities and government research agencies review opportunities for researchers to better share in the benefits of commercialisation with particular encouragement for the formation of start-up and spin-off companies

Although most of us would strongly support these recommendations, Batterham, rather surprisingly does not estimate any dollar values to implement them. Furthermore, his emphasis is on universities rather than government institutions such as CSIRO and the nation's Geological Surveys.

How the government will deal with these in Cabinet when no dollars are attached is unclear to say the least.

Miles

The second report, presented by David Miles, the Chair of the Innovation Summit Implementation Group, was also delivered in August 2000. This report called ***'Innovation - Unlocking the future'*** was the main output from the Innovation Summit held in Melbourne in February 2000. ISIG comprised nine leaders from government, industry and academia, and their report is concise, focused and contains dollar signs.

There are a total of 24 recommendations under the key headings of: ***Creating an ideas culture, Generating ideas,*** and ***Acting on ideas***. Notice the similarities to the clustering in the Batterham report.

I will not go through the report at length, but it is a good read and well presented. Perhaps one example to give you the flavour of the text would be useful. Under the heading ***'Generating Ideas'***, after showing that the levels of spending on R&D in Australian have been falling in the past five years, the report proposes specific actions. Thus we have:

Recommendation 12

To build Australian research capability, Commonwealth Government funding for the competitive research grants schemes administered by the Australian Research Council be doubled over a five year period.

Continued On Page 16

(Editor's note, the two reports can be viewed on the web at: www.isr.gov.au/ science/review for 'The Chance to Change' and at http://www.isr.gov.au/ industry/summit/ ISIGreport.pdf for the Miles Report).

New Members

We would like to welcome the following new members to the ASEG. Their membership was approved at the August and September 2000 Federal Executive meetings.

NAME	AFFILIATION	STATE
Sergio A. Morais Machado	Anglo American	Brazil
Peter Annan	Sensoft	Canada
Pierter Willem Gabriels	Norske Shell	Norway
G. David Collier	Santos	QLD
Werner Dutler	Santos	QLD
Rajendra Singh	Santos	QLD
Raymond Earnest Smith	CSIRO	WA
Heitor Franco	Univ. of Brasilia	Brazil
Gregg Kevin Spencer	Santos	QLD
David Ian Close	Univ. Tas	TAS
Jacob Wayne Russel	Univ. Tas	TAS
Julie-Ann Crockford	Univ. Adelaide	SA
Kate Procko	Univ. Adelaide	SA
Alastair Haldane	Univ. Adelaide	SA
Christopher Hudson	Curtin Univ.	WA
Robert Graham Ellis	BHP	Canada
Detlef Gerhard Eberle	Bund. F. Geowiss u. Rohslaffe.	Germany
Christpher John Henry	Coffey Geophys	NSW
Ryz Evangelista	Univ. Sydney	NSW

Continued From Page 15

Cost: would rise from some $50 million in the first year to $240 million by the fifth year. Responsibility for action: Commonwealth Government to provide outlay, research institutions and their researchers to undertake world-class R&D

There are some interesting quotations sprinkled through the report. I particularly like the one attributed to Albert Szent-Gyorgi: 'Discovery consists of seeing what everyone else has seen and thinking what no-one else has thought.'

Anyway the report calls for boost in government funding of about $800 million per year, which is very close to the $1 billion proposed by FASTS (see Preview 87).

Furthermore, the government now has to respond to both reports. The normal course of events in this situation is for an IDC, chaired by the department with carriage of the issues, to consider options to put to Cabinet in the budget context.

Let us see how Finance and Treasury deal with this on budget night next year.

Eristicus, Canberra September 2000

An Approach to Using Seismic Reflection Imaging in Mineral Provinces - An Example at a Province Scale

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Introduction

The seismic reflection method, widely used by the petroleum industry, has had limited success in mineral exploration. In mineral provinces, seismic velocities typically are very high and vary between 5.0 and 7.0 km/s. For frequencies used in seismic reflection profiling wavelengths are large and resolution is limited, despite the fact that ore bodies may have significant seismic impedance contrasts with the host rocks (Salisbury et al. 1996). Often these ore bodies lie in highly deformed host rocks that provide coherent reflection surfaces that are small compared to the Fresnel Zone. Geological structures are dominantly three dimensional, so the sections from two-dimensional seismic profiles are contaminated by diffractions and out of plane energy. Therefore, application of seismic migration in mineral provinces also has limited success.

Factors defining vertical and horizontal resolution of the seismic reflection method are critically important for its successful implementation. When using seismic methods in mineralised regions, the focus must be on geological features that are at scales of the seismic Fresnel Zone diameter. Recent research at AGSO has attempted to use the principles of mineral systems to address this problem. The following case study looks at using seismic data at regional scale in the Eastern Goldfield Province of the Yilgarn Craton in Western Australia (Goleby et al., 1997).

Mineral Systems

Mineral systems are analogous to petroleum systems in a sense that they describe the relationship between source rock and an accumulation (Wyborn et al., 1994; Magoon and Dow, 1991). Using this definition, a mineral system can be described simply as a fluid source, a migration pathway, and a trapping mechanism that scavenges the minerals from the fluids.

The fluid source may be basin brines or deep-seated lower crustal or upper mantle hydrated rocks. Identifying fluid source regions in seismic images may be difficult. The dehydration of a large area of crust, particularly in metamorphic rocks, to create mineralising fluids will not necessarily leave an observable seismic contrast on the rocks that distinguish one region from any other region.

Fluid migration pathways are needed to transport the fluids from their source into the trap. Many mineral deposits lie on, or are adjacent to, major faults or shear zones, which suggests a causal relationship. Fault systems provide fracture porosity as well as a focussing mechanism. In the case of basin brines, the general distribution of permeable and impermeable rocks of the basin strata also allows fluid flow and influences its form. Large volumes of rock can be effectively dehydrated over time by relatively low fluid flux rates. If fluids are concentrated into fracture-induced permeability zones along faults, then higher flux rates will occur along the faults.

Intrinsic fault zone reflectivity may result from a number of causes. Alteration haloes along faults and metasomatism within the fault zones cause a contrast in density between the fault zone and hence the seismic impedance, compared with the adjacent country rock. Where a fault zone is the focus of high strain, mylonite zones may develop. These zones usually have a well-developed fabric which is anisotropic (e.g. Siegesmund and Kern, 1990) and, when the anisotropy is at the scale of kilometres, can contribute to reflectivity (Jones and Nur, 1984). Constructive interference of reflections from the bands of altered and strained anisotropic rock within the mylonite zones can also enhance reflectivity. This case study is based upon the work by Drummond and Goleby (1993) who interpreted some elements of crustal reflectivity in the Archaean Eastern Goldfields Province of Western Australia in terms of fluid pathways through the crust.

Trapping mechanisms take a variety of forms. These require the superposition of physical barriers to fluid flow (e.g. local structure, stratigraphy and permeability) with the appropriate chemical, thermal and palaeogeographic settings for the minerals to be deposited. Many studies that

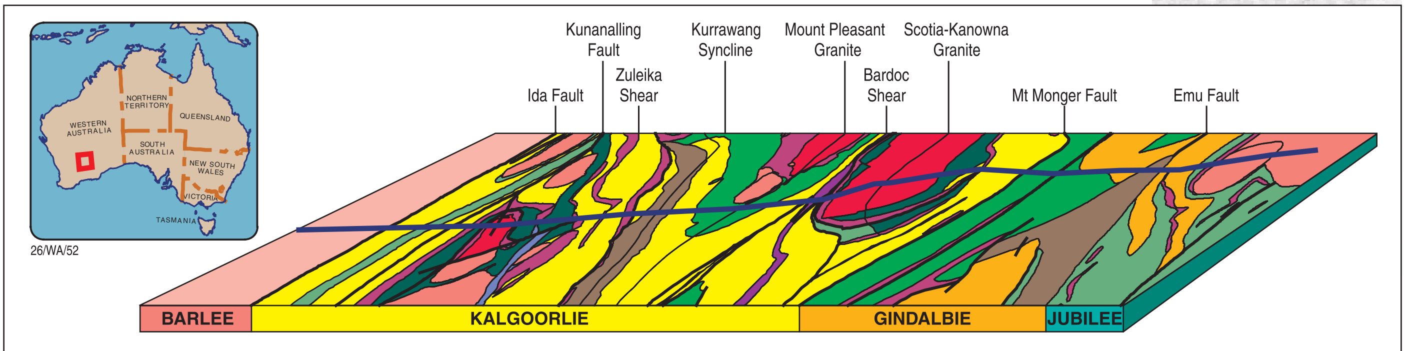


Fig. 1. Isometric view of the granite-greenstone geology of the Eastern Goldfields region. The position of the 1991 deep seismic traverse, EGF01, is shown for reference.

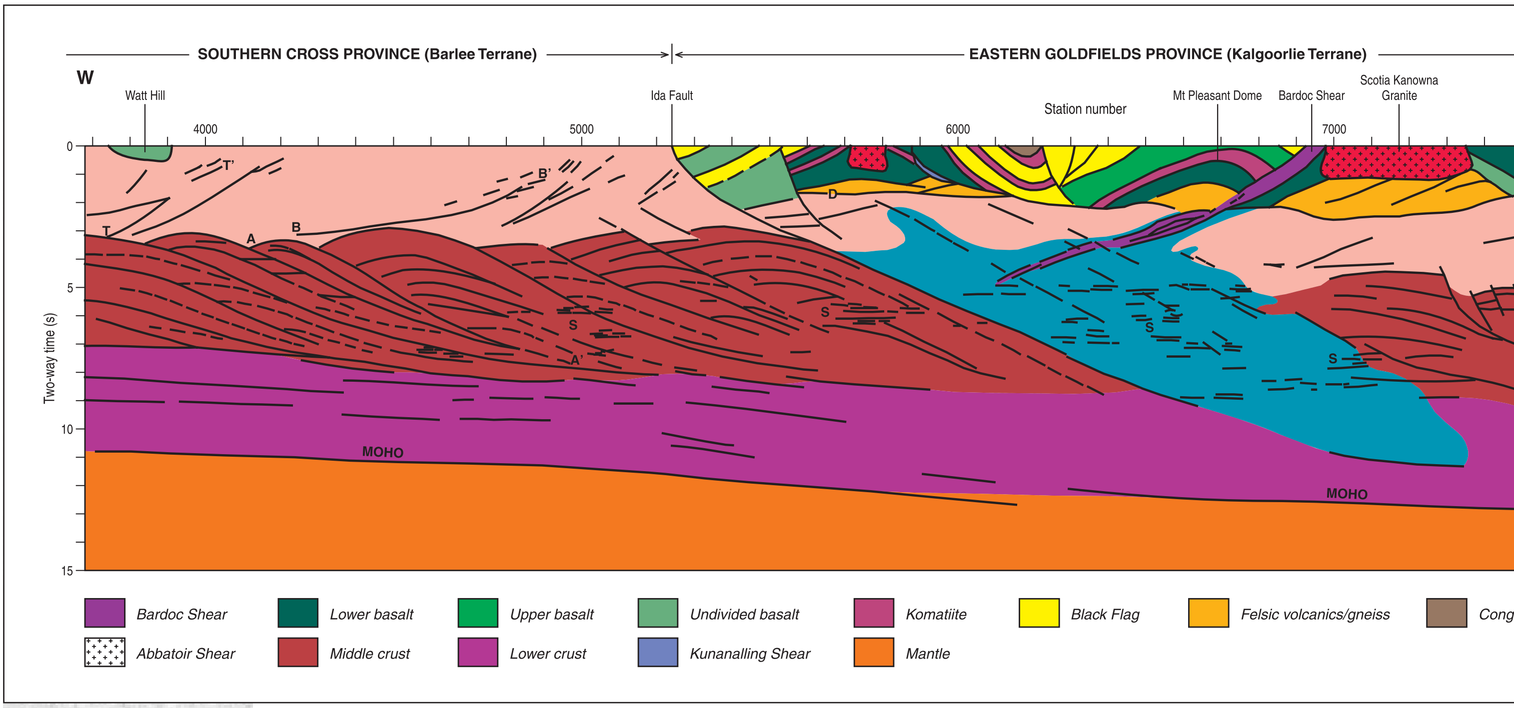


Fig. 2. Interpretation of the deep seismic reflection section along the traverse EGF01. This traverse imaged major structures within granite-greenstone terranes of the Eastern Goldfields region. The migrated seismic data are shown as a backdrop. This interpretation highlights the large mid-crustal zone of anomalous reflectivity (V:H=1:1).

analyse the trapping mechanisms of mineral deposits tend towards describing their complexity rather than examing the underlying elements of the mineral system. Trapping structures and ore bodies are thus difficult to image using the seismic reflection technique. Direct targeting of orebodies during exploration with seismic imaging therefore is usually not viable. However, a number of studies have been successful where the target of the seismic survey is the mineralising system around the ore body, rather than the orebody itself (Milkereit et al., 1996; Goleby et al., 1997). Such applications are often more viable during the ongoing development stage of a mature mine, rather than during exploration.

The Eastern Goldfields of Western Australia

The Yilgarn Craton consists of several geological provinces. Gneissic granitoids, granite plutons and greenstone supracrustal rocks are common in all provinces. Each province can be divided into a number of terranes that are defined by the distinct stratigraphy of its volcanic and sedimentary supracrustal rocks. The Eastern Goldfields Province is host to much of the Craton's known gold deposits, many of which occur in the west of the province. The Ida Fault separates it from the Southern Cross Province to the west.

A 213 km long regional scale seismic reflection traverse was positioned east-west across the regional strike (Fig.1) (Goleby et al., 1993). The interpretation of the shallow part of the seismic data was described by Swager et al. (1997). The greenstone supracrustal rocks lie above a subhorizontal detachment between 1.5 and 2.5 s two-way time (~4.5 and ~7.5 km), which is interpreted as a tectonic boundary with the underlying basement. Many of the faults in the greenstones such as Zuleika Shear (Fig. 2) are not reflective and are interpreted by their truncations of coherent reflectors. These faults can be mapped laterally over considerable distances within the greenstones, but they are not deeply penetrating and sole on to the detachment surface.

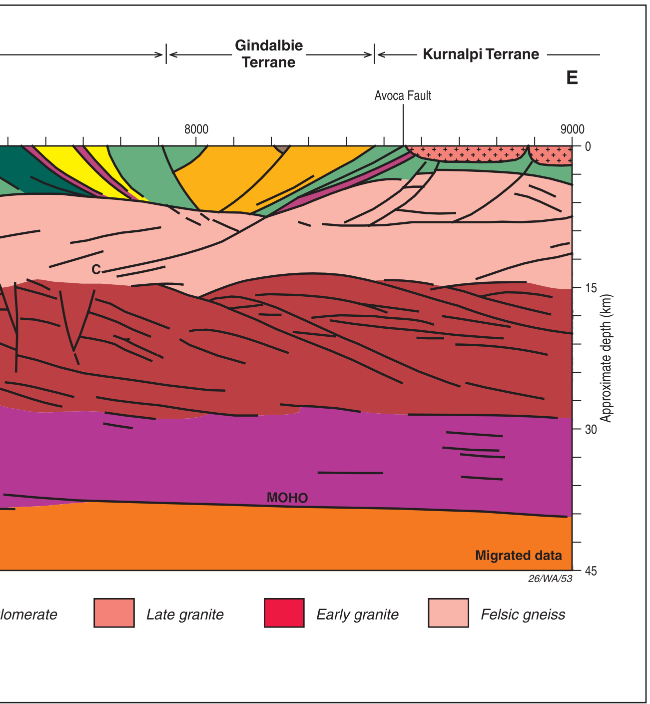
However, several faults are reflective and appear to penetrate the detachment surface. Within the seismic section, the Ida Fault and the Bardoc Shear are the prominent examples. The Ida Fault dips approximately 30° to the east and extends to 25-30 km depth. The Bardoc Shear dips west, penetrates the detachment surface, and truncates against the Ida Fault at about 15 km depth (Fig. 3).

Many of the faults in the region, including those that do not penetrate the detachment, can be associated spatially with gold deposits. The Bardoc Shear and its southern extension (Boorara Shear near Kalgoorlie, Lefroy Fault near Kambalda) are associated spatially with major gold districts, including the Golden Mile at Kalgoorlie and the Kamdalda-St Ives deposits. Many of the gold deposits lie to the west of the shear, i.e. in the hanging wall block.

Controls on Fluid Migration

Drummond and Goleby (1993) proposed a model where mineralising fluids migrating from the lower crust to higher levels in the greenstones followed a path that was into and along east-dipping shear zones within the lower crust and then into the Bardoc Shear. From there they percolated into the hanging wall block. Some fluids leaked along the detachment and into other faults within the greenstone sequence that splay from the detachment (e.g. Zuleika Shear), but most would concentrate in the greenstones, immediately above and to the west of the Bardoc Shear.

Numerical modelling of the fluid flow supports this linked fluid-pathway model (Upton et al., 1997). This modelling predicted that fluids were driven up the Ida Fault from depth and down the Ida Fault from the surface. These mixed and flowed up the Bardoc Shear, resulting in a high degree of chemical alteration and hence mineral deposition within the upper crust, particularly within the greenstones. The modelling demonstrated that the crust-penetrating faults probably formed permeability discontinuities that



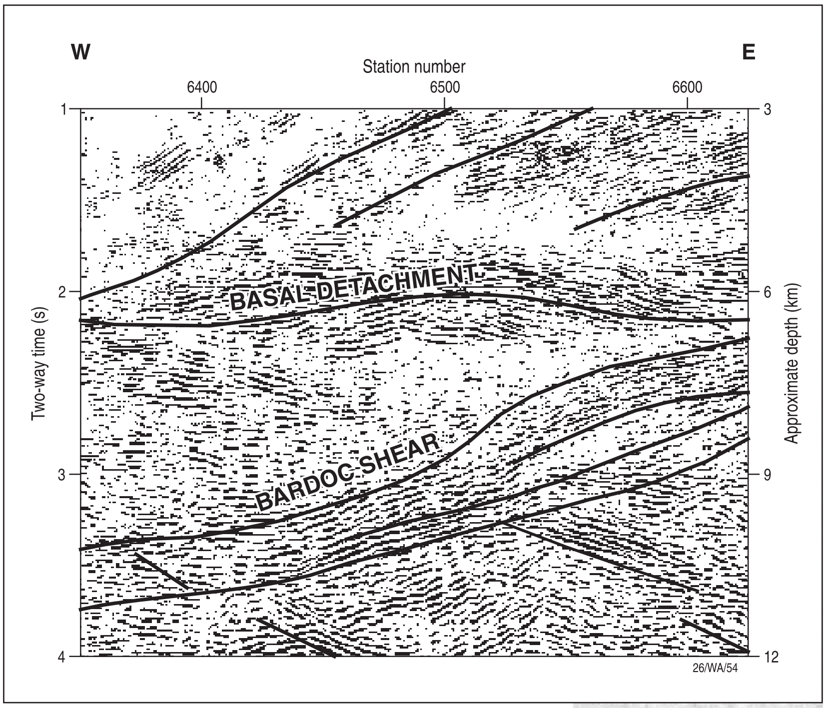


Fig. 3. Expanded portion of the seismic data near the intersection of the Bardoc Shear and the basal detachment of the greenstone rocks. Note that the reflectors are characterised by laterally continuous zones of short reflections. V/H=1; length of section ~11 km.

controlled the location and size of fluid convection cells. This ultimately led to the localisation of gold deposits within the greenstone supracrustal rocks.

Conclusion

Seismic images from mineral provinces can appear initially to be a confusion of primary reflections, diffractions and out of plane energy. However, when interpreted using constraints from surface geology and qualitative and quantitative modelling of other geophysical data, coherent images of the crust are obtained. When intrinsic reflectivity of shear zones is interpreted as evidence of fluid movement through the crust, the seismic data provide constraints in mineral system models. This provides evidence of fluid migration pathways and therefore pointers to regions of likely mineralisation.

Acknowledgement

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Advances in Seismic Interpretation, 1990 - 2000

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Introduction

In the last decade, enormous workflow changes have taken place in the field of seismic interpretation. Gone are the days of the geophysicist, geologist, petrophysicist, and engineer working in separate buildings or separate floors on a single project.

It was the decade of routine utilisation of 3D seismic data for exploration in many basins of the world. The amount of data that the average seismic interpreter had at his hands increased exponentially through the availability of large non-exclusive 3D datasets. This increased volume of data necessitated the development of new tools with which to interpret the data.

The use of 3D seismic data also continued to expand in the areas of reservoir characterisation. The need to thoroughly describe the reservoir drove the adaptation of new work environments, workflows, and the formation of integrated teams. Seismic attribute and AVO (amplitude verses offset) interpretation increased dramatically throughout the 1990s.

Seismic interpretation is a field where the disciplines of geology and geophysics are combined. The successful seismic interpreter makes the most reasonable and accurate interpretation of subsurface geology by using seismic data as his primary tool. In both of the fields of geology and geophysics, there were interesting advances over the last decade. For geology, workers continued to develop and refine depositional systems and structural models, primarily from the tremendous exploration activity in new deepwater basins around the world. In the field of geophysics, considerable advances were made in both acquisition and processing. Excellent treatment of these areas is included in previous editions of *Preview* this year.

Descriptions of advances in the parent fields of seismic interpretation will not be described here. What we will describe is our perception of the technology changes that the seismic interpreter witnessed over the past decade. We will organise these observations into new interpretation techniques and tools that have been developed to allow the seismic interpreter to adapt his workflow to changes in the exploration environment. Most changes came from the adaptation of new tools and techniques, with which the interpreter could make, depict, and describe their ideas and observations.

Interpretation Techniques

Changing political environments, the development of new technologies, and the availability of new data opened vast new under-explored areas to the oil and gas industry over the past decade. As these areas were opened, geoscientists continued to formulate new ideas regarding the habitat of hydrocarbons. Most notable was the increase in the exploration of deepwater basins around the globe, as technologies were developed to allow for the economic production of hydrocarbons in greater water depths.

Hydrocarbon exploration is now being conducted in plays and geological environments that are much more complex. Focus was devoted to difficult plays such as the subsalt of the deepwater Gulf of Mexico and Africa, and to thrust-fold belts. These plays present new and challenging imaging problems that require such solutions as 2D and 3D Pre-stack Depth Migration (PSDM). Where once the seismic interpreter was called only occasionally into the seismic processor's office to examine picked velocities, now the interpreter is working side-by-side with the processor to create complex structural models as input into iterative processing streams. The most critical aspect to a valid PSDM is the accuracy of the velocity model. It is critical that the model is structurally accurate as it's integrity will have a strong influence on the migration results (Figure 1). In some areas, where the imaging of key horizons is difficult, the interpretation must be model-based. The interpreter follows a geological model using structural relationships derived from better data areas and other datasets, such as potential field information and structural restoration.

Interpretation tools and techniques that utilise artificial neural networks to learn and recognise trends in seismic data came into use in the 1990s in two primary areas; 1) horizon-based post-stack data pattern recognition, and 2) multi-attribute analysis for reservoir property description. These tools dramatically increased the amount of information that the seismic interpreter could derive from the seismic dataset. Horizon-based algorithms became widely available and allowed the interpreter to define rough structural trends in the data and then have the application recognise and learn patterns in the seismic traces. Resulting output from this software allows the seismic interpreter to detect and understand details such as important depositional patterns (Figure 2). Multi-attribute analysis technology involves the prediction of reservoir characteristics such as porosity, Sw, V-shale, or any other log property utilising combinations of seismic attributes. Initially, a phase of training takes place in the application, where the seismic attributes are correlated at the well locations and combined using multi-linear regression or artificial neural network techniques. Then, the learned relationships are propagated throughout the seismic volume to produce a pseudo log trace at every seismic trace. Critical to the process are the well ties and sufficient representation of reservoir variations in order to avoid over-training the data set.

Tremendous advances were made in the understanding of seismic attributes. The integration of these attributes with petrophysics, and geological modeling has allowed geoscientists to derive much more information than was previously possible from the seismic data. The direct detection of hydrocarbons and lithology through a wide range of evolving pre-stack, and post-stack inversion techniques as well as a multitude of perturbations of the amplitude versus offset (AVO) methodology gained importance.

Over the past decade, seismic inversion techniques have continued to advance. Two of these techniques, acoustic impedance (AI) inversion and elastic impedance (EI) inversion have become important tools in the interpreter's tool chest.

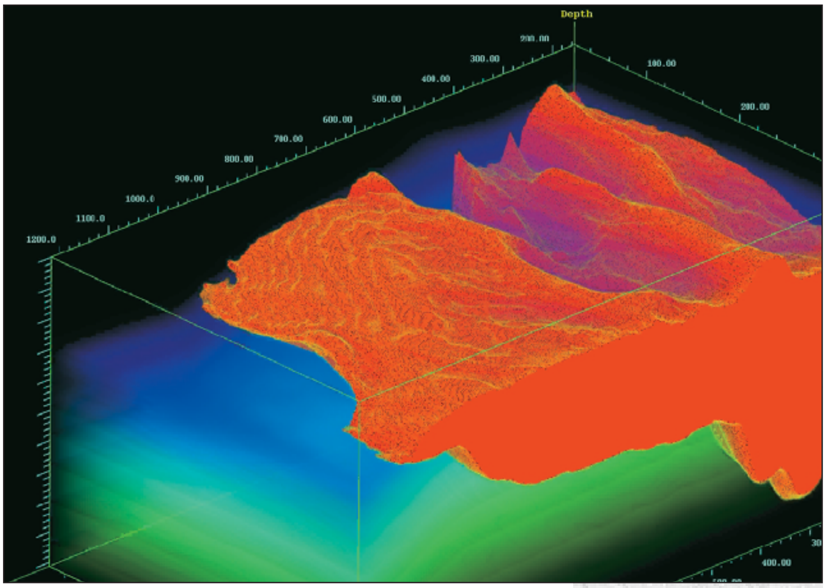
AI is the product of rock density and P-wave velocity and is therefore a rock property rather than a seismic interface. Figures 3 a and b illustrate the significant resolution and dynamic range improvement in AI data versus seismic reflectivity data.

EI is the extension of the AI algorithms to pre-stack seismic attributes. Over the past decade, it has been recognised that most basins in the world exhibit some form of distinguishable AVO response. The ability to utilise the advantages of both AVO response and AI inversion concepts is powerful in the hands of the interpreter.

One of the most promising new AVO approximations was introduced by Goodway et al. (1997, 1999)) who related the Knott-Zoeppritz equations to the Lame's modulii parameters of rigidity (μ) and incompressibility (λ). Separation of these two terms allows for pore fluid identification (Figure 4) using the incompressibility term and lithology identification using the rigidity term.

AVO analysis was further enhanced in the 90s through the cross-plotting of two AVO attributes for fluid and lithology changes similar to petrophysical log cross-plotting. Petrophysical cross plotting has been a mainstay in the petrophysicist's tool kit for years, but has just made its way into geophysics in the last five years. In the past, conventional seismic processing has output a single trace at each CDP location, however, AVO processing outputs two traces which can be cross-plotted for fluid or lithology separation (Figure 5). These relationships make quantification for reservoir modelling more robust.

The use of AVO and other seismic attributes in reservoir modeling has grown significantly in the past decade and will continue to expand in the years to come. Introduction of seismic data to reservoir modelling calls for integration of all the geoscience disciplines. Petrophysics to build the correlation between the reservoir and seismic data, geology to discriminate facies, geostatistics for combining the different data types into a single model, and finally reservoir simulation to QC the model and predict the next drilling location.



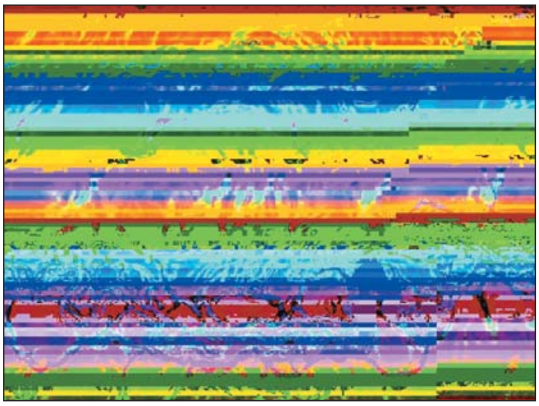


Fig. 1. (top) Voxel Cube of a velocity model for a complex subsalt PSDM. Salt velocities are shown in red. The velocity of the surrounding sediment is reflected in the color of the voxels that range from blue to green. Note the rugosity in the top of the salt body as reflected in the velocity model.

Fig. 2. Resultant attribute display from a 3D dataset from offshore Nigeria. This display was created through the use of artificial neural network seismic pattern recognition associated with an interpreted seismic structural horizon. Note the deepwater channel that runs from left to right near the bottom of the figure. The interpretation application has highlighted detailed meander-loops in the channel, an important reservoir target in the area.

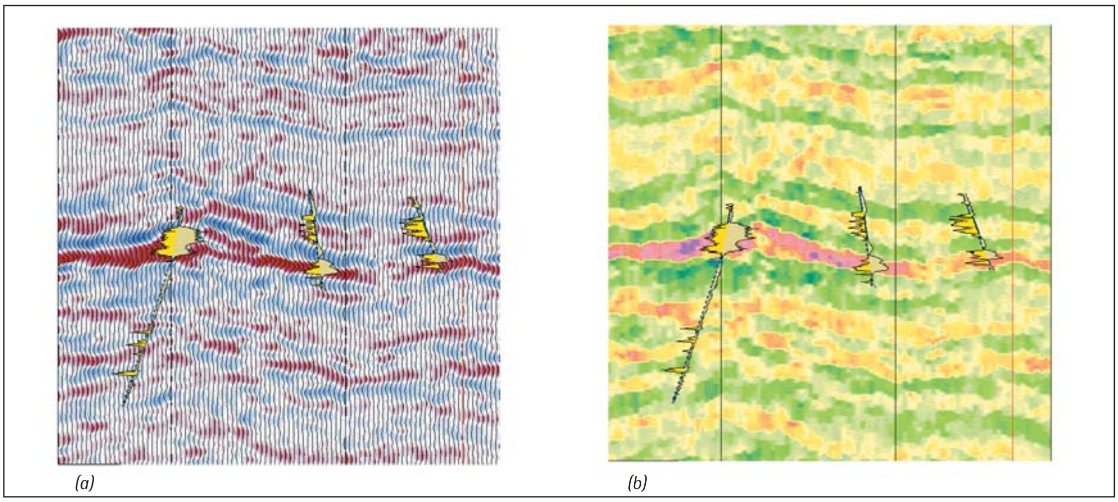


Fig. 3. a) A Seismic reflectivity section where the colors represent the polarity of the seismic event (red positive and blues negative). The intensity of the colors represents amplitude strength. b) Seismic AI. AI is a layer property and not an acoustic boundary. Note how the AI section allows for a better log tie and amplitude separation.

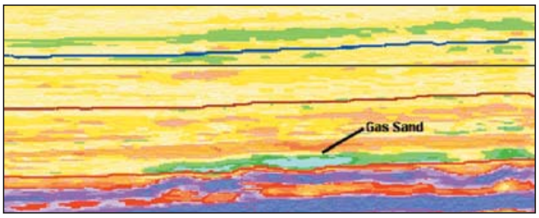


Fig. 4. Figure showing the identification of a gas sand using λ AVO attribute.

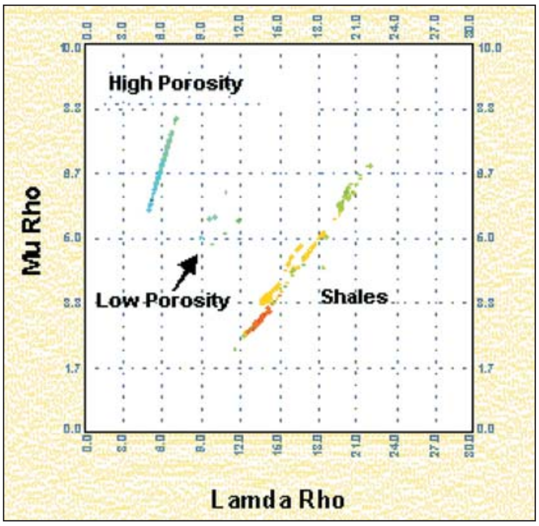


Fig. 5. Cross-plot of two AVO attributes showing the separation in sands and shales as well as the highlighting of reservoir quality.

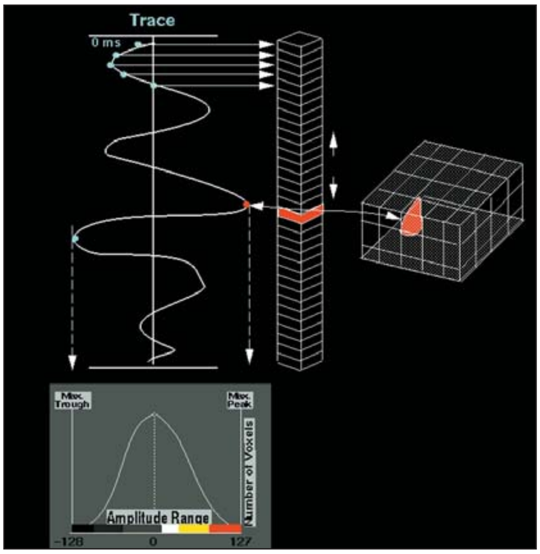


Fig. 6. Diagram relating voxels and the seismic trace. Seismic samples can be converted to voxels (or 3D pixels) that are assigned attributes (such as amplitude or coherency). The voxel can then be turned on or off dependant on what attribute the interpreter wishes to focus on.

Interpretation Tools

Many seismic interpreters are faced with the challenge of creating geologic models from seismic datasets that can reach several thousand square kilometres in size. In today's fast-moving exploration environment, these geoscientists are also required to make more rapid exploration decisions from this data. In order to reduce risk and shorten the cycle time between data acquisition and drill decision, it has become imperative that modern seismic interpreters have the tools at hand to enable them to interpret more of this data in the most efficient manner.

During the past decade, the seismic interpreter witnessed the continued development of innovative interpretation software. These applications are increasingly written to take advantage of the high-end graphics capabilities of modern scientific workstations. In the late 1980s and early 1990s, workstation interpretation systems were utilised primarily as devices with which the geoscientist could better manage his seismic data, view and digitise on planes selected from that dataset, and convert his digitisation into a map that most accurately described the subsurface. In the late 1990s, volume interpretation became popular. In volume interpretation, the data is displayed as voxels (or 3D pixels) (Figure 6). Voxels are assigned certain attributes (such as amplitude) that can be made transparent, allowing the interpreter to 'see through' a large seismic dataset (Figure 7). This display gives the user a sense of depth and an immediate appreciation of the structural detail of an area. Within the voxel volume, the interpreter has control over how the data are scaled and can isolate certain parts of the data spectrum. Such manipulation is ideal for bringing out fine structural and stratigraphic detail

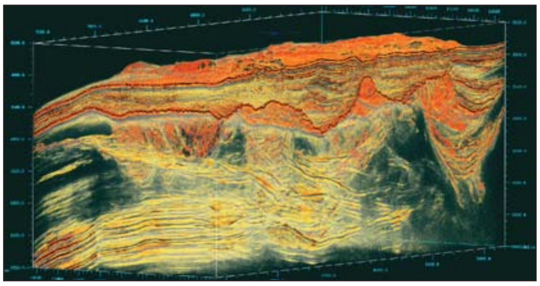


Fig. 7. (above) Voxel cube from the deepwater Gulf of Mexico. This cube is from a 3D survey that is approximately 875 km^2 in surface area. Note how some voxels have been turned off allowing the interpreter to 'see through' salt. Manipulation of such data cubes can allow the seismic interpreter to more rapidly understand areas of complex structure.

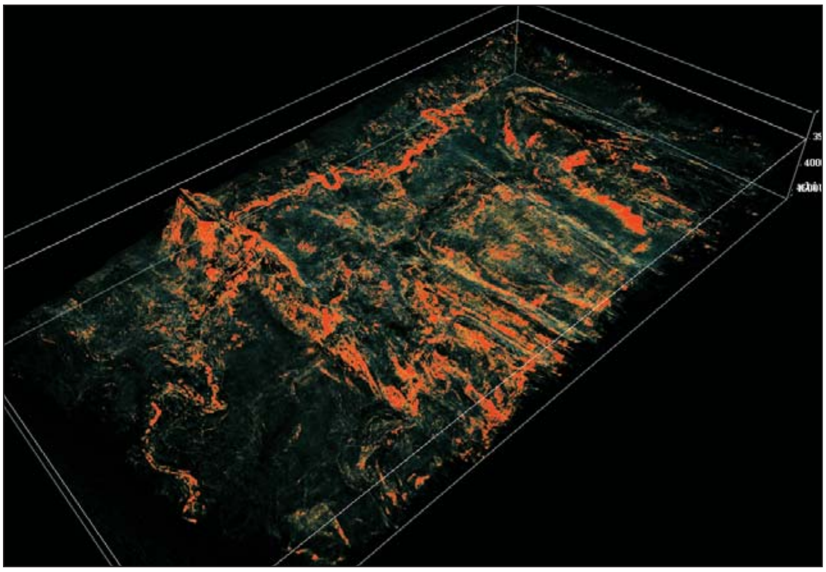


Fig. 8. (right) Voxel cube from deepwater Nigeria. Note how selective display of certain voxels allows the interpretation of a deepwater channel running E-W through the dataset. Channels such as this one can be sand-filled and serve as important hydrocarbon reservoirs.

Fig. 9. Veritas' collaborative Visualisation Centre in Perth, Australia. Centres such as this are allowing scientists from different disciplines to collaborate on difficult interpretation problems.

(Figure 8). Through such displays, a good seismic interpreter can make important geological observations before he even begins to digitise and map on the dataset.

Gone are the days where the geophysical interpreter is isolated in his office or workroom with geophysical sections displayed on computer screens. Now entire exploration teams are working in collaborative visualisation centres. These centres come in many forms and are becoming quite commonplace in many large oil companies. Some centres utilise immersive techniques where the interpreter is surrounded by data through the use of curved screens and rear-projected images on walls. Other centres create giant workstation environments where large groups of people can interact on a problem in front of large rear-projected 'powerwalls' (Figure 9). A significant advantage of these facilities is that they allow for easier interaction between groups of geoscientists that are concerned with the same or similar interpretation problem.

With the increased power of computer graphics now being employed in these visualisation centres, much structural information can be derived through the effect of parallax by putting large complex voxel volumes in motion. Pre-drill management meetings occur in visualisation centres where the interpreter shows and moves a 3D cube of the seismic data, his interpretation, and the proposed well path with anticipated stratigraphy indicated along the well bore (Figure 10). Because of the prospect generator's ability to put the cube in motion and freely select what elements of his data are to be displayed, the audience can view the proposed exploration idea from any prospective. Many visualisation centres also make use of stereo imagery. This effect gives the audience added depth perception to more fully understand 3D relationships.

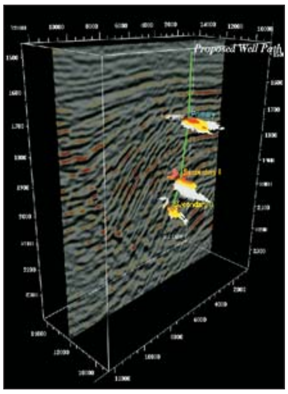


Fig. 10. Voxel volume, interpretation and well projection displayed for a well proposal. The 3D relationships between well projection, seismic anomalies, and interpreted horizons are made clear in displays such as this, especially when they are put in motion. Figure courtesy of Paradigm Geophysical.

Conclusions

As the volume and resolution of seismic data continues to increase, the role of the seismic interpreter will only grow in importance. The seismic interpreter will participate more in higher-end seismic processing streams and will be a key player on integrated work groups designed to fully describe complex reservoirs. As new techniques continue to be developed to derive greater information from seismic data, it is certain that seismic interpretation will play a more significant part in the exploration stream of the future.

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3D Visualisation and Volume-Based Interpretation

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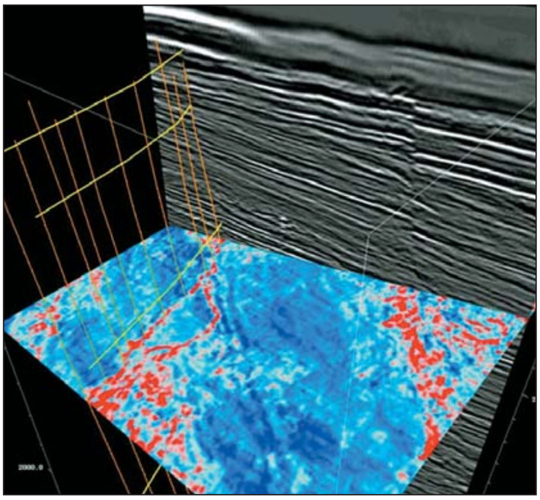


Fig. 1. An example of slice-based visualisation using amplitude on a vertical arbitrary plane and anomaly (edge) detection on time slice. This type of display is used in fault interpretation.

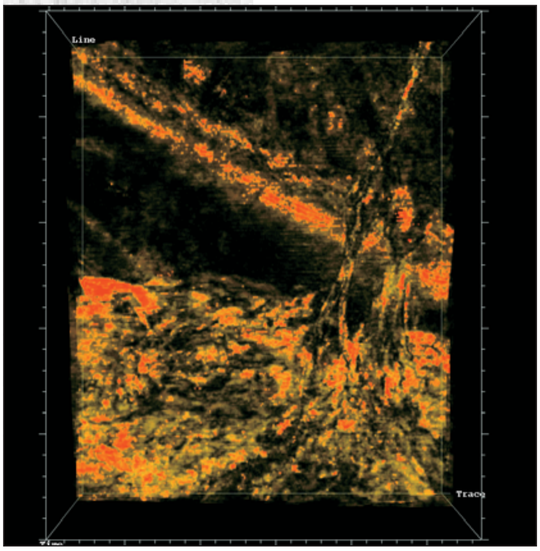
Over the past few years, 3D visualisation of seismic data by oil and gas companies has become much more widely used. Here I discuss the different types of 3D seismic visualisation and how 3D seismic visualisation is used to interpret seismic data.

There are actually two distinctly different types of 3D visualisation. The first type is **slice-based visualisation**. When working in a 3D data cube, 2D slices (such as inlines or crosslines) are represented as planes, which cut through the seismic volume. There are numerous types of slice displays and include such things as sections that cut orthogonal to the seismic survey, arbitrary traverses, box and chaircut displays. Box and chaircut displays are composites of inline, crossline, and time/depth slices. The various slice displays are often used together and are usually accompanied by 3D representations of horizon grids, fault surfaces, well data, and other digitised objects (Figure 1).

The second type of 3D seismic visualisation is referred to as **volume-based visualisation**. This type of visualisation uses either the entire volume or sub-divisions of the volume to focus on specific targets. Fundamental to volume visualisation is the use of opacity or, putting it another way, the degree of transparency. Opacity is used to selectively turn off data outside of the interpretation objective. Because opacity is applied to the entire volume, volume visualisation also uses data focusing techniques such as volume trimming or volume trimming around horizons or faults (Figure 2). Other important considerations in volume visualisation include viewing angle, foreground and background colour contrast, and foreground colour. However, in practice, volume-based visualisation is often used at the same time as slice based visualisation (Figure 3). For example, semi-transparent volume-based visualisations are displayed at the same time as arbitrary slices and well data in order to establish correlation between the visualisation and existing well information.

As interpretation while using slice-based visualisation is really an extension of 2D, line-based interpretations, many of the workflows are similar. For instance, intersecting vertical and horizontal planes are used to interpret horizons and faults in a similar fashion as in 2D based line interpretation. Because several slice orientations can be displayed simultaneously in 3D, complex structural relationships can be determined and understood more easily than working in 2D displays of the same data.

Volume-based interpretation techniques are fundamentally different to slice-based interpretation techniques. Volume-based interpretation itself is tied very closely to the 3D seismic visualisation process. The visualisation is used to restrict and possibly identify areas of interpretation interest before any detailed mapping is done. **Sub-volume detection** (SVD), the process of extracting seismic bodies, is the most frequently used volume-based interpretation technique. SVD can be done in several ways. Bodies can be tracked from a starting seed point using connectivity and an attribute range or they can be tracked using only attribute criteria. When bodies are tracked using attribute criteria only, 10s of thousands of bodies are identified and additional body filtering is performed.



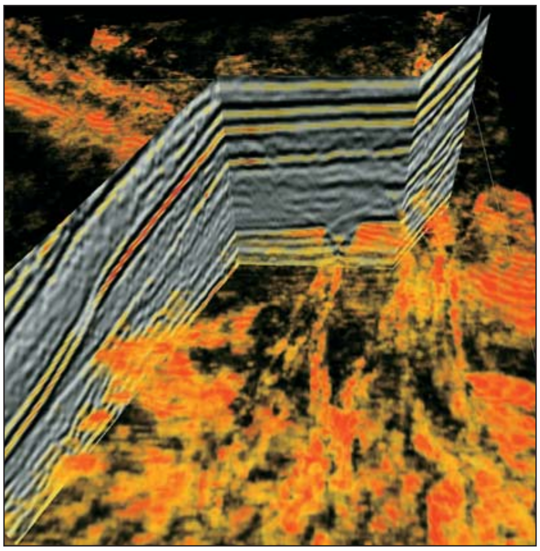


Fig. 2. (below left) A volume-based visualisation using horizon trimming to reduce data being visualised. Notice the two large incised valleys.

Fig. 3. (below right) A combined slice-based and volume based visualisation showing same visualisation as in Figure 2. The vertical slice is used to correlate the volume visualisation to a standard variable density seismic display.

Bundaberg Groundwater Project – a Unique Groundwater Geophysics and Hydrogeological Case Study

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Introduction

In 1998/99 a major study of the groundwater system of the Bundaberg Irrigation Area (BIA) was undertaken (Geo-Eng Australia, 2000). The project, a joint study involving the Department of Natural Resources (DNR) in Bundaberg and Geo-Eng Australia, was arguably the largest integrated geophysical, drilling and hydrogeological project for water resources assessment undertaken in Australia, involving up to 41 Geo-Eng, DNR and subcontractor personnel.

One of the primary objectives of the study was to acquire sufficient data on the extent and properties of the groundwater system to enable the establishment of a new groundwater model of the whole groundwater system of the BIA. Another primary objective was to systematically apply geophysical, geological and hydrogeological techniques in a combined study and gather permeability data by various methods for identification of permeability trends.

The project provides a case study, with many unique aspects, showing the value of a strong commitment to the use of geophysics through all phases of a major groundwater investigation. Firstly, the project budget enabled the use of ground resistivity and mineral industry slimline geophysical logging technology on a scale not usually affordable in groundwater studies. Extensive electrical geophysics guided a major drilling program of 130 new holes. Secondly, the study also showed the value of an integrated analysis of new and existing geophysical, hydrogeological and geophysical log data. Thirdly the application of modern sequence stratigraphic analysis techniques to the existing and new geophysical log data provided a more comprehensive understanding of the hydrogeology for sustainable management of the coastal Tertiary aquifer system groundwater resource. Finally, the geophysical logs proved pivotal in providing an assessment of permeability trends.

Groundwater Resources

The BIA is the third largest sugar producing area in Queensland, with a heavy reliance on groundwater to irrigate crops. The BIA is located approximately 370 km north of Brisbane on the Burnett River, and covers approximately 55 600 hectares from Childers to Bundaberg and Gin Gin (Figure 1). The deeper, higher yielding aquifer in the area lies entirely below sea level. Over-exploitation of the groundwater system in the 1960s led to saltwater encroachment into the aquifer system. A relatively small area within the BIA is currently a proclaimed groundwater area (PGA in Figure 1).

Seawater intrusion is a major issue facing coastal groundwater users who seek to exploit the aquifers for irrigation and town water supplies. An understanding of

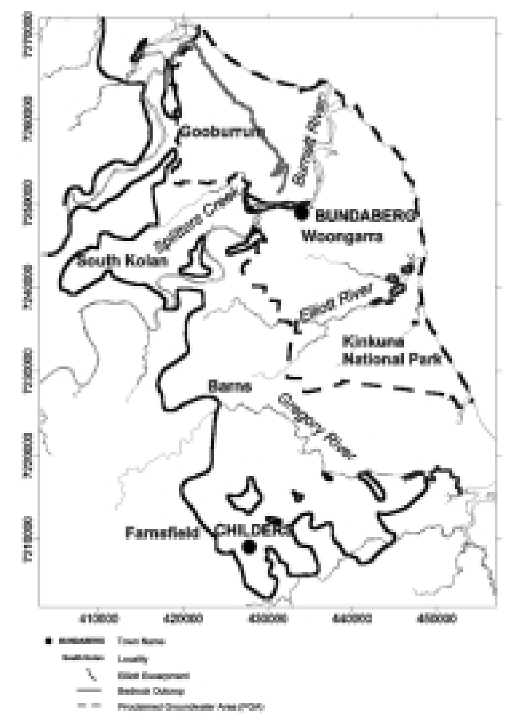


Fig. 1. Location of the project area, the coordinates are in metres (AMG).

the geometry of the groundwater basin and the aquifers within it is therefore critical to the management of groundwater extraction and the implications that groundwater extraction has for movement of the saltwater/freshwater interface.

To assist in planning and management of groundwater resources into the future the DNR is conducting a review of the groundwater system of the BIA, with a view to constructing a new groundwater model and reviewing the boundary of the PGA. The 1998/99 Bundaberg groundwater investigation was a key step towards realising the DNR groundwater management plan.

Geology/ Hydrogeology

The BIA groundwater basin, a shallow coastal Tertiary Basin with intra-Tertiary volcanics overlying arkosic Cretaceous sediments, is a common groundwater basin environment in coastal Australia, providing many challenges to geophysics and hydrogeology.

The basement rocks of the area are Cretaceous shales, siltstones, sandstones, greywackes, conglomerates and minor coal beds of the Burrum Coal Measures and the Maryborough Formation. Near the coast, the deeply weathered, early Tertiary Pemberton Grange Basalt (PGB) overlies the basement rocks. The basalt is extensively weathered to clay, and is generally considered to comprise part of the hydraulic basement, which is up to 120 m in depth. The final hydraulic bedrock elevation map, from the BIA investigation, is shown in Figure 4.

The overlying Tertiary aquifer system, beneath the coastal floodplain of the Kolan, Burnett, Elliott and Gregory Rivers, consists of the high yielding basal coarse sands and gravels of the Fairymead Beds and the shallower, lower yielding shoe-string sands of the more extensive Elliott Formation. The Gooburrum Clay, a thick sequence (up to 18 m) of grey clay and minor sandy clay separates the Elliott Formation and Fairymead Beds in the Gooburrum area and its distribution elsewhere is uncertain. In the past many bores bottomed in Gooburrum Clay (which was often falsely identified as bedrock) and possibly missed underlying Fairymead Beds. The Tertiary/Quaternary sediments, derived from up to four different river valleys, are variable, tending to be siltier north of the Burnett River. The aquifer system continues offshore and the effect of sea-level changes is not understood.

Figure 5 is the overall sediment thickness map. Figure 6 shows the extent of the upper unit of the basal Fairymead Beds. The Bundaberg Groundwater investigation has shown the deeper aquifer to be largely confined to a proto-Gregory River valley. The eastern edge of the proto-Gregory system on the Woongarra coast is weathered Pemberton Grange Basalt.

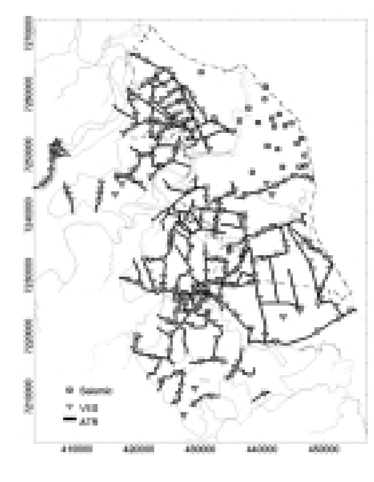
The water table/piezometric surface depth tends to be a few metres near the coast and near or below bedrock levels outside the deep aquifer channel towards the basin margins.

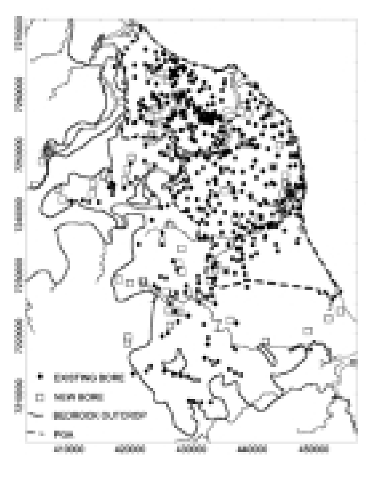
Pleistocene basalts (Hummock Basalt), containing low yielding, mainly perched aquifers occupy the prominent bulging coastal area of approximately 150 km^2 between the Burnett River to just south of the Elliott River. In this area a low basalt cone (Sloping Hummock) is a dominant feature on an otherwise relatively flat coastal plain landscape.

Groundwater quality varies, with water resistivities (Rw) less than 0.3 Ωm (sea water) to greater than 10 Ωm.

Fig. 2. (below left) Location of ATR traverses and VES and Seismic Soundings, the coordinates are in metres (AMG).

Fig. 3. (below right) Location of new and existing bores, the coordinates are in metres (AMG).





Geophysical Challenges

The aim with the geophysics and drilling was to systematically revise the hydrogeology and to install a more representative series of piezometers in the groundwater system. The challenge for the geophysics, over the project area (approximately 1800 km^2) was to guide the major drilling program in re-mapping the bedrock geometry and aquifer systems and dispelling ambiguity about Burrum Formation bedrock definition due to the unknown Gooburrum Clay distribution. The geophysics in particular was used to initially map the extent of the basal Fairymead Beds (a good aquifer, mostly saturated and of limited areal extent), the shallow Elliott Formation (a widespread, poorer aquifer often unsaturated) and if possible the intervening Gooburrum Clay. In addition there were buried basalts (distribution unknown). The physical challenge of daily processing and interpretation of data from three geophysical crews for the closely following 3-rig drilling program was a major concentrated effort and the almost constant feed back from drilling of the geophysical interpretations was unique and valuable.

It also became apparent early in the program that the geophysics would have to contend with:-

- variable depth to the water table in the Tertiary sediments (0 to 100% of bedrock depth),
- complex faulting in the sediments,
- variable water resistivities and
- an often high clay content with variable degrees of silt content in the sediments.

During the drilling program it also became obvious that the basal aquifer sands were often pyritic and this was important for geophysical log interpretation.

Summary of Work Undertaken

The Bundaberg Groundwater project consisted of the following work program:-

- Desk study including compilation of existing bedrock, water level and groundwater resistivity data from 300+ bores, previous ground geophysics (DC VES and seismic refraction), imaging and interpretation of topography data for recent faulting, interpretation of radiometrics for avoidance of clay soils that were detrimental to pilot radar surveys, interpretation of aeromagnetics for mapping of buried and offshore basalts and use of Landsat TM to visually assess the area.
- Prior to production geophysics, a phase of pilot geo-physics was undertaken to test a range of geophysical techniques that could enable mapping of bedrock depth, water table elevation, and changes in strata. The pilot geophysics program consisted of a total of 54 km of ground penetrating radar traversing, 32 VES, 14.6 km of DC Schlumberger resistivity traversing, 45.4 km of EM conductivity (EM34 and EM31) traversing and five shallow seismic reflection soundings.
- A major production geophysics program which (including the pilot geophysics) consisted of 705 km of DC Schlumberger resistivity traversing, 273 VES and 41 shallow seismic reflection soundings (see location of geophysical traverses and soundings in Figure 2). This

data from three geophysics crews was interpreted daily to site up to three bores per day.

- Production drilling with three rigs, in two phases totalling 5200 m of drilling of 134 boreholes on 90 sites (including 106 new constructed piezometers, a fully cored hole, 15 full length screen salt monitoring piezometers and 27 abandoned bores). The location of new and existing bores is shown in Figure 3.
- Geophysical logging by sub-contractor Geoscience Associates of 99 new open holes and 148 existing cased bores. Logs run included AMDEL pits calibrated gamma, neutron, dual density, caliper, focussed resistivity, induction conductivity, point resistance, SP and sonic. This was in addition to the database of 300+ DNR existing gamma ray logged holes.
- A program of slug testing for aquifer hydraulic conductivity of 61 bores.
- An aquifer sampling program of over 4200 samples, 496 sieve tests and 24 laboratory permeameter tests.
- Petroleum basin studies sequence stratigraphic analysis of geophysical and lithological logs to totally redefine the aquifer sequences.
- Analysis of all sample data, hydraulic conductivity data and VES and geophysical log data to test for various options for aquifer permeability determination.
- Data synthesis, interpretation and reporting.

Geophysical Investigation Results

The experience, both geophysical and geological, gained from this project is summarised below; space permits only a few illustrations of the results from the five volume survey report. To understand the hydrogeological context of the geophysical results, refer to the final bedrock elevation map (Figure 4), sediment thickness map (Figure 5), deep aquifer distribution (Figure 6 - upper unit shown) and water resistivity (Figure 7).

Landsat

Geocoded Landsat TM (better than 20 m accuracy in AMG) and digital cadastre with handheld GPS units proved in valuable for daily field crew navigation. The Landsat provided up-to-date definition of surface water dams and cropping activity and mapping of a previously unknown freshwater outflow just offshore of the Kincuna National Park. River outflows showed a Landsat water surface thermal anomaly whereas the dispersed sea-floor outflow had no surface thermal anomaly but a visible water bottom sea grass vegetation anomaly.

Topography

Lineament analysis of a DTM sun-angle image (topography being the simplest of all geophysical datasets) if available, is a recommended routine 'geophysical' methodology in hydrogeological investigations. Derived from the AUSLIG 20 m contour data and enhanced with stream profile data, the existing DNR 20 m x 20 m DTM proved surprisingly accurate (1.2 m RMS error). The lineament analysis of the BIA topography image is shown in Figure 8. The DTM has given a new insight to location of minor faults that have profound effects on modern (and presumably geo-historical) stream flows, influenced aquifer and volcanics distribution and created different coastlines over time.

Many Australian extensional Cretaceous/Tertiary basins, now under compression, have experienced extensive minor fault reactivation in Recent/Cainozoic times. The lineament analysis of the DTM image shows significant linear features, interpreted as possibly reactivated Cretaceous faults, throughout the project area (faults with a NW and NNW strike are dominant). One major fault detected during this project, and tentatively named the Childers Fault, is considered to have altered the course of the palaeo-Gregory River, diverting it along the course that it follows to this day. In addition, movement along major faults such as the Bullyard Fault appear to have isolated the Childers area, to a degree, (thicker sediment region in southwest of Figure 5) from the rest of the groundwater system. Study of Figures 5 and 6 gives an overall appreciation of structural control of sediment distribution.

Much of the surface drainage (Figure 1) in the region appears to be fault controlled, with faults appearing to have disrupted the continuity of the Tertiary cover (eg Splitters Creek). Faults with throws of a little as 2 m have been detected and knowledge of their occurrence in aquifers less than 5 m thick as is often the case in the BIA, is critical to an understanding of aquifer continuity in ongoing groundwater modelling and management.

Radiometrics

The early AGSO radiometrics was of low quality (1.5 l crystal, flying height of 150 m and 1.5 km line-spacing) but higher quality data to the north showed the promise of radiometrics for soil mapping. Despite the low data quality, the AGSO radiometrics proved useful in mapping the low clay soil areas for choice of GPR test sites. The radiometrics also mapped the Hummock Basalt low potassium nepheline basaltic soils and gave insights into the possible effects of recent faulting and the four river valleys on soil distribution across the coastal plain. Correlation with recent DNR soil maps was very good.

Aeromagnetics & Water Chemistry

Horizontal derivative with AGC processing of the earlier low quality AGSO aeromagnetics economically mapped the low susceptibility subsurface and offshore volcanic distribution. A key result was demonstrating the confinement of at least the early stages the Hummock Basalt to offshore of a postulated older coastline, which coincided with a clear degradation in groundwater quality, seaward of this older coastline in the Woongarra area, evident in the groundwater resistivity image (Figure 7). The topography image (Figure 8) also supported the prior coastline postulate. The coastline can also be seen on the long section (Figure 10).

The lower water qualities historically experienced in Woongarra could be explained by long exposure of the aquifer to the sea-bed and mixing effects in the aquifer and not seawater intrusion due to over-pumping of the aquifer. A low fresh water drive in the aquifer, implying poor aquifer recharge and slow release of salt store in the aquifers clays would need to be invoked to explain the water chemistry. The implications of this are considerable for groundwater management in the Woongarra area. This combined magnetics/ water chemistry/ topography data analysis has demonstrated the value of data integration.

Note: In Figures 4, 5 & 6 the colour bar units are in metres; in Figure 7 the colour bar units are in Ωm and in Figure 9 the colour bar units are in Ωm². Figure 11 only displays the style of the composite logs used in the interpretation.

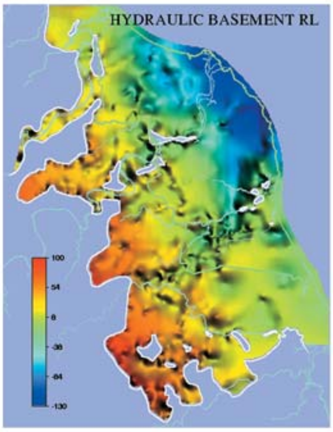


Fig. 4. Bedrock RL

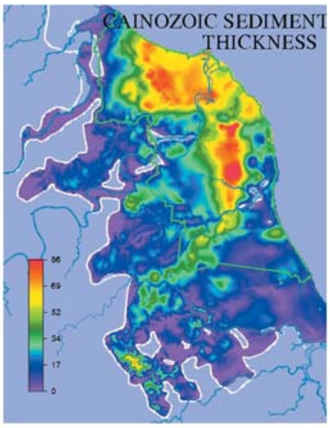


Fig. 5. Sediment thickness

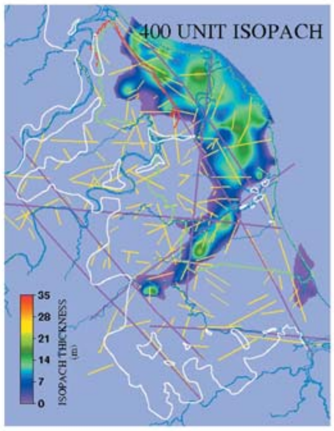


Fig. 6. Deep aquifer location

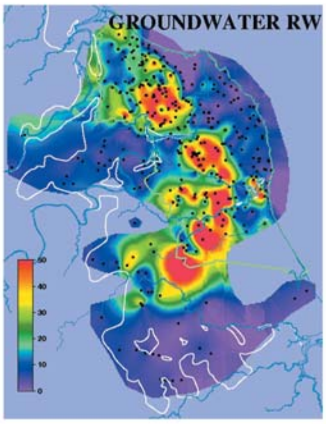


Fig. 7. Water resistivity

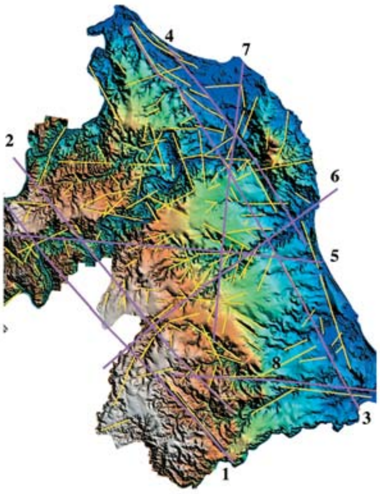


Fig. 8. Topography and interpreted structure

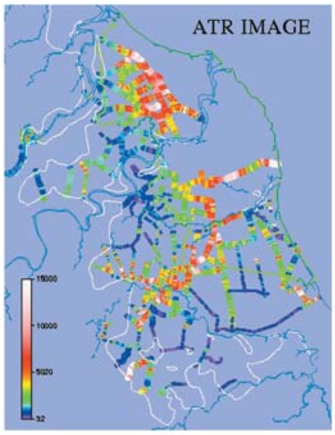


Fig. 9. ATR results

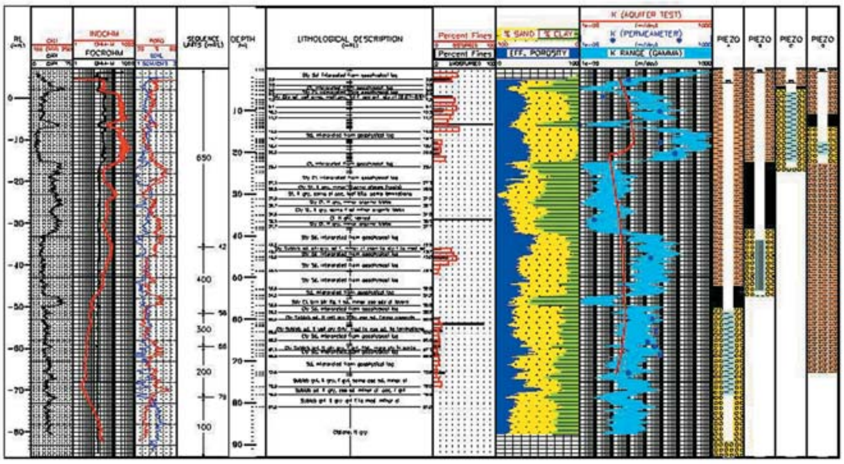


Fig. 11. Composite Log

Ground Penetrating Radar

GPR was trialled but proved to be of little value in the BIA. Despite choice of sandy soil areas delimited by radiometrics, a generally clayey substrate limited GPR penetration to typically less than 5 m with 25/ 50 MHz radar, too shallow for water table/ aquifer/ bedrock mapping even on the basin margins.

Resistivity Traversing & VES

Resistivity traversing for mapping the sediment/ aquifer apparent transverse resistance (ATR), followed up by VES, proved useful in locating permeable areas for piezometer siting and mapping the basin margins and was continued through the production phase of geophysics (see locations Figure 2). Three Schlumberger traversing crews (AB/2 = 30 or 60 m) traversed up to 10 km per day along roads. The VES tested ATR anomalies prior to bore siting.

Apparent transverse resistance (ATR) is the resistivity - thickness product of the dominant resistive layer in the sediments. Although affected by sediment thickness, water quality variations and water table depth, high ATR values generally indicate predominantly higher resistivity, sandy (or silty) sediments (above and /or below the water table) and low ATR values indicate the predominance of lower resistivity clays (again above and /or below the water table). Figure 9 shows the ATR image. High ATR values correlate well with the deep, northerly trending, Fairymead Beds aquifer distribution (Figure 6). Narrower ATR anomalies indicate shallower, east-west trending, aquifer channels in the Elliott Formation.

Figure 10 shows a long section down the proto-Gregory deeper aquifer (Figure 6), from the Childers area to the sea, just south of the Burnett River mouth. The cross-section shows the salient aspects of the redefined groundwater system and shows variations in topography, sequence distribution, basement elevation, water quality and ATR values normalized for water resistivity (which is effectively apparent Formation Factor x thickness in geophysical logging parlance). Subtle changes in bedrock level correspond closely to limits of extent of successive aquifer sequences, suggestive of a history of fault movements controlling the evolution of the groundwater system sediment sequence. Localized ATR/Rw highs indicate shallow aquifer channelling, often against local minor faults.

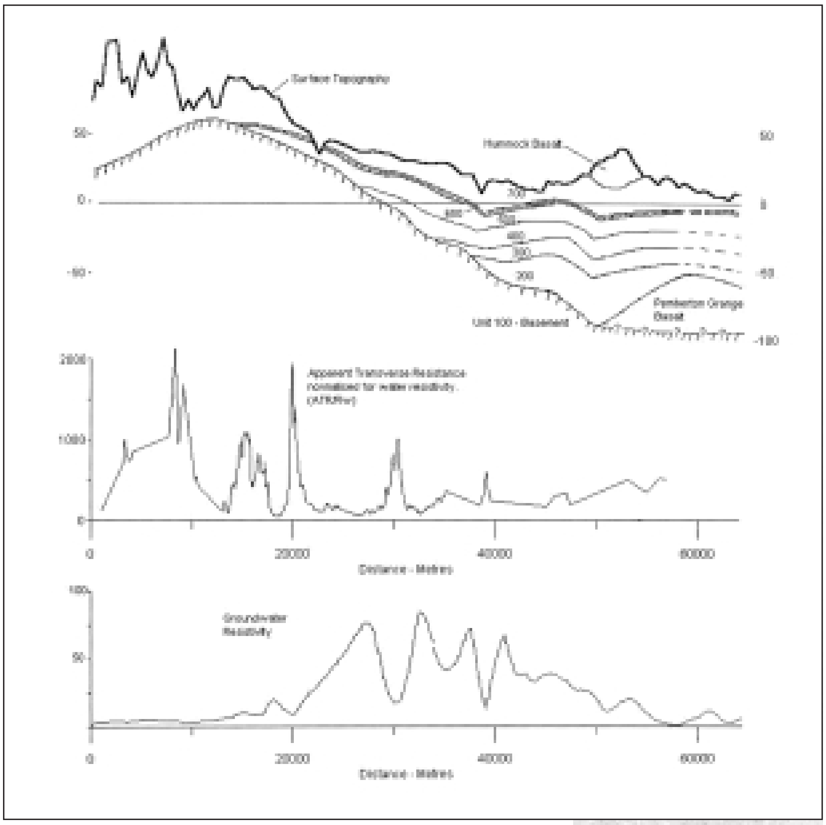


Fig. 10. Geological (ordinates in metres), and ATR/Rw Groundwater Resistivity (ordinates in Ωm) Cross Sections

In favourable circumstances the ATR values can also be empirically correlated to aquifer transmissivities (hydraulic conductivity - thickness product), where sediments are mostly saturated and clay and/or silt contents are not too great. These favourable circumstances rarely pertained in the BIA (only in the upper proto-Gregory region), due to the generally low elevation of the water table and the high clay content of most of the aquifer.

The dominant resistive (high ATR) layer occasionally proved to be dry aquifer above the water table. The ATR approach still proved valuable however in giving a regional picture of permeability (sand) distribution, synthesizing the considerable amount of borehole data (Figure 3).

Shallow Seismic Reflection

Shallow seismic reflection surveys using a Betsy gun source, 30 Hz geophones and a simple digital seismograph accurately mapped the sediment/bedrock interface (from <30 m to >120 m depth). Seismic proved particularly cost effective, compared with VES, in mapping both bedrock deeper than 60 m and the ridge of Pemberton Grange Basalt near the coast (see Figure 10).

Geophysical Logging & Log Interpretation

The majority of new bores were geophysically logged prior to bore construction or abandonment. The logs aided interpretation of bedrock (induction conductivity, density, gamma, neutron), and interpretation of lithology (gamma, focussed resistivity). The sonic log, intended as a porosity log, proved unusable in the aerated muds of the shallow holes drilled during this project. Pyrite nodules in the lower aquifer prevented use of the calibrated density log for porosity determination also. Gamma corrected neutron (to overcome the effects of clay porosity) was used to estimate effective porosity and gamma was used to estimate clay content. A simple three-component (clay/ sand/ porosity) petrophysical model of the sediments was calculated.

Considerable effort was made to correlate various log combinations with field aquifer tests, laboratory permeameter and sieve analysis derived permeabilities. Nine orders of magnitude variation in permeability were encountered in the Bundaberg sediments. In the end a simple correlation of calibrated API gamma with permeability was used (+/- one order of magnitude error in permeability was estimated).

Figure 11 shows a typical composite log depicting the calibrated logs, lithology, sample analysis, sand/clay/ porosity, laboratory and field permeabilities, log derived maximum - minimum permeabilities, and multi-level piezometer construction. The calibrated logging program and composite log displays set a new standard in Tertiary groundwater investigations and demonstrate the possibilities and limitations of using modern calibrated logging suites in clay affected unconsolidated sediments.

Sequence Stratigraphy

The conventional log interpretation approach in unconsolidated sediment groundwater investigations is connecting bodies of sand or clay. A sequence analysis of lithological logs, the new suite of geophysical logs and simple gamma logs of existing bores was undertaken with the aim of mapping the succession of geological sequences, relating distinctive changes in deposition environment caused by geological events (e.g. sea-level change, fault reactivation and stream energy changes). The sequence analysis process determined the stratigraphic framework on which all other interpretations would be based. This sequence analysis resulted in the delineation of 10 units (including basement, two basaltic units, three Fairymead Bed units, a Gooburrum Clay Unit, two Elliott Formation units and a Holocene coastal sediment unit). This scheme subdivides the previous two aquifer conceptual model and gives a better hydrogeological understanding (refer to Figure 10).

From the bedrock elevation map (Figure 4) and the sequence analysis, a series of sequence top and isopach maps (eg Figure 6 - 400 unit) showing the distribution and development of the sequences over the area was produced. Often structural control is suggested (eg movement on the Childers Fault resulted in cessation of deposition of the 400 unit (Figure 6) and subsequent marine ingress and deposition of the Gooburrum Clay - 500 unit).

The sequence stratigraphic maps and log-derived permeabilities were combined to produce variations in sequence permeabilities across the region. All this data is available for input to future groundwater models.

Conclusion

The mass scale of this investigation and the ability to comprehensively analyse in an integrated fashion many disparate geophysical and hydrogeological datasets has provided the opportunity to develop and test different methodologies in groundwater geophysics. Normal groundwater investigation budgets do not generally support this type of effort. The benefits and limitations of data integration, pilot geophysical programs, major use of electrical geophysics, calibrated logs, modern sequence stratigraphic approaches and a systematic program of permeability estimation has been demonstrated through the Bundaberg Groundwater investigation.

Acknowledgements

Credit is given to DNR project management staff Bill Souter and Peter Baker for their foresight, encouragement and support in bringing this project to fruition. Peter Baker's former experience of geophysics and large budgets, as a petroleum geologist, proved pivotal in this regard. We thank DNR for permission to publish the paper.

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Geo-EngAustralia, 2000 - Bundaberg Groundwater Investigation Project, 1998/99 - Phase 1 & 2 Final Report.

Expressions of Interest

Storage and Distribution of ASEG Publications

The ASEG is seeking Expressions of Interest from members willing to manage the storage and distribution of back-issues of ASEG publications (Exploration Geophysics, Preview and Special Publications).

The following outlines the requirements:

· Clean storage and accessibility for about 2-3 cubic metres of books.
· Provide an order receipt and delivery service.
· Provide stocktake and sales summary reports.

The ASEG will reimburse a reasonable monthly fee for storage and management of the stock, plus a commission on each sale.

For further information and expressions of interest, please phone Andrew Mutton (07 3327 7610) or email: **andrew.mutton@riotinto.com**

Andrew Mutton
ASEG Publications Committee Chairman

Major Gravity Survey Planned for NT

The NTGS has announced that a major gravity survey over part of the Tennant Inlier in the Northern Territory will soon be starting. The survey will combine new stations with existing gravity data that has been kindly provided by a number of companies who have historically worked in the area.

They will collect approximately 1500 stations at 4x4 and 2x2 km spacing over the Tennant Creek 1:250 000 Sheet area and the northern part of the Bonney Well 1:250 000 Sheet area. The survey will be jointly funded by the NTGS and AGSO.

The NTGS will welcome expressions of interest by anyone wanting additional stations collected in the region, or wishing to utilize the gravity crew whilst it is in the Tennant Creek area.

Please contact Andrew Johnstone (andrew.johnstone@nt.gov.au) on 08 8999-5340 if you have any questions, or require additional details.

Data Releases from NTGS

The NTGS, has recently released a spatial index of open file company geophysical data currently held in digital format by NTGS. The index, available in both MapInfo and ArcView formats, is downloadable from the NTGS website at:

http://www.dme.nt.gov.au/ntgs/geophysics/company_surveys.html

This index will be updated approximately every three months as additional surveys are released into the public domain.

Digital data corresponding to individual surveys can be ordered through NTGS at:

mailto:geoscience.products@dme.nt.gov.au clearly stating your desire to obtain open file company geophysical data associated with a company report (CR) identified from the spatial index.

Any queries to: Tracey Rogers (Manager Geoscience Information) on 08 8999-5279.

Encom Awarded Grant to Develop an Expert System for 3D Magnetic and Gravity Interpretation

Encom Technology has been awarded an Australian Federal Government R&D 'Start Grant' of $700k, to assist with the development of a new concept in magnetic and gravity interpretation. The research project is entitled, 'A User Guided Expert system for 3D Solid Geology Mapping from Magnetic and Gravity Data.'

Encom already has an advanced 3D magnetic modeling system called ModelVision Pro that is used throughout the world by mineral and petroleum exploration companies. ModelVision Pro is used to solve a range of simple and complex geological problems with joint modeling of magnetic and gravity data. The system is designed for professionals who need to constantly test different geological problems.

Encom's Managing Director, Dr David Pratt recognised that there is also a need for a fast and accurate tool that solves routine problems associated with the interpretation of magnetic and gravity data. "Worldwide exploration is focused on buried targets where the depth of cover varies from a few meters to a few kilometers. The truncation of magnetic lithologies at the buried unconformity surface produces magnetic anomalies in aeromagnetic surveys. From these anomalies we can determine the map location of the geological unit, its depth and magnetic properties. The magnetic properties can also be used to help interpret the lithology of the magnetic source rocks."

Encom's research grant is to develop Expert System technology for rapid determination of the distribution of magnetic rocks below cover. The Expert System applies the knowledge of an experienced geophysical interpreter to routine magnetic interpretation problems and is suitable for use by geologists and geophysicists.

The first two products from this research are called QuickMag and QuickPipe. QuickMag is due for release later this year and will be capable of resolving an irregularly shaped magnetic anomaly by mapping the boundary, depth and distribution of magnetic properties at the unconformity surface. QuickPipe is a fast solution for mapping the shape, depth and average magnetic properties of an intrusive pipe.

For more information about the Quick research project, contact:
Graham Butt, Business Development Manager
Encom Technology Pty Ltd
Tel: +61 2 9957 4117 (grahamb@encom.com.au)

Mineral Exploration Bottoms Out, Petroleum Still in Decline

Minerals up

In seasonally adjusted terms, mineral exploration expenditure for the June quarter 2000 increased by 4% ($7M) to $170M, the first increase in seasonally adjusted exploration expenditure since June quarter 1997 (see Figure 1).

However, the best news, in the figures released last month by the Australian Bureau of Statistics, was the significant increase in exploration expenditure in areas outside production leases. In the June quarter, expenditure on production leases was $37M while that on other areas was $145M, the healthiest result since June 1998. The drilling results reinforced the trend. While 408 km were drilled on production leases, a massive 1409 km were reported from other areas. This is the best result (in terms of 'green field/brown field ratio') since before 1998.

In actual expenditure, the figure reported for the June quarter 2000 increased by 34% ($46M) to $183M, the first increase since the June quarter 1999. Western Australia was the main contributor to the June quarter increase, up 33% ($28M), with Queensland and Northern Territory contributing $6m each, up 35% and 67% respectively.

Exploration expenditure for gold increased by 53% ($38M) for the June quarter 2000. This was the first time since June quarter 1999 that gold exploration expenditure has shown an upward movement. The majority of the increase for gold occurred in Western Australia, up 62% ($29M). Between the March and June quarters 2000, exploration expenditure for base metals (copper, silver-lead-zinc, nickel and cobalt) increased 5% to $40M.

Petroleum down

Although the mineral exploration levels appear to have bottomed out, the situation in petroleum continues to decline. In spite of record prices for oil in global markets the money spent in Australia over the last few years to find more oil has gone down and down and down. The reported expenditure on petroleum exploration in the June quarter 2000 was $146M, 9% ($15M) lower than the March quarter 2000.

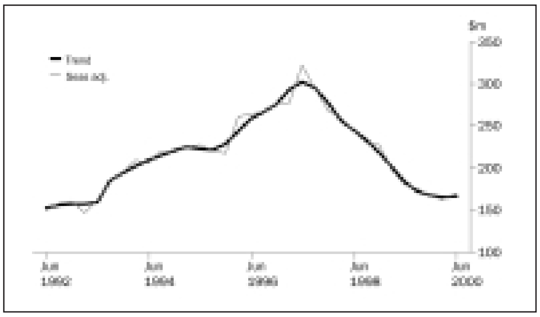

Fig. 1. Mineral exploration expenditure June 1992 to June 2000.

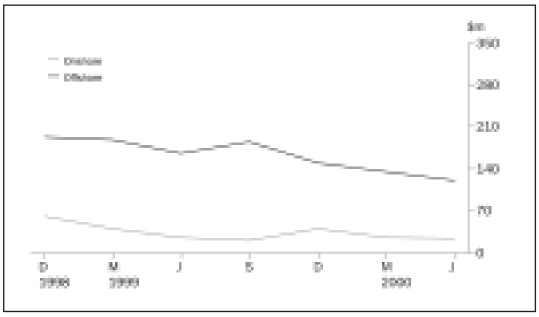

Fig. 2. Petroleum exploration expenditure December 1998 to June 2000.

Charts provided with permission of the Australian Bureau of Statistics.

Expenditure on onshore exploration fell by 3% ($1M) from the March quarter 2000 to a total of $24M, with onshore drilling expenditure falling by $2M in the quarter. The offshore figures fell by 27% to a record low of $122M. The poor result contributed to the 1999/00 expenditure being the lowest levels ($704M) since the $689M reported for the 1994/95 financial year. Figure 2 tells the story.

Rio Tinto ups the bid for Ashton Mining but De Beers likely to win

Takeovers are still the flavour of the month, and after Rio Tinto's successful bid for North, it is now closing in on Ashton Mining. Interest in the diamond producer has been keen over the last few months with De Beers kicking off the auction with an offer of $1.62 a share on 31st July. This was rejected on 12th September 2000 by the Board of Ashton Mining, which advised shareholders that an 'Independent Expert', KPMG Corporate Finance, had valued the company at $2.23 to $2.70 per share.

Naturally the Ashton Directors painted a rosy picture with a forecast net profit of $41.49M for 2000, more than double the $17.46M profit recorded for 1999, and rising to $48.57M in 2001. Earnings per share are forecast to rise to 12.6 cents in 2000, from 5.2 cents in 1999, and further to 14.9 cents in 2001.

The key features in the analysis were identified as:

- the strength in diamond prices which is widely expected to continue in the medium term;
- the likely extension to the mine life at the Argyle diamond mine to beyond 2018;
- exciting exploration success at Mauritania, where Ashton has announced the discovery of a diamondiferous kimberlite; and
- the potential that production at the Merlin diamond project in the Northern Territory will extend beyond current expectations after drilling there last month showed that several Merlin pipes increase in size at depth.

Meanwhile Rio Tinto made a counter offer on 29th August 2000 comprising:

- a cash offer of A$1.85 per Ashton share
- one Rio Tinto Limited share for every 15 Ashton shares
- one Rio Tinto plc share for every 15 Ashton shares

Ashton's largest shareholder, Malaysian Mining Corporation Berhad, which has a 49.9% shareholding, has entered into a pre-acceptance agreement with Rio Tinto in respect of 19.9% of Ashton's issued capital.

On 19th September 2000 Rio Tinto's Bidder's Statement for Ashton Mining Limited was lodged with the Australian Securities and Investments Commission, sent to Ashton, and filed with ASX. It looks like Rio Tinto will take the diamond prize. However, on 15th October De Beers raised its bid to $2.28, valuing the target at $745M. At the time of going to press it looks like Rio Tinto will not re-enter the bidding war.

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Tony Spenceley is an independent consultant based in Brisbane Australia. He established his own processing business in 1996 after working in Australia and overseas for Petty-Ray Geophysical and Veritas DGC. He is presently involved with the processing of a large 480-fold 3D data volume.

When is a Static Problem not a Problem of Statics?

Static corrections are computed and applied to seismic data in order to obtain a correct structural interpretation and to produce a high resolution section which can be used for stratigraphic interpretation (Marsden, 1993a). They are required to remove the effect of near-surface velocity variations; changes in the thickness of the weathered layer; and variations in surface elevations above the processing datum. There are a number of ways in which static corrections can be derived, the general principles of which have been reviewed briefly by Marsden (1993a,b,c).

It is a requirement of seismic data processing that intersecting lines tie in time within a specified tolerance limit. This is done by ensuring that any computed field statics at line intersections either fall within accepted limits or are tied back to a static value derived from uphole information. This latter approach ensures that the same field statics are applied to intersecting lines at that location. In spite of all these precautions, it is still possible for stacked sections from two intersecting lines to display significant mis-ties in time when compared with each other.

Consider the following simple one-layer weathering model, outlined in Figure 1 and Table 1, which typifies situations commonly found in parts of western Queensland. The model comprises two flat surfaces, at an elevation of 100 m and 50 m respectively, which are connected by a steep incline.

Table 1: Model Details

Weathered layer:	Vw=1000 m/s; Depth=20 m
Sub-weathering:	Vsw=2000 m/s
Processing Datum:	0 m
Station Interval:	25 m
Shot Interval:	25 m
# live channels:	96, symmetrical split spread
Fold:	48

Figure 1: Model of Data

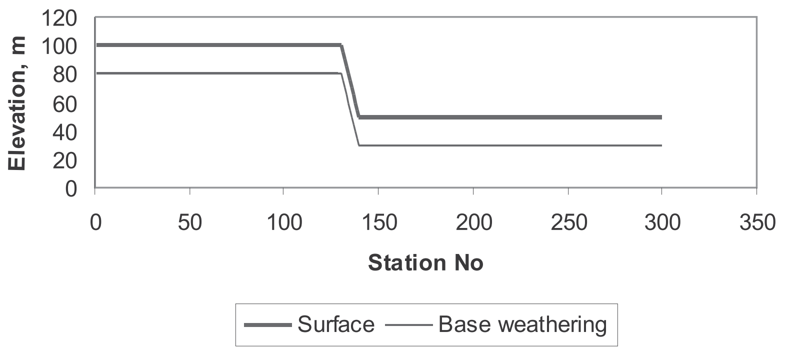
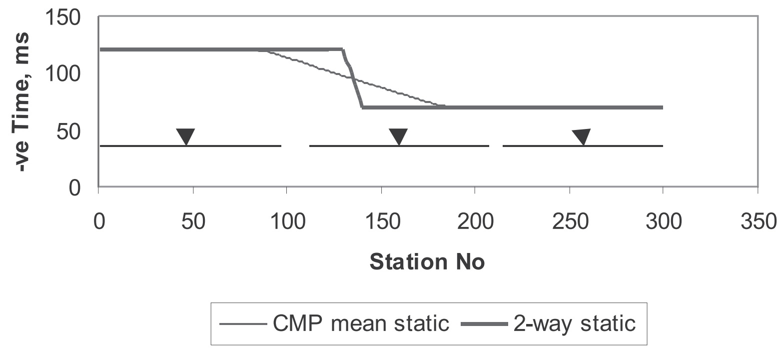


Figure 2: Static Profiles



Field statics derived from this model are presented in Figure 2. Two-way time statics vary from -120 ms on the upper surface to -70 ms on the lower surface. Values associated with the steep incline are interpolated between the two limits.

Statics are usually applied during the processing of land data in two steps. A mean static is derived for values within a CMP gather from which deviation statics are computed. These high frequency statics are applied pre-stack whilst the CMP mean statics are applied post-stack. This allows most of the trace-to-trace jitter within a gather to be removed. A surface consistent approach is used for processes such as the derivation and application of stacking velocity functions and mutes. The deviation statics are usually small compared with the CMP mean statics. What is important is the fact that the application of the deviation statics does not move the relative location of the CMP in time. This is achieved with the application of CMP mean statics.

Figure 2 illustrates the effect that statics associated with the steep incline have on the computation of CMP mean statics. The short lines at the bottom of the graph indicate the receiver stations which would contribute information to the CMP mean static calculations within CMPs located at stations 48, 160 and 260. These calculations are shown in Table 2. Inspection of Figure 2 reveals that the values of the field statics and the CMP statics are identical between stations 1 to 83 and 187 to 300. Differences of up to 20 ms occur at the intermediate stations. Values for the field statics are greater than the CMP mean statics between stations 84 to 134 and are less between stations 136 to 186.

The next step is to introduce an additional line, line 2, which intersects line 1 at right angles. Identical field and CMP mean statics will be derived for line 2 irrespective of where it intersects line 1 because of the constant elevations and depths of weathering imposed by the model. However, there will be significant differences in the applied CMP mean statics for the two lines depending on the location of the intersecting lines. Consider the statics which are derived and applied at intersections located at stations 48, 160 and 260 on line 1.

Table 2:

Computed two-way Field (A) and CMP Mean Statics (B), ms

	Line 1		Line 2	
	A	B	A	B
Station 48	-120	-120	-120	-120
Station 160	-70	-82	-70	-70
Station 260	-70	-70	-70	-70

Stack sections will tie if the lines intersect at either station 48 or 160 on line 1. However, the data on a stack section for line 2, which intersects line 1 at station 160, would be located 12 ms later in time in comparison with the data on line 1. The differences between the field and CMP mean statics noted above means that any line which intersects line 1 between stations 84 and 186, with the exception of station 135, will have a different CMP mean static. This will result in the two lines *never* being able to tie in time. Data on line 2 will be located closer to the surface in time if they intersect line 1 between stations 84 to 134. Conversely, they will be later in time if they intersect line 1 between stations 136 and 186. The nett result of an incorrect location in time for the data on line 1 will cause an incorrect derived depth section in that area.

The model used in this exercise was constructed to demonstrate the effect of a change in surface elevations on the derivation and application of statics during the processing of data, assuming a constant depth of weathering. Similar effects could result if there were minimal variations in surface elevations but significant directional changes in the sub-surface due combinations of variations in weathering velocities and depths of weathering within an area. These could be associated with buried channels or structural components such as near-surface graben.

It is perhaps ironic that the problem described above will have been exacerbated as our ability to acquire more data has improved. This is due to the fact that spread lengths have increased in conjunction with the number of recorded channels. Whereas 15 years ago 2D data were recorded, in Australia, with 120 channels spread over 1500 m (symetrical split spread), data are recorded more commonly today with 240 channels and a far offset of at least 3000 m. Consequently, the potential extent along a line which could be influenced by intersection misties in time could have doubled with an associated increase in line lengths which could have incorrect time-depth conversions and associated interpretation problems.

What this model demonstrates is that not all mis-ties within 2D data sets result from the inappropriate derivation and application of field statics. This is because attempts are being made to resolve what is a spatial problem using 2D data acquisition, derivation and application techniques. The problems would be minimised if the data were collected and processed using 3D techniques.

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Academic Press

ISBN 0-12-643140-X
1417 pages
ARP: A$185.00

Reviewer:

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Modern volcanology has benefited greatly over the last 20 years from people who have invested time and effort into compiling large, comprehensive books on different aspects of volcanism. Mammoth compilations that come to mind are *Basaltic Volcanism of the Terrestrial Planets* (1981); the USGS's Professional Papers on Hawaiian volcanism (a double mega-volume) and the Mount St Helens 1981 eruption; and, most recently, the *Fire and Mud* volume on the 1991 Mount Pinatubo eruption in the Philippines. Now these giant publications have been joined by a heavyweight newcomer, *Encyclopedia of Volcanoes*. This impressive compilation of information covers all major aspects of volcanism. It runs to 1417 numbered pages, weighs 3.7 kg, has an editorial team of five well known names in volcanology (led admirably by Haraldur Sigurdsson), relies on no less than 112 contributors, and contains 82 separate articles. No other single volume on volcanology published previously is so comprehensive in approach and detailed in content. *Encyclopedia of Volcanoes* was compiled at the end of the previous millennium. What better platform to take volcanology forward into the new millennium than to have this volume published in the year 2000.

The scope of the book can be appreciated by scanning the following list of titles of the nine parts that make up the volume: Origin and Transport of Magma; Eruption (eruptions in global overview); Effusive Volcanism; Explosive Volcanism (by far the largest of the nine parts); Extraterrestrial Volcanism; Volcanic Interactions (the least well defined of the nine parts); Volcanic Hazards; Eruption Response and Mitigation; and Economic Benefits and Cultural Aspects of Volcanism. There is not much that is left out from the volume. Even petrology and rock geochemistry find appropriate places, which was good to see, bearing in mind the aversion that some of the older generation of physical volcanologists still seem to have towards these topics!

Encyclopedia of Volcanoes is easy of use. There is a general summary at the beginning of each of the nine parts. Each article (within each part) in well organised, and has a glossary at the beginning and references at the end, so making each contribution self-contained. The readability of the articles is enhanced by effective editing and by an apparent absence of cross-referencing between articles, which otherwise would interrupt the flow of reading. There is an index of articles (arranged alphabetically) at the front of the book, as well as a good general index of subjects at the back. Also tucked away at the back in Appendix B is a 'Catalog of Historically Active Volcanoes on Earth' by Tom Simkin and Lee Siebert, developed and condensed for the Encyclopedia from another benchmark publication of the late twentieth century, *Volcanoes of the World* (Geoscience Press, 1994). This appendix is especially valuable, particularly taken in conjunction with the compact article on global volcanism on page 249 (also by Simkin and Siebert). There are several sections devoted to colour photographs of eruptions, deposits, volcanic landforms, and so forth. These enhance the overall attractiveness of the Encyclopedia and are a valuable resource in themselves for people needing to give slide and Powerpoint lectures on volcanism.

The logic of the arrangement of articles in the nine parts is quite easy to follow, although I did stumble about a bit at first. For example, I looked under the Economic Benefits part (Part IX) for something on copper-gold mineral deposits in volcanoes, but found the appropriate article in Part VI on 'Volcanic Interactions'. Similarly, Steve McNutt's well-constructed piece on volcanic seismicity appeared under Volcanic Hazards (Part VII) yet the article was not intended to be about hazards. Indeed, volcano-monitoring information in general was scattered throughout the Encyclopedia - readily accessible through the index, yes, but scattered nevertheless. An excellent Synthesis of Volcano Monitoring is provided (by three of the Associate Editors) perhaps to counteract this, but the synthesis appears under Part VIII (Eruption Response and Mitigation). Perhaps consideration should have been given to having volcano monitoring as a separate part to the Encyclopedia.

Works of this type have the potential to be inherently flawed and imbalanced because uniformity of quality depends, unreasonably, upon the sum of the equal contributions from different authors with different approaches, skills and abilities. *Encyclopedia of Volcanoes* largely escapes this pitfall. However, several articles do tend to have an overemphasis on the USA or else remain quite parochial in relation to the all-embracive 'global' title of the article. I made the mistake of trying to pick out some of the better articles (for the purposes of preparing this review) but failed miserably as the general quality is so high and such choices are mainly subjective anyway.

I have discussed with colleagues whether the title of the volume rather understates the scope and style of the subject matter. Most people, I think, would regard an 'encyclopedia' as a compendium of topics or subjects arranged alphabetically under single-word (or phrase) titles, rather like in the venerated, English-language, *Encyclopedia Britannica*. A better title might have been just *Volcanology*, had this not been used for previous books on the subject. The final name is probably fine, however, given that this Academic Press production will probably now be referred to simply, and unambiguously, as '*The Encyclopedia*'.

Congratulations must be extended to the contributors, editors, article reviewers, and publishers of a fine piece of work. The Encyclopedia is a monumental achievement and will form a standard reference for many years to come. I remember a colleague of mine in 1981 having a carpenter make for him a special wooden lectern for his copy of the huge *Basaltic Volcanism of the Terrestrial Planets*. He set the short lectern near his desk and would rotate repeatedly on his swivel chair to access the book behind him and 'mine' it for information. Such veneration! I am thinking of doing the same thing with my copy of The Encyclopedia.

Volumes like this one are of course terrifying, to the extent that they set such high standards and may frighten off otherwise bold people from the essential challenge and on-going task of synthesising bodies of information that grow exponentially. Digital information management in volcanology is likely to gain prominence in the not-too-distant future and perhaps is an issue that could be addressed by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) in conjunction with volcanological agencies with experience in such matters. The Encyclopedia serves to focus attention on this emerging issue.

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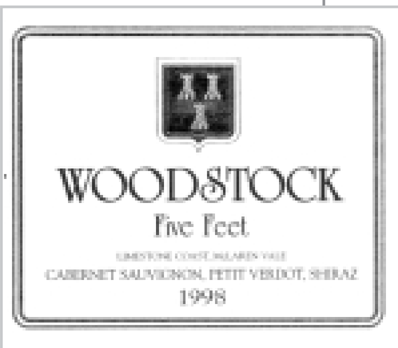
The ASEG SA Branch is pleased to be able to present the following two wines to you after tasting a field of wines in the price range. These wines were found by the tasting panel to be enjoyable drinking and excellent value. The price of each wine includes bulk delivery to a distribution point in each capital city. Delivery is planned for early December.

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

Woodstock 'Five Feet' 1998

Cabernet Sauvignon, Petit Verdot, Shiraz

Made from McLaren Vale and Limestone Coast fruit. The palate delivers Cabernet Black currant and eucalypt, then violets and Mocha from the Petit Verdot finished by the rich spice of Shiraz. The flavours will combine and evolve with bottle maturation.



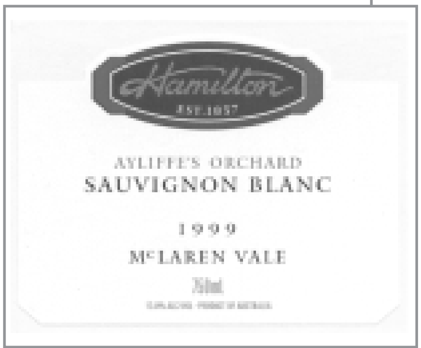
The name 'Five Feet' comes from the wooden stocks found in the town of Woodstock in England. These stocks have five holes, to hold five feet. The wine was named for the mysterious (and unfortunate) feet that these stocks were designed for.

Normal retail price is around $180 to $195 per dozen.

Hamilton Ayliffe's Orchard

Sauvignon Blanc 1999

The fruit for this wine comes from two vineyards in the McLaren Vale each with distinct soil and micro-climate. The palate displays a refreshing burst of ripe passion fruit and guava, finishing with a cleansing lick of crisp and savoury natural acidity. Ideal to drink now with a range of light and medium flavoured dishes.



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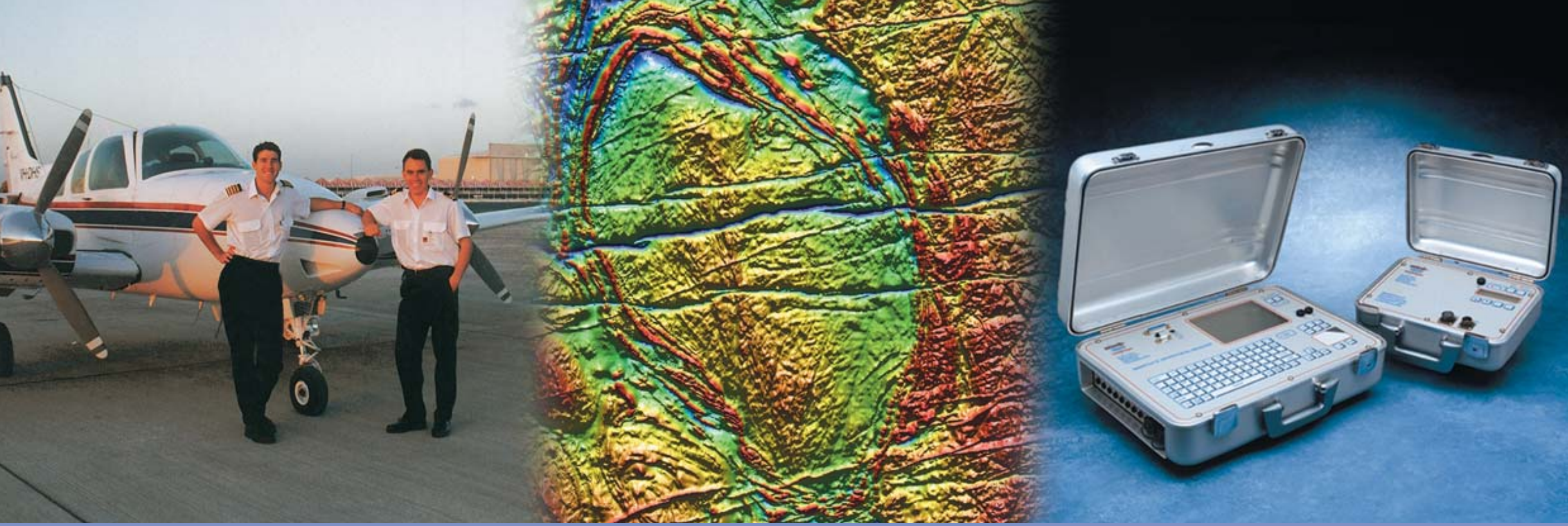

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