

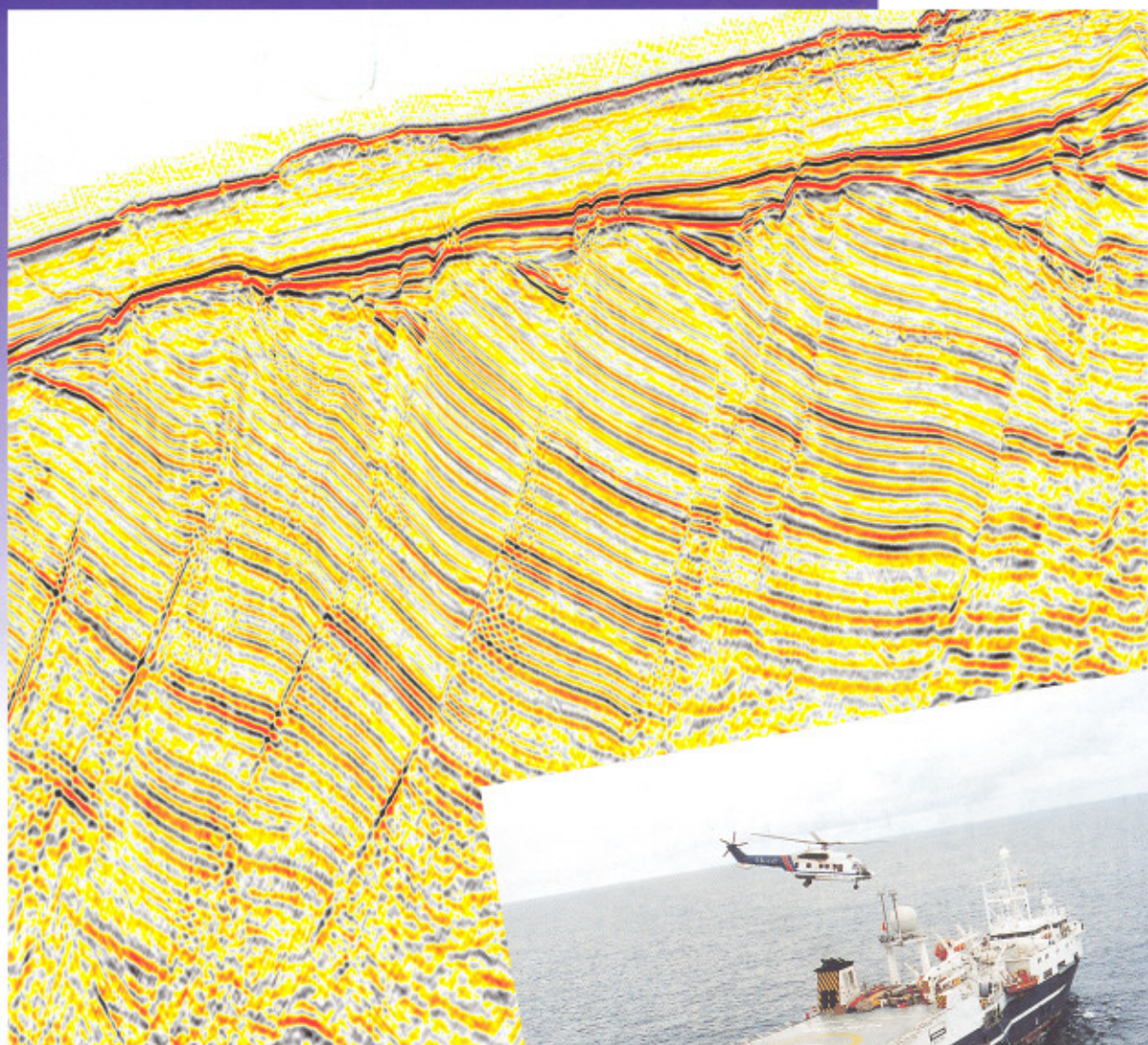
Preview



Australian Society of Exploration Geophysicists

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December 1999 Issue No. 83



Petroleum Offshore Exploration:
Where Has the Effort Gone ?

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I recently attended the 'Science meets Parliament' day at Parliament House in Canberra. The day was organised by FASTS, the Federation of Australian Scientific and Technological Societies, and comprised a series of meetings between 170 scientists and 140 parliamentarians. The aim of the day was to increase the level of awareness in the parliament, and with 170 scientists wandering around the House we made a noticeable impact, albeit for one day only.

The Hansard for that day contains several references to science but perhaps the best was the motion by Senator Stott Despoja:

That the Senate-

(a) notes that:

- (i) 24th November is 'Science Meets Parliament Day' in Canberra, and
- (ii) this event provides a great opportunity for members of parliament to meet scientists from their electorates;

(b) congratulates the Federation of Australian Scientific and Technological Societies for organising this event; and

(c) urges all political parties to recognise the importance of science to this nation's future, economically, socially, culturally and environmentally, and to adopt policies which reflect this. (my italics)

Most people, and I am sure all our readers, would agree that science and technology is vital for Australia's future. However, debate on this issue is usually restricted to our universities, research institutions, and the policy branches of government departments. It is time there was public debate on the role of science and technology in Australia, and what level of public investment should be provided. If nothing else the day on 'The Hill' raised the profile of Science in the Parliament.

The ASEG was represented by our President, Mike Smith, and Ray Shaw; the Australian Geoscience Council by its President, Bob Day; the Geological Society of Australia, by Gary Lowder, Sue Keay, and myself; and the Australian Institute of Geoscientists by Greg Corbett. In addition, the Geosciences were represented by Bob Carter (JCU), Malcolm McCullogh (RSES), Jock Keene (Uni. Sydney), Tom Loutit (SRK) and Brian Embleton (CSIRO).

I am sure that Mike Smith will expand on this event in his next President's piece, but I would like to take the opportunity to say a little about FASTS. This represents about 60 science and technology societies, and has a seat on the Prime Minister's Science, Engineering and Innovation Council and is frequently consulted by government on a range of issues. It is therefore in the position to be a very powerful lobby group.



The Earth Science cluster contains the following 'societies' under the umbrella of the Australian Geoscience Council:

- Association of Exploration Geochemists
- Australian Geoscience Information Association (AGIA)
- Australasian Institute of Mining and Metallurgy
- Australian Institute of Geoscientists
- Australian Society of Exploration Geophysicists
- Geological Society of Australia
- Institute of Australian Geographers
- Petroleum Exploration Society of Australia (PESA)

We therefore have a good conduit to government on matters relating to science policy.

So much for the politics of science. I would like now to thank all those contributors to Preview 82. Our new Publisher produced a quality output and the feedback I have had has for the most part been very positive, particularly with respect to the quality of the Feature Articles. There are still improvements we can make, and I would appreciate any feedback on ways we can make Preview even better. Please send in your suggestions.

One initiative we would like to make is to have a regular website column on sites that may be of interest to Geophysicists. So if anyone would like to surf the web and provide interesting chat on these sites, let me know.

This is the last issue of Preview until the Conference Edition. I hope all our readers had a relaxing Christmas, and I look forward to the challenges 2000 will surely bring.

David Denham, Editor

69th SEG Annual Meeting



As ASEG President I had the privilege of representing our Society at the SEG Council Meeting, at various SEG Committee events and in the Exhibition Hall of the 69th Annual Meeting in Houston, Texas, from 31st October to 4th November 1999. The Council Meeting received reports from the Executive and approved changes to the SEG Bylaws as well as providing the opportunity to meet many office-holders including past, present and future Presidents of SEG.

The dominant theme of SEG management over 1998/99 has been Fiscal Responsibility - that is, careful monitoring of expenditure against income, with reductions in outlay where possible (mostly in the area of publication costs - see for example Lee Lawyer's column From the Other Side in Vol.18 No.6 of The Leading Edge. The very close parallels with the primary concerns of the SEG and those of the ASEG Federal Executive so far during 1999 are particularly striking, and our operations can certainly benefit from the experience and decisions of the SEG. In this respect our Society is most fortunate in having Brian Spies as our current Vice-President and 2000/01 President-Elect. There was considerable evidence of Brian's previous contributions to the decision-making process within the SEG (culminating in his award of Life Membership) and I was repeatedly asked of Brian's well being and whereabouts. The ASEG has progressed the development of a Procedures Manual for the ASEG Secretariat in Brisbane and plans to move towards a comprehensive Procedures Manual detailing all functions of the ASEG, using the SEG Manual as a base document.

A feature of all of the contacts with SEG staff was the enthusiastic expression of a strong commitment of SEG leadership, including the then President Brian Russell and newly elected President Bill Barkhouse, to support overseas members. It was frequently remarked that more than forty per cent of SEG membership lives outside USA and this percentage continues to increase over time. Our Perth 2000 received special mention by President Brian Russell, and the Perth Conference is promoted at all international conferences that the SEG supports. Both Brian Russell and newly elected President, Bill Barkhouse, will be attending the ASEG Conference in Perth.

The Houston conference attracted an impressive total of 11 090 registrants. The exhibition area was huge and very spacious with a dominant petroleum perspective as would be expected in Houston. The opportunity to participate in immersion 3D reflection interpretation was a remarkable experience, especially when the interpreter in downtown Houston telephoned the supervisor of the drill rig located offshore and they independently manipulated the 3D display while discussing drilling strategies. Another display permitted the user to rotate a cube, thereby rotating a three dimensional seismic section, with movable bars to advance or retract sections of data (a stimulating experience for a humble minerals geophysicist). The exhibition area also featured a 19 computer Internet Café sponsored by Sun Microsystems, which allowed convenient

sending and receiving of emails (as well as Rugby World Cup reports - important, as there was no television coverage). The ASEG's complimentary booth was well positioned to provide brochures on the Perth 2000 conference and other data on Australia. The lecture halls and the poster areas were also very spacious, with impressively large three-panel displays for each poster. The dominant use of PowerPoint presentations was also notable.

Student Geophysics

Kay Wyatt is the dynamic chairman of the SEG Student Section, the achievements of which include a student newsletter, student exposition, electronic mentor system and two slide sets. The mentor system is supported by 42 volunteer mentors who provide online answers to student's questions about exploration geophysics. Excellent geophysical teaching material is provided on the SEG Student Connection at <http://students.seg.org>, and also on the SEG museum site on <http://seg.org/museum/>. The site contains a Virtual Museum, which is accessed at <http://seg.org/museum/VM/>. There is potential for the ASEG to contribute student site information on environmental geophysics and mining geophysics.

Geophysical Inspiration

A highlight of the SEG was meeting petroleum geophysicist Jaime Jaramillo from Colombia who has spent over 25 years rescuing neglected and abandoned children from the alleys and sewers of Bogota. His aim is to provide a safe, caring and healthy environment for these kids with their rehabilitation ultimately leading to training and employment in the petroleum industry. Jaime's remarkable story is presented in Children of the Darkness published in January this year by Cartographics S.A. - reference number ISBN 958-96643-0-X and his charitable Fundacion Ninos de los Andes has the web site www.ninandes.com. It would be terrific to have Jaime speak to audiences in Australia one day.

European Connection

During the conference, many rewarding encounters occurred with EAGE representatives Markku Peltoniemi (President), Etienne Robein (Vice-President), Anton van Gerwin (Business Manager) and Jean-Claude Grosset (Secretary-Treasurer), focussing on participation in the Perth 2000 Conference. The second issue of high interest was the Rugby World Cup where my use of the SEG Exhibition Internet Café enabled me to be the first to advise the delegates from France of their team's great rugby victory over the New Zealand All Blacks on the first day of the SEG Meeting.

Australian Geoscience Council

The representatives of the AGC met in Brisbane on 16th October for a Saturday planning meeting, which resulted in substantial changes to the operation of the Council requiring changes to the Council's constitution. The key change is that members will be represented on the AGC by very senior members of the executives of the member organisations (President, Vice President or CEO). This ensures that AGC issues involve the executives of member

bodies with a commitment to implement approved procedures. The ASEG has taken on the task of submitting revisions to the AGC constitution and feedback on these draft changes have already been received. The Council, which is no longer based in any particular city, met again by teleconference on 11th November and allocated responsibilities for various other tasks. The member organisations voted to give the required one-year notice of withdrawal from FASTS (- this was last done in 1994 but the notice was subsequently withdrawn). Meanwhile, the ASEG will participate with other bodies in monitoring of the role of FASTS, which receives substantial funding from the AGC.

accompanying workshops. Mark 12th-16th March in your calendar, plan for travel, plan for accommodation and plan for pleasure. U.S. delegates who attended the Hobart Conference spoke in praise of ASEG's ability to organise high quality technical events, and Perth 2000 is likely to be bigger and better.



Perth 2000

Finally I would like to remind members to work on their planning to attend ASEG's Perth 2000 Conference and the

Mike Smith
President
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MANAGING EDITOR

EXPLORATION GEOPHYSICS

Applications are invited for the position of Managing Editor - Exploration Geophysics, to oversee the editorial content and the production of all issues of Exploration Geophysics.

The role will be similar to that of the current Editor, but with greater management input, and with more of the 'hands-on' editing role to be assigned to Associate (or Special) Editors. The Managing Editor will be required to work with the ASEG publisher to ensure that the ASEG's long-term financial and technical publishing goals for Exploration Geophysics are met.

The term of the appointment is for three years from July 2000 to June 2003. The Managing Editor will be responsible for all issues of Exploration Geophysics (including the 2001 and 2003 conference issues), as well as any Special Publications.

As with all ASEG offices, the position is honorary. However, in recognition of the scope of the role, the ASEG will assign the Managing Editor a budget (to be negotiated) to cover the Managing Editor's and Associate/Special Editors' costs and/or honoraria.

Applications should be sent before 28 February 2000 to:

Andrew Mutton
ASEG Publications Committee Chairman
GPO Box 459, Brisbane Qld 4001

Inquiries can be made to Andrew Mutton (email andrew.mutton@riotinto.com or phone 07 33073500) or to Brian Spies (phone 02 9850 9292).



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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.

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Deadlines

Preview is published bi-monthly, February, April, June, August, October and December. The deadline for submission of all material to the Editor is the 15th of the Month prior to issue date.

Therefore, editorial copy deadline for the February 2000 (ASEG Conference Edition) edition is 15th January 2000.

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 first week of the month of issue. Therefore, the advertising copy deadline for the February 2000 edition is the first week of February.



Events for 2000/2001

2000

March 12-16

Australian Society of Exploration Geophysicists, 14th International Conference and Exhibition, Perth, WA.

'Exploration Beyond 2000'

Address: PO Box 890, Canning Bridge, WA 6153

Tel: (61) (08) 9332 2900

Fax: (61) (08) 9332 2911

Email: promaco@promaco.com.au

Website: <http://www.promaco.com.au/conference/2000/aseg/>

March 16

Southern Africa-Australia

Mineral Sector Synergies Symposium

AusIMM 5th annual Australia-foreign mineral country collaborative symposium

Information: hancock@geology.anu.edu.au

April 26-27

4th Australian Geomagnetism Workshop, Canberra ACT

Organised jointly by the AGSO and the ANU

Tel: (61) (02)-6249 9111

Fax: (61) (02)-6249 9913

Email: Heather.McCreadie@agso.gov.au

Website: <http://www.agso.gov.au/geophysics/geomag/>

May 7-10

APPEA 2000, Brisbane, Queensland, "Innovation for the Third Millennium". Call for papers to: Steve Taylor, Santos,

Email: steve.taylor@santos.com.au

Website: <http://www.appea.com.au>

May 23-26

The 8th International Conference on Ground Penetrating Radar, (GPR 2000) Gold Coast, Queensland, Australia.

Call for Papers and information to:

Email: grp2000@csee.uq.edu.au

Website: <http://www.cssip.uq.edu.au/gpr2000>

May 29-June 2

European Association of Geoscientists & Engineers, 62nd EAGE Conference and Technical Exhibition, Glasgow, UK.

Website: <http://www.eage.nl>

June 11-15

16th World petroleum Congress, Calgary, Canada

Email: cdn.assoc@wpc2000.com

Website: www.wpc2000.com

2001

August 6-9

Australian Society of Exploration Geophysicists, 15th International Conference and Exhibition, Brisbane, QLD.

Website: <http://www.aseg.org.au>

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Conference Workshops

PETROLEUM INDUSTRY WORKSHOPS

a) Practical Reservoir Geostatistics for the Petroleum Industry

Date: Saturday 11th March

Venue: WACA Ground

Fee: A\$350 (includes morning/afternoon tea, lunch)

Presenter: Loz Darmon

Course Content

This course is intended to provide a practical introduction to the basic concepts of Reservoir Geostatistics, and how these techniques can be applied to Oil and Gas Industry data. Special attention is paid to both the advantages and limitations of each approach, illustrated by examples from a variety of data types. These analysis methods are both flexible & powerful, but like any approach, must be understood for maximum benefit. The course is intended for a broad spectrum of professionals, and does not require any statistical background. Topics include:

- Introduction to Geostatistics - how to use in the real world - typical applications.
- Basic Theory - Univariate and Bivariate Statistics.
- Spatial Continuity Analysis - the Variogram and Correlogram.
- Spatial Interpolation using Kriging.
- Incorporation of Seismic Data using Cokriging.
- Incorporation of Seismic Data using External Drift.
- Sequential Gaussian Simulation & Cosimulation.
- Analysis and use of the results - Volumetric applications.
- Classification - combination of methods.

Each section contains a workshop example to illustrate the subject, which will be performed by the students on a (UNIX) workstation.

b) The Fundamentals of Seismic Attribute Analysis

Date: Saturday 11th March

Venue: WACA Ground

Fee: A\$540 (includes morning/afternoon tea, lunch)

Presenter: Christopher Lewis

Course Content

The use of seismic attributes to predict variations in a variety of sub-surface properties has become increasingly commonplace. There are however some fundamentals that should be followed to ensure reliable and believable results. Basic fundamentals should be understood and limitations appreciated to ensure 'best practices' use of attributes in the exploration, appraisal or development work program.

The aim of this course is to teach the participants the fundamentals of seismic attributes and attribute analysis. The course is tailored to those new to special projects geophysics workflow, or in need of a refresher of the basics. Of principle importance will be the limitations of the

method and when to, as well as when not to, use it. Calibration to well information, uncertainty of prediction and issues of scale (geological / geophysical / engineering) will all be covered.

The context of the course will be basic theory and practice, followed up and reinforced by learning through case studies. These case histories will include local examples, lithology and fluid prediction, time lapse 3D, detailed structural mapping and 3D volume segmentation and body tracking.

c) Risk and Uncertainty Modeling in Geophysics

Date: Sunday 12th March

Venue: WACA Ground

Fee: A\$195 (includes morning tea and lunch)

Presenter: Alistair Fletcher

Course Content

The management of exploration, appraisal and production is a problem of leveraging the expertise of a company to maximize the potential of the asset. The management of the asset is a process that requires the gathering and integration of evidence of many different types from different experts with all kinds of uncertainties.

A brief overview of risk and uncertainty within the oil and gas industries will be given at the start of the workshop, including an overview of some software products designed to manage these risks and uncertainties.

This workshop will then focus on a methodology and tool for handling the management of an asset with reference to its development uncertainties. It is a generic technology that can be applied across the business. Originally developed by the University of Bristol, it has recently been extended by CSIRO. However, the specific focus of this workshop will be on the subsurface where the likelihood of success of a prospect will be addressed. Case study results from applications will be presented.

The method has three elements:

1. A process model of the management process highlighting dependencies.
2. A record of the attributes of the process.
3. A rich uncertainty calculus for the integration of uncertainties.

The uncertainties are expressed using interval probability that allows the evidence for success to be separated from the evidence against success. The whole approach is implemented in a highly visual graphical environment that allows new users to build new models very quickly.

Case studies have shown that the added value comes not just from the numerical assessment of the overall dependability of the project, but from improved communications both inside and outside the team. A shared understanding of the situation is developed and misunderstandings resolved. The model gives a one page pictorial overview of where the project stands, showing

The following pre-conference workshops will be held on Saturday 11th March and Sunday 12th March.

Some workshops will have limited numbers so early booking is advised.

Further details will be available on the conference website: www.promaco.com.au/conference/2000/ASEG/

Otherwise enquiries can be directed to:

John Jackson on email: jacksonj@sog.com.au or Anita Heath on email: Haddon@ozemail.com.au



where the vulnerabilities and sensitivities are. In terms of corporate memory it provides an easy-to-assimilate record of how the conclusions were reached and a shared memory for the team.

d) Seismic Facies Analysis – The Application of Geological Knowledge to Seismic Interpretation

Date: Sunday 12th March

Venue: WACA Ground

Fee: A\$350 (includes morning/afternoon tea, lunch)

Presenter: Loz Darmon

Course Content

Hydrocarbon Exploration and Production activities now involve increasingly complex reservoir systems. At all phases of the exploration and production cycle, seismic data play an essential role in the interpretation process of such systems. A key element to this process – and one that is often difficult to perform – is the effective application of geological knowledge to this interpretation.

Seismic Facies Analysis uses a slightly different approach to the traditional attribute-based methodologies. It is based on the following premise: 'Does the shape of the seismic trace contain geological information – if so, can it be classified & quantified?' Seismic Facies analysis uses trace shape and Neural Network techniques to provide an objective classification of reservoir heterogeneity.

The workshop concentrates on the practical aspects of this quick and extremely efficient approach. Examples are given to illustrate the approach from start to finish. Each section contains an example to illustrate the subject, which will be performed by the students on a (UNIX) workstation. Topics include:

- Introduction to the Seismic Facies Map.
- Defining the reservoir interval.
- How the Neural Network is used to classify trace shape.
- Creating a Seismic Facies Map.
- Seismic Facies Analysis & Quality Control.
- Piloted and unpiloted methods – using well data to calibrate the map.
- Refining the Seismic Facies Map.
- Combining the classification with traditional attributes.
- Practical use of the Seismic Facies Map in Exploration & Production Scenarios.
- New applications and possible uses.

e) Industry Forum on Multi-component and Elastic Wave Applications

Date: Sunday 12th March

Venue: WACA Ground

Fee: A\$95 (includes afternoon tea)

Presenter: Various

Course Content

An industry forum has been proposed to discuss the applications and experience of multi-component seismic to reservoir characterization and structural investigation. Multi-component seismic can be considered in the general

sense of accessing the elastic wave field through multi-component sea-bed systems, by 3 component VSP data or access to the shear wave field through advanced down hole sonic systems. There have been a number of developments in these areas that are applicable to exploration environments in Australia. The topic is equally attractive to petroleum and mineral industries and the proceedings will reflect applications in both arenas. We expect that it will provide a forum for vigorous discussion.

We are taking advantage of the gathering of geophysicists at the ASEG to provide this forum. In doing so we are keen to gauge the interest of potential attendees and their interests. Please contact **Kevin Dodds** at k.dodds@dpr.csiro.au to register your interest.

MINERAL INDUSTRY WORKSHOPS

a) Aeromagnetism – State of the Art Enhancement

Date: Saturday 11th March

Venue: University of Western Australia

Fee: A\$240 (includes morning tea, lunch and afternoon tea)

Presenter: Gordon Cooper, Duncan Cowan and Mike Dentith.

Course Content

This course will cover the theory and practice of enhancement of aeromagnetic data using the wavelet transform and comparisons with Fourier methods, methods based on fractals and chaos theory, texture filtering and also separation filtering and enhanced analytic signal. The course will consist of theory/lecture sessions with hands-on practical sessions using the filters covered in the theory. PC's with the data and software will be provided.

b) Geological Applications of Airborne Electromagnetics

Date: Saturday 11th March

Venue: WACA Ground

Fee: A\$130 (includes morning tea, lunch and afternoon tea)

Presenter: Richard Smith, Stephen Thomson, Peter Wolfram, Ken Witherly, Jovan Silic and Mike Hallett.

Course Content

The airborne electromagnetic (AEM) techniques have proven their value in the direct detection of mineral deposits, as well as such applications as geological mapping, kimberlite exploration and soil salinity mapping. This one-day course is designed to give geologists and geophysicists an overview of the possibilities and limitations of AEM for both, helicopter and fixed-wing systems with the focus on case histories and practical examples. The course starts with a brief overview on the basics of planning, operating, and interpreting an AEM survey. Using a series of modern case histories including discoveries from recent exploration projects, the capabilities of AEM systems are reviewed and discussed. This provides a basis for the practical interpretation of survey data. The course illustrates the benefits from new AEM systems as well as the latest technology for interpretative processing and visualization.



c) Advances in Electromagnetics for Exploration and Mapping in Australia – the View from CRC AMET

Date: Sunday 12th March

Venue: WACA Ground

Fee: A\$70 (includes morning tea, lunch, afternoon tea)

Presenter: G. (Jock) Buselli, Lisa Worrall, E. Tom Eadie, Tom Whiting, Brian R. Spies, Andy A. Green, Jim Macnae, Richard Lane, Tim Munday and Art Raiche.

Course Content

The Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET) has focused on the development of airborne electromagnetic (AEM) technology for Australian conditions for the last seven years. This workshop will give an overview of research outcomes, including developments in hardware, processing, interpretation and regolith characterisation, and lessons learned in collaborative R&D over the life of the CRC.

This will be followed by an open discussion on future directions in geophysical exploration technologies, research and development.

Presentations include:

Andy Green – Designing a cost-effective airborne EM system for Australia

James Macnae – The development of rapid imaging techniques to facilitate EM interpretation

Art Raiche – Using advanced EM modelling to maximise exploration effectiveness

Richard Lane – Case studies of the TEMPEST airborne EM system for discrete target detection

Andy Green – AEM for salinity mapping

Tim Munday – Regolith – friend or foe of the explorationist?

Tim Munday / Ken Lawrie – Mineral system exploration using AEM

Lisa Worrall – Using AEM for geochemical exploration

Jock Buselli – Ground electromagnetics for environmental monitoring

Tom Eadie (Pasminco) – The importance of new technology in an exploration program

Steve Massey (Western Geoscience) – AEM applied to mapping regolith thickness over gold deposits in the Laverton District, W.A.

Brian Spies – Cooperation, competition and coercion in collaborative R&D

d) Spectral & Hyperspectral Remote Sensing in Mineral Exploration

Date: Saturday 11th March / Sunday 12th March

Venue: WACA Ground

Fee: A\$ 370 (includes morning/afternoon tea and lunch)
(Computer rental not included)

Presenter: Bob Agar

Course Content

Remote sensing technologies are advancing rapidly and the exploration geologist is faced with many options when evaluating both regional and site specific exploration problems. This course is designed to develop a fundamental understanding of the principles and application of spectral remote sensing and provide the exploration geologist with the knowledge to determine where, when and how spectral data may be used. The aim is not to develop specialist image processing skills but rather to sharpen the appreciation and future application of the technology. As such, the course leans less on the purely theoretical side of remote sensing and more on the application of various data to detect and extract geological information. However, for those attendees who may wish to develop expertise in spectral remote sensing, the course nonetheless offers more than a basic introduction to the subject and is a valuable adjunct to more formalised training.

Although part of the course necessarily involves lectures and case histories, the emphasis is on hands-on practical workshop exercises in exploration scenarios using both satellite and airborne, multi- and hyperspectral data sets. A comprehensive workshop manual is provided along with CD-ROM containing the manual, lectures, case histories, data and exercises.

For the 'hands-on' practical exercises attendees are encouraged to bring their own laptops. However, a rental PC can be arranged if necessary at a cost of ~\$150. Minimum specifications for the PC would be Pentium 300MHz, minimum 1Gb free hard drive space and CD-ROM drive.

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS HONOURS AND AWARDS

During the 14th ASEG Conference to be held in Perth in March 2000, several categories of honours and awards will be presented to members who merit recognition for distinguished service to the Society and to Exploration Geophysics. ASEG Members are invited to submit nominations for the following awards:

- ☐ **ASEG Gold Medal** – for distinguished service to geophysics.
- ☐ **Honorary Membership** – for distinguished contributions to the profession of Exploration Geophysics.
- ☐ **Grahame Sands Award** – for innovation in Applied Geophysics. Is made to a person or persons who has or have been responsible for a significant practical development of benefit to Australian applied geoscience. This could be in the field of instrumentation, data acquisition, interpretation or theory.

Nominations are now called for the above awards. Any member of the Society is eligible to nominate applicants. Nominations are to be supported by a seconder and include four copies of all relevant supporting documentation. They are to be sent to:

*Chairman
ASEG Honours and Awards Committee,
8 Kearns Crescent
Ardross
WA 6153*

Tel: (08) 9316 2814 Fax: (08) 9316 1624 Email: bill@sgc.com.au

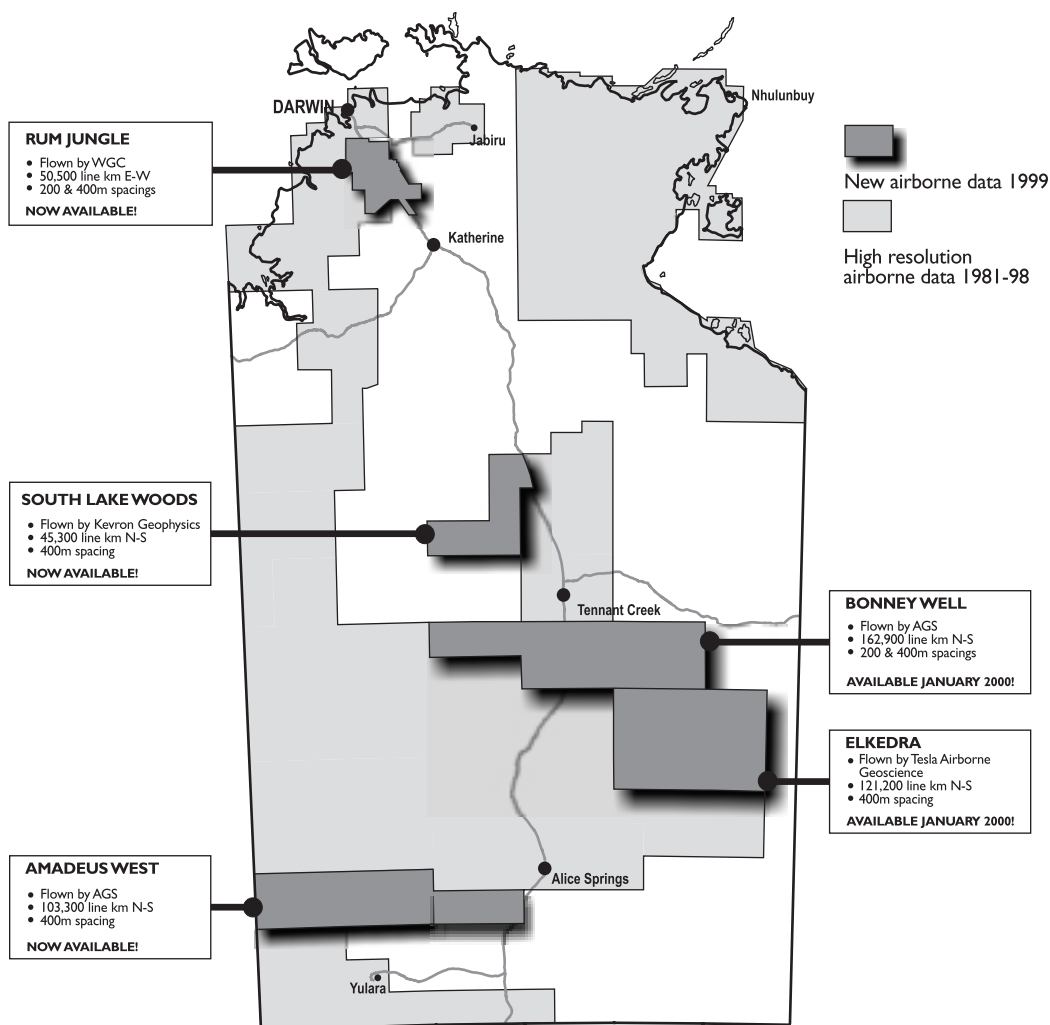
Applications will close on January 31st 2000

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 Website: www.dme.nt.gov.au/ntgs



Northern Territory Government



NORTHERN TERRITORY GEOLOGICAL SURVEY

Australian Geomechanics Society (AGS)

To ASEG members:

In these difficult times for exploration geophysics I would like to bring to the attention of ASEG members some information which may assist in broadening geophysical employment opportunities in the fields of engineering and environmental geophysics.

For the past six years I have represented the Australian Geomechanics Society (AGS) on Technical Committee No. 10 (TC10, Geophysical Site Characterisation) of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE). In 1994 this committee published the volume referenced below which I recommend to all involved in shallow geophysics. TC10 is now being hosted by the Swedish Geotechnical Society and is producing a regular newsletter that may be read at www.sgf.net/tc10.

The AGS is also organising a major international geotechnical conference, GEOENG 2000, Melbourne, 19th

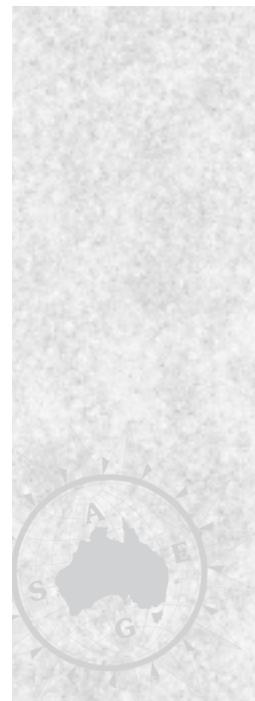
to 24th November 2000. Geophysical papers will be given at this conference and it presents an opportunity to meet and network with engineers and geoscientists from around the globe. I encourage your attendance. GEOENG 2000 can be contacted at www.icms.com.au/gеоeng2000.

If I can be of further assistance to any ASEG member on the above matters please e-mail me at bob_whiteley@coffey.com.au.

Dr Bob Whiteley
Director, Resources Division
Coffey Geosciences Pty. Ltd.

Reference

Wood, R.D. 1994. *Geophysical Characterization of Sites. Volume prepared by Technical Committee 10 for XIII ICSMFE, 1994, New Delhi India, Oxford & IBH Publishing (ISBN 81-204-0862-4) 141p.*






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Crisis in the Resource Industry

Dear Editor

Just two years ago in this magazine (Preview 70) I responded to Derecke Palmer's opinion that geophysics in Australia was in decline. At this present time exploration geophysics is in severe decline in Australia but not in a way that Derecke suggested. This time the forces causing the situation are well outside the control of our profession. I refer to the large cutbacks that have been made in the employment of geophysicists particularly by the large exploration companies. In the last two years we have as a result deleted hundreds of names from my company's contact lists. Also, scores of companies' offices in various capital cities no longer exist. Further to this see "Newspaper Headlines Tell the Story", which is just a sample of what I identified over the period November 1997 through August 1999.

It has been claimed by some that this is just one of the periodic downturns that are common to our industry and that it will bounce back up again as it has done in the past. It is my contention, from 30 odd years in the industry, that this is not just one of the troughs of our cyclic market but is primarily due to structural changes. On this occasion, there are new factors controlling the industry with important global ramifications. They include the collapse of the Soviet communist regime with a resultant flooding of the international market by their vast resources of commodities. Soon after this followed the Asian meltdown which resulted in many countries being unable to support exploration activities. This was just at a time when many Australian companies had departed the local scene for more favourable exploration prospects in other parts of the world. All the while, gold and oil prices were plummeting and gold was losing favour as a financial backing with national economies. (Recently the gold price was the lowest it has been for 20 years). In addition, many countries that were not exporting commodities in the past are now doing so, such as China and many South American countries. I believe the conjunction of all these new factors is what is driving this crisis. Until these factors change, and I can't see when and why some of them should in the short term, the current situation will continue. At the very best if we are just in a peak and trough situation and then this is the broadest and lowest trough that I can recall.

The result of this situation in Australia at least has left geophysical service companies with a greatly diminished market and consequently excess capacity. This in turn has lead to contract prices plummeting to rock bottom levels. For the customer, now has never been a better time to have a geophysical survey performed. However, the prices are so low that one wonders when the companies involved will face financial difficulties. In fact this may already even be the case already with some major companies both in Australia and overseas. I also wrote many years ago in this magazine about the danger of contractors quoting too low prices and not leaving any margin for the the necessary improvements in instrumentation, let alone making a profit. This situation is now far worse than it ever was then.

Roger Henderson

Newspaper headlines tell the story:

- 19 Nov '97 "Resource stock pounded again"
- "as the full impact of the blow down in world growth caused by the problems in Asia... BHP shares fell to its lowest levels since 1994... WMC fell... MIM down..."
- 11 Dec '97 "Trouble at mines as gold hits 18-year low"
- 19 Dec '97 "BHP slashes jobs"
- "the exploration staff in Perth Office will be halved."
- 31 Dec '97 "Goldminers facing big writedowns"
- "Copper slides to four-year low."
- 7 Jan '98 "Resources slump adds to currency strain"
- 30 Jan '98 "MIM cuts staff, halves exploration budget"
- closed its Perth office - to result in sacking of 50 staff.
- 13 March '98 "WMC slashes jobs, budget"
- "... 79 told to go... 17 from Belmont... virtually disappear from Africa."
- 28 Dec '98 "Resources stocks have crumbled"
- "All resources index has fallen 15.6% since Jan 2. The gold index has slumped."
- Jan '99 "Outlook dulls for Zinc and Lead"

A Temporary Upturn

- 16 April '99 "WMC forecast that the worst of the base metals slump was over"
- 1 May '99 "Resource stocks have stormed back to life in April".
- BHP and Rio Tinto up, but not for long
- 6 May '99 "BHP wields axe on budget, staffing"
- staffing levels and budget slashed by more than half
- will now operate out of only 3 offices in world
- job cuts in Dec '97 from 830 to 763, now 380
- budget down from US\$132M to US\$100M in Dec '97, now down to US\$50M
- 20 May '99 "AGSO jobs to be slashed"
- wholesale sackings of 72 staff
- this follows cuts of 60 in 1996
- 27 May '99 "North axes 120 jobs to cut costs"
- part of program to reduce costs by \$130M/yr
- 16 June '99 "Gold teeters at brink of abyss"
- "gold companies are focussed purely on survival with little time for exploration."
- 24 June '99 "Placer Dome fire 200 staff"
- one third of total
- "Australia was a logical place to slash exploration budgets as there were more prospective and cheaper locations to explore."

and still it goes on

- 13 Aug '99 "More staff cuts at Rio Tinto"
(pers com) (the third in less than 2 years)
- Brisbane office closed



SEG Prize for Australian Student

Tom Ridsdill-Smith, a Ph.D. student at The University of Western Australia (UWA), has been selected to receive SEG's Best Student Paper presented at the 1998 Annual Meeting in New Orleans. Tom's paper was entitled, Separating Aeromagnetic Anomalies Using Wavelet Matched Filters.

Tom is in the final year of his Ph.D. at UWA and is jointly enrolled in the Departments of Geology & Geophysics and Mathematics. He is holder of an Australian Postgraduate Award (Industry) scholarship, with World Geoscience Corporation the industry partner. In addition, he also holds a Minerals and Energy Research Institute of Western Australia (MERIWA) top-up scholarship.

This is not the first prize Tom has received for his research and its presentation. In 1994 he won the prize for best technical presentation at the student night organised by the WA Branch of the ASEG.

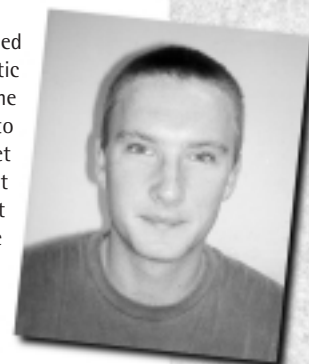
Tom's main area of research is the application of wavelet transforms to the processing and interpretation of aeromagnetic data. He is particularly interested in the application of operators to both located and gridded data in order to produce enhancements for geological interpretation. In certain cases, wavelet transforms provide a robust and effective alternative to conventional Fourier-domain and spatial-convolution techniques.

Wavelet transforms are a recent development in signal processing and have already made significant improvements to the processing of data in a number of other disciplines. The success of wavelet methods in other fields suggests that they be usefully applied to the processing of aeromagnetic data.

Wavelet transforms are part of a general class of algorithms known as time-frequency decompositions. These generate information about both the frequency content of a signal and its variation with time. Time-frequency decompositions are useful for analysing signals that change in statistical character with position, often referred to as non-stationary signals. Aeromagnetic signals are an example of a (weakly) non-stationary signal. The analysis is achieved by decomposing the signal into a set of basis functions that are localised in both position and frequency. In the case of the wavelet transform, these functions are known as the wavelets. The wavelet basis

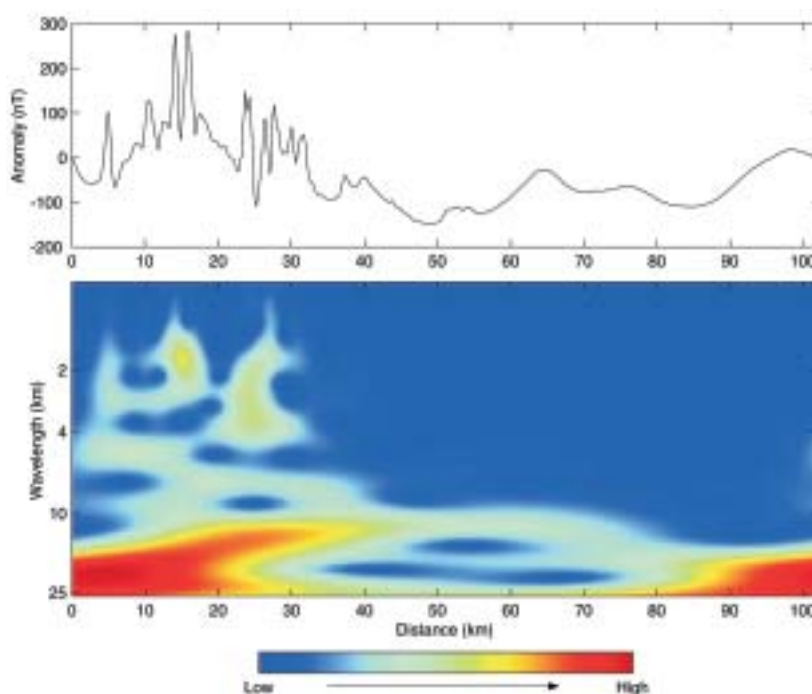
contains a set of functions that are re-scaled and shifted copies of a single characteristic shape, known as the mother wavelet. The amplitudes of the wavelets needed to represent the signal are called the wavelet coefficients. A significant benefit of wavelet analysis is that it uses basis functions that vary in size (scale) depending on the frequency of the feature being analysed. For example, to examine low frequency features in the signal a wide wavelet is used, giving good frequency localisation. To examine high-frequency, short wavelength features a narrow wavelet is used giving good positional localisation. Another commonly used time-frequency decomposition is the windowed or short-time Fourier transform (STFT), however, the STFT is limited to a single size of basis function and thus cannot be optimised for all frequencies in the signal.

Wavelet analysis can be further classified into the continuous wavelet transform (CWT) and the discrete wavelet transform (DWT). The CWT uses basis functions over a continuous range of scales and shifts resulting in a highly redundant set of wavelet coefficients. The redundancy is useful in statistical analysis of the time-frequency content of the signal. In contrast, the DWT only uses basis functions at a discrete set of dyadic (powers of two) scales and shifts. This provides a highly efficient representation of the signal. By discarding small wavelet



Thomas Ridsdill-Smith

Continued On Page 16



Wavelet transform of an aeromagnetic profile from the Canning Basin, Western Australia. The wavelet coefficients map changes in frequency content (vertical axis) with distance along the profile (horizontal axis) and clearly show the change in magnetic character between the left-hand and right-hand ends of the profile.



Brian Spies Heads Physics Division

Brian Spies, ASEG Vice President, has a new challenge and will take up a three-year secondment from CSIRO to ANSTO, from the end of November this year when he will be employed as Director of the Physics Division.

The aim of the secondment is to expand collaboration and strengthen links between ANSTO, CSIRO and industry. Brian will continue as Director of the Cooperative Research Centre for Australian Mineral Exploration Technologies working on average one to two days per week on key Centre activities.

In a message to staff, Brian said, "CRC AMET will remain an important priority for me, both professionally and personally, and I would like to emphasise my continued

commitment to the success of the Centre. For most staff it will be 'business as usual', and the Centre will continue all its planned activities. I look forward to working closely with all of you to ensure the Centre's success."

Brian has been a dynamic leader of AMET since he took over as Director, and we wish him well at ANSTO.

Award To Brian Evans

Congratulations to Brian Evans of Curtin University. He has been awarded the '1999 Vice-Chancellor's Award for Excellence' for his outstanding contribution to the University.

Continued From Page 15

coefficients we can obtain effective signal compression, with obvious advantages for designing efficient processing techniques.

Tom has examined several applications of wavelet analysis. The CWT provides a useful method for analysing the time-frequency behaviour of aeromagnetic data. Statistical models of magnetic sources can be conveniently represented in terms of frequencies, and as such these calculations are commonly made via the Fourier transform. However, Fourier analysis does not take into account the changes in geology with position, and thus tends to produce a blurred picture that represents the overall averaged properties of the survey area. In contrast, the CWT analyses the frequency content of the data locally. This allows the design of position-varying adaptive matched filters that optimally separate the effects of different

magnetic layers in the data. Work has been undertaken on the design of CWT-based matched filters to compare their effectiveness with STFT and conventional Fourier-based matched filtering. This work may also lead to other position-varying filters, such as reduction to the pole for regional datasets.

Work has also been completed on the design of a suite of DWT-based filters for calculating a range of derivative operators for profile data. These filters have the advantage of a highly efficient implementation with superior noise suppression compared with conventional Fourier or spatial convolution methods. The compression properties of the DWT have also been applied to a potential-field forward modelling algorithm that can rapidly calculate the theoretical response of arbitrary distributions of magnetisation functions. Finally, work has recently been completed on an efficient altitude correction for aeromagnetic survey data using a DWT-based equivalent source model.

Full details of Tom's research are available from his web page <http://geolpc42.geol.uwa.edu.au/default.htm>. From there it is possible to download some of his papers, including that which won the prize at the SEG, a recent paper in Geophysics and several papers that have appeared, or are due to appear, in Exploration Geophysics.

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Geof Fethers	Geologist	Ross Caughey	Geologist
Nigel Hungerford	Geophysicist	Alaster Edwards	Geologist
Paul Hamlyn	Geologist	Jovan Silic	Geophysicist

New Members

OCTOBER APPLICATION

(approved on 13/10/99)

NAME	COMPANY	STATE
Dennis Cooke	Santos	SA
Birgit Cropp	Woodside Energy	WA
Jeremy Fitzpatrick	Woodside Energy	WA
Terrence Folkers	Woodside Energy	WA
Julian Green	Woodside Energy	WA
Christopher Hall	Geco-Prakla	QLD
Colin Hawke	Woodside Energy	WA
Philip McBride	Western Geophysical	SA
Michael Muerz	Woodside Shell	WA
Makhosini Nyoni	Avmin Ltd	SOUTH AFRICA
Witold Seweryn	PIRSA	SA
Saverio Sioni	CGG	WA
Amanda Van Lyk	PGS	WA
Jun Zhou	Western Geophysical	WA
Anastasia Boylson		QLD
Mohammad Norozi	Western Geophysical	WA
Daniel Howe	QUT	QLD
J Pomeroy	Flinders Uni	SA

OCTOBER APPLICATION

(approved on 10/11/99)

NAME	COMPANY	STATE
Tuong Ing Huong		Malaysia
William Smith	Scintrex/Auslog	QLD

LEFT OVER FROM SEPTEMBER

(approved on 13/10/99)

NAME	COMPANY	STATE
Mark Beeson		WA
Howard Golden	WMC Resources	WA
Christopher Jenkins	Thomson Marconi	NSW
	Sonar Pty Ltd	
Rachel Loomes	TGC-Nopec	WA
Steven Miller	LGC	WA
Brad Pitts	De Beer	SOUTH AFRICA
Antonie Wolmarans	De Beer	SOUTH AFRICA
TJ Howe		WA
Peter Andrews	Macquarie Uni	NSW
Deian Humphreys	Macquarie Uni	NSW
John Jackson	QUT	QLD
Abello Jenny	ANU	ACT
Trevena Jessica	ANU	ACT
Alex Johnston	ANU	ACT
Benjamin Junea	Macquarie Uni	NSW
Robert Lacey	ANU	ACT
Seumas Meharg	ANU	ACT
Christopher Nicholson	ANU	ACT
Martin Sholtez	ANU	ACT
Samantha Williams	ANU	ACT

Lost Members

We are trying to contact the following members. If anyone knows their whereabouts please contact Koya Suto at Koya.Suto@oca.boral.com.au or the Secretariat at secretary@aseg.org.au

NAME	COMPANY	STATE/COUNTRY
Kunal Chakravorty	PGS Data Mgt	WA
Harry Cornelius		AUSTRALIA
Brian Dent	Saudi Aramco	DHAHRAN
Robert Elliott-Lockhart	Shell	VIC
Seevarat Haridharan		NSW
Jim Leven	AGSO	ACT
William McLellan		BOTSWANA
Craig McNeilage		NSW
Martin Pott	Mobil	WA
Greg Reudavey		WA
Allister Wood		UK
Adam Wooldridge	Mineral Services	SOUTH AFRICA
Stefano Zannoni		WA



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 Fax: (08) 94141277
 3 Baron Way, Jandakot, WA 6164
 Email: crabb@agspl.com.au
www.agspl.com.au



Policy Changes – ASEG Publications

The Federal Executive has approved the following policy changes recommended by the ASEG Publications Subcommittee:

Colour page charges

A new standard rate to authors of \$400 per page will apply from the next issue of Exploration Geophysics (December 1999, and including 2000 Conference issue), as well as Preview feature articles. This is a decrease from the previous rate, the main reason for this being that new costs for colour printing are significantly less than were charged by the previous publisher, due to a different method of colour printing and page organisation. The ASEG also wants to encourage authors to publish in colour to add to the appeal of the publications.

Authors will be advised, in advance of publication, of the anticipated cost. Papers will not be published in colour unless the publisher has received agreement from the author to pay the colour charges. The charges may be waived in exceptional circumstances at the Editor's discretion.

Reprints (off-prints)

The ASEG has previously supplied 25 free reprints of papers published in Exploration Geophysics to the authors, who could order more copies if required from the publisher at their cost. Due to increasing costs of providing this service and questions over the need for reprints, the ASEG will discontinue providing free reprints from the forthcoming issues of Exploration Geophysics.

In lieu of this, each author will be provided at no charge a CD containing the complete paper as a "pdf" file, from which good quality prints in 'as published' format may be

obtained. Under the new policy, if authors definitely require printed reprints, they can arrange that directly with the publisher at the cost set by the publisher.

New Editorial organisation for Exploration Geophysics (EG)

The ASEG has agreed to change the editorial organisation for EG from 2000 by the appointment of a Managing Editor for a term of three years. The Managing Editor will be responsible for all issues of EG from July 2000 to June 2003, plus any Special Publications (including 2001 and 2003 Conference EG's). The main reason for this change is the increasing need to manage the cost of publishing EG (ASEG's greatest individual cost item), and to manage the complex editorial requirements for the range of EG publications (conference versus regular versus special issues),

The Managing Editor's role will be similar to that of the current Editor, but with a greater management requirement, and with more of the 'hands-on' editing role assigned to Associate (or Special) Editors. The Managing Editor will be assigned a budget to cover the Managing Editor's and Associate/Special Editors' costs and/or honoraria, and will be required to work closely with the ASEG publisher to help meet the ASEG's long-term financial and technical publishing goals.

Any ASEG member who is interested in taking on this challenging but rewarding role is invited to apply for the position (see notice on page 5 in this issue of Preview).

Andrew Mutton
ASEG Publications Committee Chairman

Notice of ASEG Annual General Meeting

The 2000 Annual General Meeting of the Australian Society of Exploration Geophysicists for the Election of Officers will be held in the Burswood Resort Superdome, Perth, on Wednesday 15th March 2000.

More details will be made available at the Convention.



WA Branch – by Jim Dirstein

Technical and general meetings are held every third Wednesday of each month at the Celtic Club, 48 Ord Street, West Perth, from 5:30pm.

Abstracts for all past technical presentations are available on the WA Web page, www.aseg.org.au/wa, under Technical Meetings.

October Meetings

October saw the annual migration of Curtin University Geophysics students to the West Perth Celtic Club, to put on their displays of geophysical finery in order to attract a suitable prize, or else just consume copious quantities of alcohol in the vain hope that this will give them courage to face the discerning crowd.

Over the years, both the quantity and quality of the presentations have increased dramatically and this year was no exception. And the winners are...

- Jason McKenna (Supervisor Brian Evans), who presented, The Seismic Effects of Changing Fluid Flow Properties in Simulated Reservoirs, and
- Lee Sampson (Supervisor Paul Wilkes), who presented, The Geophysical Characteristics of Shale Hosted Polymetallic and Sulphide Mineralisation in the Mount Barren Basin, Ravensthorpe, Western Australia.

Congratulations to these students and all the others who braved the spotlight to give excellent presentations.

ASEG-WA would also like to thank the sponsors for the 1999 Student Nights: Geosoft Australia, GeoCom, Woodside, CGG, Apache and CSIRO.

November Meetings

The Technical meeting held on Wednesday, November 17th, 1999 was sponsored by Fractal Graphics and Desmond Fitzgerald & Assoc.

The first presentation, Resurrecting Collections of Potential Field Data to Enhance Value for Interpretation, by John Brett & James Heywood, Desmond FitzGerald and Associates, was a 'Southern Margin Frontier' case study involving magnetic and gravity data.

The second presentation, Introduction to the 'Worms', by Fabio Boschetti, CSIRO Division of Exploration and Mining, was a 3D representation of 2D images in terms of multiscale edges.

In November we had the usual call for ASEG-WA Executive nominations for 2000. Treasurer, Secretary and President are up for grabs. Elections were held on December 8th, at AGM in the Celtic Club (details will be published in the February Preview).

ASEG Awards – nominations from State Branches for ASEG Service Certificate and ASEG Service Medal are being called at this time.

On Wednesday 24th November 1999, the Third CGG Processing Technical Seminar was held in Perth.

The day of Technical Talks included:

- Research Trends towards Improved Reservoir Assessment
- Advanced Preserved Amplitude Demultiple Processes
- High Density Velocity Analysis
- Towards an Effective Compromise between Stolt and Full Kirchhoff PreSTM: the PSI approach
- 3D PSDM – Latest Developments

As we have reached the end of another year, Jim Dirstein would like to have some feedback and on what members like/dislike about the way we operate and any ideas about how we could improve things for 2000. Please email comments to Jim on dirstein@inet.net.au.

ACT Branch – by Nick Direen

On September 23rd, Professor Paul Morgan, Macquarie University, addressed a joint GSA/ASEG meeting at the ANU. The Professor spoke to an audience of over 50 members and guests on planetary thermal evolution. His talk was entitled 'Venus – a Planet with a Midlife Crisis'.

No October meeting was scheduled.

On Friday 5th November, members of the ACT Branch were invited to a BBQ and open day for the nearly-completed Australian Magnetometer Calibration Facility at AGSO's Canberra Magnetic Observatory. When completed it will be similar to the Finnish facility shown in the photograph and will be installed by a joint Finnish/Ukrainian team in late November this year. It has been funded by the Department of Defence and will be operated by AGSO. It will be available to anyone who wishes to calibrate their vector-magnetometers and be capable of measuring temperature-dependent linearity, baseline, scale-value, and orientation parameters. Further information is available from Peter.Crosthwaite@agso.gov.au.



The picture shows the Finnish calibration coil system. This comprises of four sets of copper windings on each of the three orthogonal axes. The frame is made of aluminium.

South Australia Branch – by Michael Hatch

Well, 1999 is finally winding down, and so are the activities of the South Australian Branch. Since we last wrote, we have had two technical meetings and a social event. First things first.

Our October meeting was held on the 20th of the month, and was our annual Industry Night. We had speakers from



four local companies that are involved with the geophysical industry. Each person spoke for 10 to 15 minutes on the state of exploration and geophysics in their respective companies. The group was diverse, and all of the talks were interesting. The speakers were, Paul Howe, Woodward Clyde; Paul Tredgett, Baker Hughes; Graham Boyd, Normandy and Stephen Sullivan, Maptek.

Our November meeting was held on the 24th of the month, and was our annual Student Presentation Night. Honours students from all the local universities provided short presentations on their recently completed honours theses. Awards were based on technical content, and presentation quality. Overall the talks were extremely enjoyable and bode well for the state of our industry in the future. The speakers were, Ben McLean, NCPGG/University of South Australia; Jaime Livesey, NCPGG/University of South

Australia; Tom Wilson, Flinders University; Andrew Shearer, University of Adelaide and Lisa Ryan, NCPGG. The Best Technical Paper award went to Lisa Ryan, while the Best Presentation award went to Ben McClean. Both received \$150 scholarships for their efforts.

The big social event on the SA calendar since the last Preview was our Melbourne Cup Lunch, which was as much fun as ever (nice to see a long odds horse do so well). The action was furious, lots of money changed hands, but it didn't look as if anyone came out with big losses. Many thanks to Suzanne Roberts, and Neil Gibbons for organising the event (too bad that you couldn't be there Neil), and to Rod Lovibond for MCing.

Finally, we hope that you all remembered to order your wine. If you didn't, oh well. And if you did, enjoy!

Queensland Branch - by Natasha Hendrick

Well after a somewhat quiet mid-year, Queensland Branch has sprung back into action. Technical meetings during the latter part of this year have been extremely well attended. In September we had a visit from Barry Long who found time to relay some of the trials and tribulations he encounters working on seismic acquisition in Thailand. During October Satyavan Reymond from Schlumberger - Geosciences Group shared with us some of the new seismic data types and visualisation tools now being used in the seismic industry.

Queensland Branch continues its support of geophysics students, and in November will be holding its annual Student Presentation and prize-giving night. Two University of Queensland students will be presenting results from their Honours research projects: Daryn Voss will discuss 'The Application of Generalised Linear Inversion to Prestack Multiple Attenuation', and Ruth Kettle will present results on a 'Resolution Analysis of Seismic Tomography for Mineral Exploration'.

Our Conference Organising Committee has started the long journey towards bringing you all a successful and innovative conference in 2001. The Queensland Branch would again like to extend a 'thank-you' to all of our volunteers who so willingly give up their time for the promotion & development of geophysics in Australia.

Kathlene Oliver has taken on the role of Website Manager for our Branch Website. If you have anything to contribute to the site please contact Kathlene on ksoliver@one.net.au. All Branch activities will be published on the website.

The end of 1999 was celebrated on Thursday 16th December at About Face, 252 Kelvin Grove Rd, Kelvin Grove.

We hope everyone had a happy and safe festive season, and 2000 will be a successful year. And remember, life is like a park - sometimes you are the statue and sometimes you're the pigeon. But keep on keeping on!

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Victoria Branch - by Trudi Hoogenboom

Monthly meetings are held at the Kelvin Club, Melbourne usually on the 3rd Tuesday of every month. In October there were two meetings:

On October 12th we held our Student Research Presentations:

- Leanne Frederiksen (Supervisor: Greg Houseman, Monash University), presented, 'Amplitude Variation with Offset Analysis in the Moomba Field of the Cooper Basin'.

- Miranda Mayle (Supervisor: Greg Houseman, Monash University), presented, 'Rayleigh Wave Phase Velocities in Western Victoria'.

- Lucy Kirwan (Supervisor: Lindsay Thomas, Melbourne University), 'The Spectral Characteristics of Seismic Background Noise'.

On October 29th at the Selwyn Memorial Symposium, Dr Walter Pitman presented, 'Noah's Flood- The Geological Evidence'. The Victorian ASEG Branch provided sponsorship to the Geological Society of Australia (GSA).

Preparation continues on the publication of Mark Jessel's Structural Geophysics Atlas.



New South Wales Branch - by Richard Facer

The October technical meeting was very well received. Ian Acworth presented a stimulating address on 'The Electrical Image Method for Environmental Engineering and Groundwater Investigation'. Ian's address prompted a wide-ranging discussion from those present.

The Branch's involvement with the wider role of the profession has been shown by recent 'events' - modest financial support was given to the Geological Society of Australia (NSW) for its inaugural lecture (by Walt Pitman on Noah's flood), and to a workshop on the future of geomagnetic/palaeomagnetic laboratories in eastern Australia; the Branch was recognised at the launch of the National Network of Earth Science and Engineering Learning (NNESEL) for its support; and the committee wrote to the Minister for Mineral Resources in support of the Discovery 2000 Initiative (as a complement to support from the Federal Executive).

The November meeting was the Annual Students Night presentation of research results.

We hope you all have a prosperous 2000. I would like to thank the committee for their help - especially Katherine McKenna. Dave Robson has also been of considerable help by 'ferrying' projectors to the meetings.

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Acquisitions Create World Leader in Airborne EM

In October, Fugro N.V. announced it was set to acquire both World Geoscience and Geoterrex-Dighem from their respective parent companies. This will make Fugro the undisputed world leader in airborne EM and provide it with enormous strength globally in the airborne geophysical contracting business.

World Geoscience Corporation Pty Ltd

Fugro has signed an agreement to acquire the business and assets of World Geoscience Corporation Pty Ltd. from its present owners, Aerodata Holdings Limited. The acquisition is subject to the approval of the shareholders of Aerodata. World Geoscience has its headquarters in Perth, Western Australia and operates throughout the world with permanent representation in North and South America, Europe, Africa and the Middle East. The company employs 130 people of whom 18 are involved in R+D programmes. Over the last three years, although the company has incurred significant losses which have led to a substantial restructuring, it has successfully brought to the market 'Tempest', its latest generation of Electro-Magnetic (EM) technology. In conjunction with the Australian government, the company is also close to bringing to the market its 'Cerberus' system, which allows multiple airborne geophysical techniques to be deployed simultaneously. The introduction of both systems will lead to strongly enhanced data gathering combined with improved productivity.

Geoterrex Dighem

Fugro has also signed an agreement to acquire the business and assets of Geoterrex Dighem from its present French owners, Compagnie Générale de Géophysique (CGG).

Geoterrex Dighem has its headquarters in Ottawa, Canada, and also operates throughout the world with permanent representation in Europe, Africa and Australia. Geoterrex employs 155 people and, like World Geoscience, directs its business strategy towards the high-end geophysical market. The company has been profitable over the past few years and despite the market downturn in the current period is presently not making a loss.

These acquisitions fit Fugro's strategic development. The market that is served by both companies possesses the same characteristics as those of Fugro's present operations; being a global niche market with high entry barriers, combining advanced technology with talented personnel and acquiring, processing and producing quality data to demanding clients.

The airborne geophysical industry uses light aircraft and helicopters to carry specialised equipment to explore specific areas, both onshore and offshore, in order to identify geological structures and potential drill targets. The equipment allows the use of various techniques, which include the measuring of radiation from the ground

(radiometrics), electro-magnetics, airborne laser fluorescence and magnetic influences. The cost per line kilometre of data collection from the air is significantly less than that of other methods and the effectiveness of the method is being further enhanced by more sophisticated data collection and processing techniques.

Within the airborne geophysical industry there are three main market sectors: mineral exploration, oil and gas exploration and environmental. Of the three markets mineral exploration has historically accounted for 60-80 % of the activity, oil and gas 15-35 % and environmental a small percentage. These ratios can vary in different years. The environmental market is generally funded by government and international agencies and can produce large one-off projects.

The industry can be distinguished between high and low-tech sectors. Both World Geoscience and Geoterrex are directed towards the high-tech sector to which each company presently provides a substantial contribution. Historically the minerals and oil and gas markets have been counter-cyclical but in the present cycle both markets have bottomed together.

The normal contractual acquisition processes have yet to be concluded but the combined price is expected to be about Dfl 50 million funded from existing cashflow. The transactions will not influence the profitability of Fugro in 2000 and will contribute positively in the years following. In 2000 some recovery of the principal markets is foreseen giving an indicated turnover of some Dfl 90 million. It is expected that over the following years R+D programmes will be maintained.

Today's size and characteristics of the airborne geophysical market are similar to those of the offshore geotechnical market, when Fugro acquired the McClelland group companies in 1987. The recovery of the market, the crystallisation of fragmented niche markets, the avoidance of too small scale operations, the rationalisation of operating structures and the concentration upon high technology can make such an acquisition successful. The acquisition of McClelland led to an increased turnover, cashflow and net result, which, amongst others, allowed a successful penetration of the survey and positioning markets by Fugro.'

Since the announcement on 26th October, Fugro advised that it will extend its interests in airborne geophysics and in geotechnical activities in France.

It has signed an agreement to acquire High-Sense Geophysics Limited. High-Sense specialises in airborne geophysics and complements the acquisitions of World Geoscience Corporation Pty Ltd. and Geoterrex Dighem by further enhancing Fugro's market position in airborne geophysics.

Continued On Page 23



Continued From Page 22

The combined annual turnover for Fugro in this market will amount to about A\$80 million. After finalising the acquisitions (expected in 1st January 2000) the activities of the three companies, with offices in ten countries, will be merged.

High-Sense is based in Toronto, Canada, has an annual turnover of about A\$15 million and employs about 50 people. The company operates worldwide.

Fugro Expands Oceanographic Services

Fugro GEOS recently announced the opening of its office in Perth. The office is based at the Perth headquarters of Fugro Survey Pty Limited, where the Fugro GEOS capabilities will most easily be able to complement the offshore survey and geotechnical activities.

The new office will, Fugro said, allow it to focus on the growing opportunities to provide metocean measurement, consultancy and forecasting services to support marine industries and marine engineering projects throughout Australasia.

This expands Fugro GEOS' global presence to now include offices in Swindon (Headquarters), Southampton and Aberdeen in the UK, together with Houston, Singapore and Malaysia.

As part of the office opening, Fugro GEOS also welcomed back Arthur Shrimpton as the Principal Oceanographer, to be based in Perth. Shrimpton has over 15 years of experience in providing metocean services to the offshore industry and has been based in Australasia for the past 6 years.

For further information contact:

Mr A. Shrimpton

Tel: +61 8 9322 4955 Fax: +61 8 9 3221 775

Email: A.Shrimpton@Geos.com

CSIRO Announces New Research Centre for Perth

The facility is being established as a strategic alliance between CSIRO and the Western Australian Government through the Department of Commerce and Trade. It will be located at the Bentley Technology Park, 10 km south east of Perth next to Curtin University. The \$37million Bentley project has been designed to accommodate mineral exploration, mining and petroleum research facilities and will provide twenty-first century laboratories for scientists from CSIRO Exploration and Mining and CSIRO Petroleum Resources.

For more information check <http://www.csiro.au>.

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Landmark To Acquire GMA

The Landmark Graphics Canada Division of Halliburton Group Canada Inc., a wholly owned business unit of Halliburton Company (NYSE:HAL), has signed a definitive agreement to acquire the geophysical and geological (G&G) software assets of Calgary-based Geophysical Micro Computer Applications (International) Ltd. (TSE:GMA).

The \$6.8 million (U.S.\$) asset acquisition agreement is subject to GMA shareholder approval and appropriate regulatory approval, which is expected in January 2000. The acquired GMA software assets will be managed by GeoGraphix, a wholly owned business unit of Landmark.

GMA is a recognised leader in providing geophysical modeling software used primarily to validate geological models which are developed using well and log data. GMA delivers a suite of PC and workstation-based software for critical geophysical and geological analyses.

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New Data Release From Northern Territory

Minister for Resource Development Daryl Manzie recently announced the release of a package of geoscientific data for the airborne geophysical data acquired in 1999.

These geoscientific data are designed to stimulate mineral exploration in the Northern Territory and were acquired as part of the Government's four-year \$16 million Exploration Initiative funding program announced last year.

More than \$2 million worth of geophysical data were acquired in 1999 from five major aerial surveys covering over 140,000 km² that have previously not attracted modern exploration techniques. The data acquired from these surveys will be released progressively during December 1999 and January 2000.

The South Lake Woods and Rum Jungle surveys were released on 29th December 1999 and the Amadeus West, Bonney Well and Elkedra surveys will be released on 28th January 2000.

The data will be available free of charge, in line with the Government's desire to encourage smaller exploration companies to invest in the Territory's untapped minerals potential.

"The Northern Territory Government has made a long-term commitment to provide modern geophysical data on which exploration companies can base their decisions to invest in the future of the Territory's mining industry", Mr Manzie said.

Mr Manzie also said that, in addition to the geophysical data, the NT Geological Survey had released several important new geoscience products to further encourage exploration.

These products include a comprehensive report on the Gold Deposits of the Northern Territory, the Petermann 1:250,000 Geological map and Explanatory Report, and the Milingimbi 1:250,000 Explanatory Report.

As part of the Government initiative, all data are free and are available from the Department of Mines and Energy, Geological Survey, on CD ROM.

Further information on geoscience programs and products, are contained on the Geological Survey (NTGS) website, www.dme.nt.gov.au/ntgs

Woodside Awards High Volume Pre-Stack Imaging Seismic Processing Contract

Woodside recently awarded to Veritas DGC what may be the largest dense Pre-Stack Time Migration processing contract of its type ever undertaken.

The 3600 km² offshore-Mauritania project will employ a high fold, no compromise full Kirchhoff pre-stack time migration processing approach and is forecast to be completed in record time. The project will be managed by Woodside's Geophysics group in close co-operation with their International Exploration team colleagues and Veritas' project team, located in their new West Perth processing centre. Although Veritas will supervise the project from West Perth the major computing effort will be undertaken by their Singapore centre's recently upgraded NEC (SX5) Supercomputer.

Sami Khan, Veritas' VP Marketing Asia Pacific, said, "Veritas has recently processed several 3D surveys utilising this type of technology and is pleased to have been awarded this large survey."

To put the size of this undertaking into perspective, back in 1992/3 Woodside embarked on what at that time was hailed as the world's largest single 3D marine seismic processing project, the 2746 km² (3386 km² migrated) East Dampier survey. This project employed a DMO/Stack and post-stack time domain migration approach, where essentially one trace per cmp position (post-stack) was admitted to the 3D migration process. In the Mauritania project, each of the traces comprising a cmp set of higher fold than was even acquired in the East Dampier survey, will be admitted to the full Kirchhoff 3D migration process with no reduction in output image point density. A total of 2.12×10^9 traces are being recorded for early processing and approximately 1/4 billion traces will be input (& output) during the pre-stack time migration.

As is invariably the case, Woodside with Veritas' assistance will ensure that this project is a technical success.



ER Mapper's Image Web Server Now Covers ACRES

Earth Resource Mapping (ERM) and the Australian Centre for Remote Sensing (ACRES) signed an agreement in October 1999 to establish an Internet-based method for viewing and delivering the centre's terabyte-sized images over the Internet using the new ER Mapper Image Web Server technology.

In addition to acquiring, cataloguing and processing remote sensing data from a range of remote sensing satellites, ACRES distributes the finished product for both scientific and operational applications for the benefit of the Australian community. With the help of ERM and the Image Web Server, the centre will further expand distribution via the Internet.

ACRES, a business unit of the Australian Surveying and Land Information Group (AUSLIG), Department of Industry, Science and Resources, maintains and periodically refreshes a comprehensive archive of remotely sensed satellite data over Australia.

In the past, images generated by ACRES have been extremely large, precluding the use of the Internet for distribution. With the introduction of the Image Web Server and the unique Enhanced Compressed Wavelet (ECW) open standard compression format, the ability to reach an infinitely larger audience is now a reality. Images of any size can be served and viewed in real time. As an added bonus, the images can be also be loaded directly into a range of GIS packages and Microsoft Office using free plug-ins. The agreement should enable the much greater use of ACRES' satellite imagery by making it far more accessible to a wider group of clients throughout Australia. The initial focus will be on using ER Mapper's Image Web Server technology to enhance its SPOT-LITE system, which provides on-line delivery of imagery from the SPOT series of satellites.

Further details can be obtained from the ACRES or ERMMapper web sites :

<http://www.auslig.gov.au/acres/referenc/acres5.htm> and <http://www.ermapper.com>

Revision of the International Geomagnetic Reference Field for 2000

The International Geomagnetic Reference Field (IGRF) is the internationally accepted standard mathematical description of the Earth's main field, produced by the International Association of Geomagnetism and Aeronomy. The IGRF comprises a set of spherical harmonic models that can be used to synthesise the direction and intensity of the Earth's magnetic field at a particular location and date. The IGRF has been revised recently to cover the interval 1900 to 2005.

The term 'IGRF' refers collectively to the suite of discrete epoch models comprising:

- IGRF models at 5-year epochs from 1900 to 1940
- definitive (DGRF) models at 5-year epochs from 1945 to 1990, and
- IGRF models for 1995 and 2000; the latter includes secular variation terms for forward continuation to 2005

Between five-year epochs, the field is defined by linear interpolation between coefficients of the two adjacent

epoch models. The change from the 7th generation (1995 revision) to the present 8th generation of the IGRF is the addition of IGRF 2000, which includes the secular variation (annual change) terms. The IGRF 1995 main-field coefficients are retained, i.e., no definitive model has yet been adopted for 1995.

A software package (FORTRAN or C) for computing spot or gridded values of the IGRF field and annual changes is available from the Australian Geological Survey Organisation (AGSO) for \$50. The coefficients can be downloaded from <http://www.agso.gov.au/geophysics/geomag/gmirf.html>.

Address enquiries to:

Andrew Lewis or Charles Barton
Australian Geological Survey Organisation
GPO Box 378, Canberra, ACT 2601
Tel: 06-249 9111
Fax: 06-249 9913
Email: Andrew.Lewis@agso.gov.au or Charles.Barton@agso.gov.au



Heard in Canberra...

AGSO now a Prescribed Agency

We now live in a world of Outcomes and Outputs. On 1 July 1999 AGSO became a prescribed agency under the Financial Management and Accountability Act 1997. What this means is that, while AGSO remains part of the Department of Industries Science and Resources (ISR), it has its own outcome/output structure and is funded separately to the rest of the Department. It has a Chief Executive Officer (Neil Williams) who is responsible to a minister (Parliamentary Secretary, the Hon Warren Entsch) for the delivery of the outputs planned each year.

Each year AGSO will be funded to deliver a set of outputs aimed at affecting their outcome. For 1999-2000 AGSO has received \$60 M from the budget to achieve the following outcome:

Enhanced potential for the Australian community to obtain economic, social and environmental benefits from first class geoscience research and information.

To achieve this, AGSO contributes to the following output:

Geoscience Research and Information.

Four main program areas deliver this output:

- petroleum exploration promotion and advice,
- marine zone management information,
- minerals exploration promotion and advice, and
- geohazards and geomagnetism.

The move to a Prescribed Agency puts AGSO in a similar position to IP Australia (which is responsible for patents), AusAID and the Australian Bureau of Statistics. It means there is a degree of independence from the main departments for the CEOs of these agencies, but that they are under greater direct scrutiny by ministers and the Parliament. More importantly Prescribed Agencies obtain their funding directly from the Federal Budget and not through their parent Department.

This change is not reflected in ISR's current organisational chart (www.isr.gov.au/department/orgchart.pdf) where both AGSO and IP Australia are treated the same as all the other Divisions in ISR.

The organisational chart has some unusual features. In the first place, the Business and Scientific Services Group and the Policy Analysis and Advice Group are clearly separated. This means that 'Coal and Minerals' and 'Energy and Environment', which are in the Policy and Advice areas, are separated from AGSO, which is in the Scientific Services Group. Not good, one would have thought, for maintaining strong links between the science knowledge base and policy development.

However, the most unusual aspect of the chart is at the top level. There we see that all the 'Divisions' report to 'a box' containing the Secretary and CEO, Russell Higgins and four Deputy CEOs. It is not clear what the responsibilities of the Deputy CEOs are. Do they have line management roles or

do they work as a Board of Management? Maybe the next version of the chart will clarify this.

ISR's Annual Report

The 1998/99 Annual Report has been posted on the web at http://www.isr.gov.au/department/annualreport98_99/index.html. This is a well-presented document and worth a read. The scope of the portfolio is huge, including sport, tourism, industry policy, Cooperative Research Centres and resources. However for the cynics amongst us some of the Key Achievements seem a bit thin. These include, 'Settling in New Ministers', 'A new pricing initiative for map data for Auslig' and the fact that Australian Government Analytical Laboratories made a profit. Science seems to have gone out of the window if these are identified as ISR's main achievements last year.

Why not something about the new maps or mapping services from Auslig, or the new capabilities for AGAL?

At least AGSO identifies two key achievements for 1998/99: These are a new methodology for detecting oil seeps using synthetic aperture radar data collected from satellites to locate natural hydrocarbon seeps (oil slicks); these techniques also help distinguish between pollutants and natural oil seeps, and, a new methodology for enhancing geophysical gamma ray data by reducing the noise or interference activity in the data so that the concentrations of radioelements in the soil can be better estimated.

Boost for Geothermal Energy Projects

An experimental power station using hot rock to generate electricity will be built near Sydney as part of the 'Government's continuing campaign to develop and promote Australia's renewable energy industry'.

Announcing \$6 million in Commonwealth funding for nine innovative projects, Environment Minister Robert Hill said the 'prototype Hot Dry Rock power station provided Australia with potentially the greatest opportunity to deliver large scale electricity without greenhouse emissions'. The funding is provided through the Australian Greenhouse Office under the Renewable Energy Commercialisation Program. The University of New South Wales and the ANU/Pacific Power were successful in their bids relating to this activity.

The University of New South Wales through its School for Petroleum Engineering has been offered a grant of \$1,000,000 to use its Hot Dry Rock (HDR) technology to develop Australia's first granite reservoir in the Woronora No.1 well just south of Sydney. This well was originally drilled as an oil/gas exploration well and bottoms into granite representative of Australia's extensive HDR resources. The project will develop assessment methodology and criteria, invaluable tools for characterising HDR resources and determining the most appropriate reservoir development approach. Successful completion of this project is a prerequisite to the commercial funding of projects to harvest Australia's extensive HDR resources.



Very significant greenhouse gas reductions will result from the widespread exploitation of these HDR resources. Sheik S Rahman, of the University of New South Wales, will lead the project.

The Australian National University's Department of Geology and Pacific Power have jointly been offered a grant of \$790,000 to complete the first element of the exploration of the Hot Dry Rock (HDR) resource in the Hunter Valley geothermal anomaly. By the end of 2000, the project team will determine the areal extent, temperatures, rock properties and stress conditions at a depth of around 2 km in the core of this anomaly. Successful completion of this project is expected to stimulate commercial exploitation of this potentially substantial energy resource. Doone Wyborn, of the ANU's Department of Geology, is the project leader.

Timor Gap Petroleum project goes ahead

In spite of the political situation in East Timor the majority partners in the \$US1.4 billion Bayu-Undan gas project announced on 26th October that they had decided to go-ahead to develop the resource.

The Bayu-Undan field is located in the southwest part of Area A of the Zone of Co-operation (see the diagram based on a map provided by Phillips Petroleum Co). The consortium intends to initially extract up to 400 million barrels of condensate and liquefied petroleum gas (LPG) from the field. A later stage could involve the production and export of over three trillion cubic feet of gas to supply domestic and export markets. Production is expected to begin in 2003 and would generate as much as \$40 M a year in royalties for the new East Timor Government and Australia for almost 20 years.

The first stage of the project (the construction and operation of three offshore platforms and a floating

production, storage and offloading vessel) is expected to cost about A\$2 billion.

Mr Downer, Minister for Foreign Affairs and Trade reported that the Indonesian Minister for Mines and Energy, Dr Kuntoro, had said that Indonesia would have no claim over the treaty area if East Timor became independent.

The UN would administer an East Timor in the short-term and therefore under the principle of successor states, the Timor Gap Treaty would apply to a relationship between Australia and the UN Transitional Administration in East Timor.

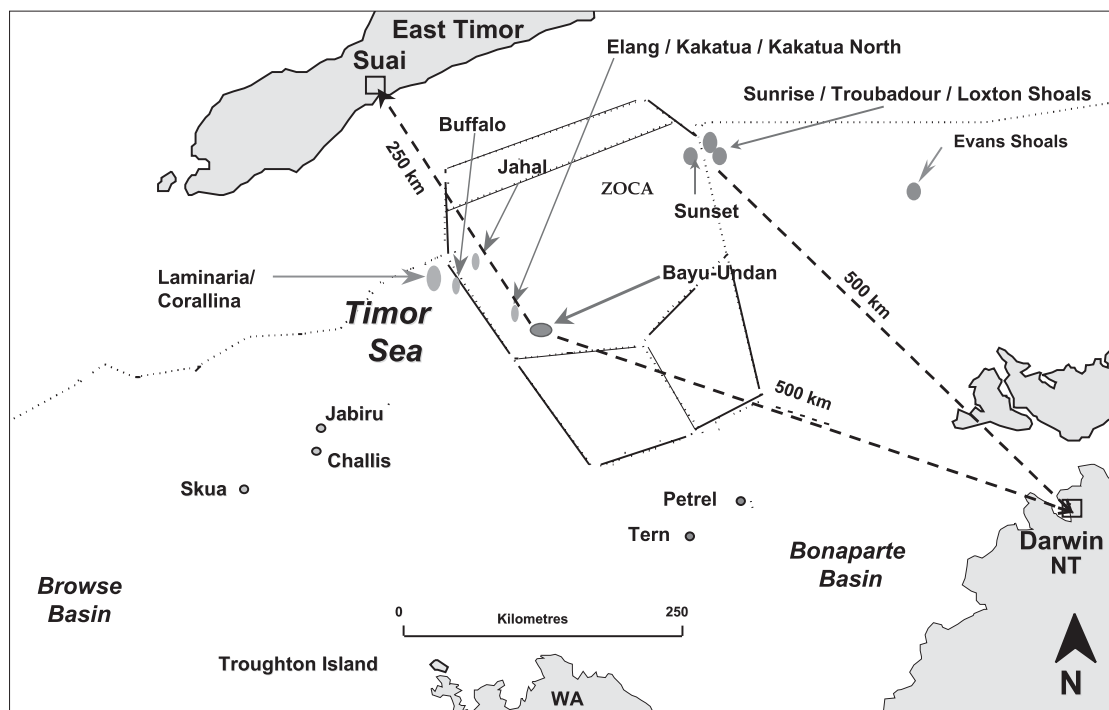
Mr Xanana Gusmao, during his recent visit to Canberra, indicated that a newly independent East Timor would in principle accept without change the Timor Gap Treaty which Australia signed with Indonesia.

The Minister for Industry, Science and Resources, Senator Nick Minchin, also welcomed the announcement that the commercial development of the Bayu-Undan project in the Timor Gap Zone of Co-operation will proceed.

Good News at Curtin University

Amid all the doom and gloom around at the moment it is good to see that Curtin University of Technology is making a firm commitment to the future of geophysics and, according to the CRC AMET Newsletter, is advertising two new professorial chairs, Petroleum Geophysics and Minerals Geophysics. These are new posts in the Centre of Excellence for Exploration and Production Geophysics. The Centre will also appoint one or more post-doctoral fellows with backgrounds in either petroleum or minerals research. Good stuff.

Eristicus, Canberra, November 1999



Location of Bayu-Undan and other oil and gas fields.

The Conductivity Environment of the Castlereagh Waste Management Centre NSW – An Airborne Electromagnetic Study

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J. Dobrolot, Waste Service NSW, Y. P. Yang and J. C. Macnae, CRC AMET

Key words:

Airborne
electromagnetics,
waste disposal sites,
ground conductivities

Abstract

In order to investigate the hydrogeological setting and potential for groundwater contamination an airborne transient-electromagnetic and magnetic study was undertaken over an area containing a 3.5 km² liquid waste disposal site. Interpretation of the AEM survey was assisted by petrophysical examination of borehole materials in laboratory studies as well as borehole gamma logging. The area was semi-urban with many sources of cultural noise although cultural features did not too adversely affect early channel conductance contours. The calculated conductances are considered to reflect relative conductivity in the shallow unconsolidated sediments, which are controlled, by water saturation, water salinity, porosity texture, and the presence of conductive solids (clays). The conductance map reflects the near surface hydrogeology with the southwestern salinity high giving way to a fresher regime to the northeast. The magnetic map reflects cultural anomalies particularly the waste cells. The study illustrates the use of airborne magnetics mapping technology to locate a major waste site and the use of airborne electromagnetics and petrophysics to investigate salinity-dependent electrical conductivity/resistivity palaeodepositional and palaeodrainage features in which the waste site was set.

Introduction

The Castlereagh Waste Management Centre (CWMC) is 50 km WNW of the Sydney CBD and is situated in Tertiary sediments of the Cumberland Basin between the western Sydney metropolitan area and the lower Blue Mountains. It lies on the Cumberland Plain woodlands in a busy, semi-urban, geophysically noisy area between the towns of Windsor and Penrith.

In 1993 a QUESTEM airborne transient-electromagnetic and magnetic study was undertaken over a 74 km² area, between Windsor and Penrith, to view the CWMC in a regional physical perspective, (Emerson & Hallett, 1994). The original aim was a 104 km² survey, but noise (power lines etc) and safety considerations (urban development) combined to reduce this. Two major high voltage powerlines pass through the survey area, a number of factories are in the vicinity and a major air force base is immediately to the north. A total of 525 line-km was flown at 120 m altitude on NW-SE traverse lines 150 m apart with the towed-bird EM detector at 60 m height. EM readings were taken at approximately every 15 m, and magnetic field readings at about 30 m along these lines. The QUESTEM system, as employed at Castlereagh, was a half-sine wave with frequency of 75 Hz and a 2 ms transmitter on time. The EM secondary field windows used for this study were the early time channels 0 and 1. Start and end times for these channels after the primary pulse were: channel 0, - 168 to 324 ms and channel 1, 272 to 428 ms. The QUESTEM system and its use in land management have been discussed by Street (1992) and Odins et al (1997). It has been upgraded a number of times since then and has been superseded for shallow environmental applications first by SALTMAP (Roberts et al 1992) and now by TEMPEST (Lane et al 1999). QUESTEM's data acquisition technology would now be regarded as inadequate.

The CWMC's trapezoidal outline is shown in Figure 1 with the airborne survey derived topography (5 m contours above msl). The two streams flanking the CWMC are Rickaby's Creek to the NW and South Creek in the SE; they enter the Hawkesbury River about 8 km to the NE, near Windsor.

Interpretation of the CWMC AEM study was petrophysics based. Throughout the area access was available to borehole materials and these were used in laboratory studies. Borehole gamma logging was also undertaken.

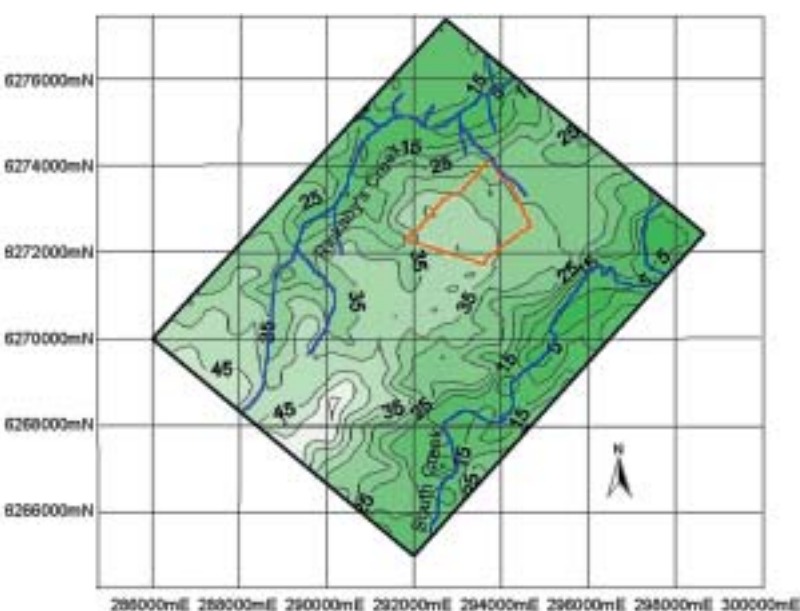


Fig. 1. Survey area topography form airborne altimeters (5m contours above msl) derived from aircraft altimeters. Trapezoidal outline is the Castlereagh Waste Management Centre for industrial liquid and sludge.

¹ Now with Fugro Airborne Surveys see page 22.

Geology

The study area comprises a sequence of Tertiary sediments overlying Triassic shale. The top Tertiary unit, the lateritised Londonderry Clay, contains the waste cells at CWMC. The bottom Tertiary unit, the Rickaby's Creek Gravels, is a clayey - gravelly bed of variable thickness and it appears to contain discontinuous sandy lenses. Underneath this the Bringelly Shale has a weathered palaeosurface. Each unit (clay, gravel, weathered shale) is roughly 10 m thick. Patchy, thin Quaternary sands sometimes lie on the clay. These remnant sands seem to be related to previous fluvial depositional episodes of the Hawkesbury-Nepean River, a major system in both the past and present and which now flows 10 km to the west and sub parallel to the CWMC's long dimension. The water table occurs in the gravels, but the overlying Tertiary is not dry and the clays can have a high degree of saturation. Jones & Clark (1991) have described the geology of the region which Old (1942) mapped as one of inferred fairly high groundwater salinity, of about half that of seawater i.e. $\sim 17\,000$ ppm NaCl ($\rho_w \sim 0.35 \Omega \text{ m}$ @ 25°C , $\sigma_w \sim 29\,000 \mu\text{S/cm}$).

Quaternary sands and gravels containing fairly fresh groundwater lie along and under Rickaby's and South Creek.

Castlereagh Waste Management Centre

The CWMC is a large industrial liquid and sludge repository covering an area of approximately 3.5 km^2 . It contains about 8000 waste cells set in the Londonderry Clay, with a minimum of 3 m of undisturbed clay beneath each cell. The cells are 20 m long, 5 m wide and 5 m deep; they are separated by 2 m and arranged in a bricklayer pattern; they are grouped in ten development stages; some of the early development employed wider cells (lagoons). Domestic refuse, which included incidental ferrous junk, was added to the cells as an absorbent. After filling, a 2 m thick clay cover was placed over each cell and surrounds. The CWMC has now been closed by a decision of the NSW Government.

Numerous monitoring bores have been drilled on and around the CWMC. Sampling of cell liquids shows a range in salinity from cell to cell: from around 1000 ppm (low) through 7000 ppm (medium) to 17 000 ppm (high) - corresponding to water resistivities of about 5, 0.7 and $0.4 \Omega \text{ m}$, with most being in the middle range ($\sigma_w \sim 14\,300 \mu\text{S/cm}$).

While there is no pattern to the cell salinities, there is some pattern to the low yielding Rickaby's Creek Gravels and weathered Bringelly Shale groundwater salinities. These appear to range from around 17 000 ppm (Old's value) to the southwest of the survey area (towards Penrith) to around 500 ppm or less to the northeast (towards Windsor).

Airborne Survey Data

Magnetic Response

The total magnetic intensity contours are shown in Figure 2 with the CWMC manifesting itself as a prominent 50 nT dipolar anomaly complex over most of the waste site. The non-anomalous parts on the NE and SW sides of the

CWMC correspond to areas of low cell development. Other cultural anomalies can be seen in Figure 2; they are associated with large steel agricultural sheds or the fringes of the suburb of South Windsor. All the anomalies are situated on a prominent magnetic gradient to the west, which seems to correspond with the flanks of a broad magnetic anomaly centred near Springwood in the Blue Mountains (see Jones & Clark, 1991, p.98, 99). The CWMC can be identified quite clearly in the airborne magnetics.

Ground magnetic surveys gave anomalies of up to about 500 nT over the waste cells, but ground surveys can be impaired by the presence of high susceptibility (up to $10\,000 \times 10^{-5} \text{ SI}$) laterite material on the Cumberland Plain surface.

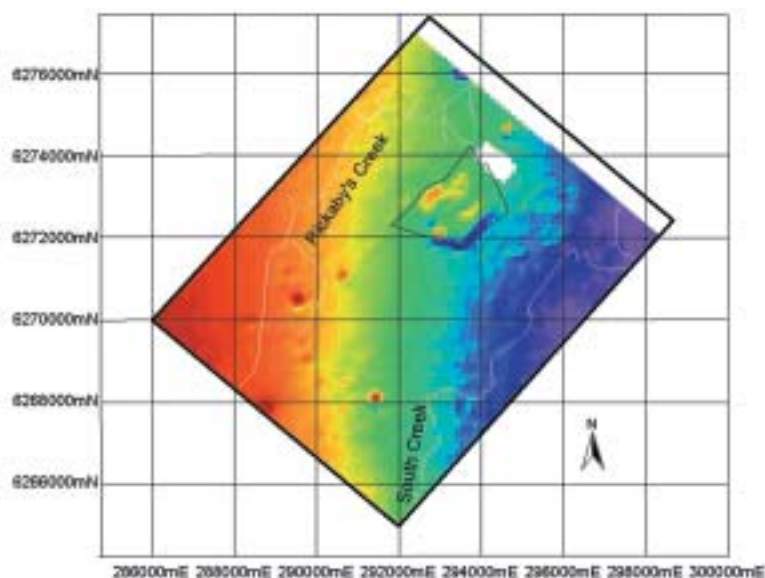


Fig. 2. Magnetic intensity image of area around. The waste site is associated with 50nT dipolar anomalies.

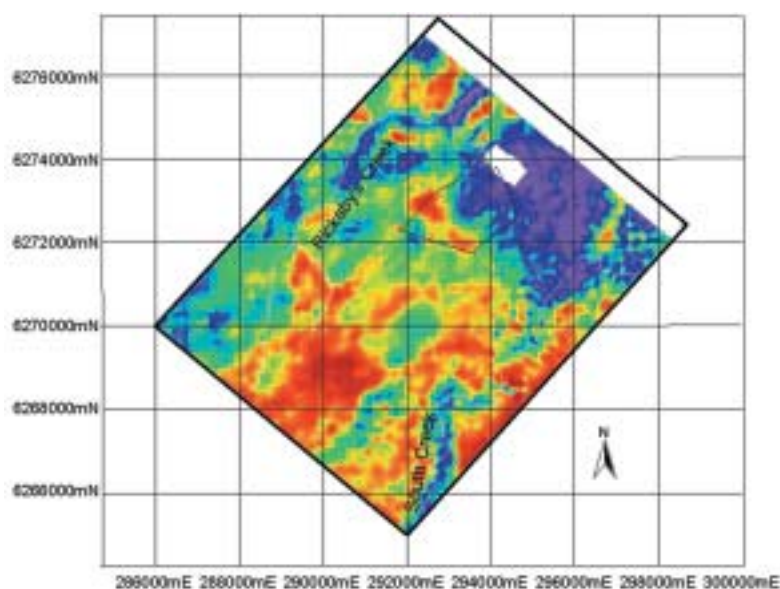


Fig. 3. Conductance derived from early QUESTEM channels for area around Castlereagh Waste Management Centre reflect conductivity in shallow Tertiary and Quaternary sediments. No anomaly is associated with waste disposal site.

Lithology	Age	Thickness (m) (approx.)	Saturant		
			Salt water $\rho_w = 0.35 \Omega m$	brackish $\rho_w = 1 \Omega m$	Fresh water $\rho_w = 10 \Omega m$
			→ FRESHENING →		
ALLUVIAL SANDS (patchy)	Quaternary <2My	0-10			40
LONDONDERRY CLAY [has waste cells] sandy (quartz to 20%) mottled Fe, grey, kaolinite/illite clay Sw=100% except at top	(Lateritisation Pliocene/Miocene ~5 My)	10 to 15 (top clay may not be saturated)	2	5	15
(gradational boundary) RICKABYS CK GRAVEL clay, silts/sands, gravel 30%, 40%, 30%	Tertiary Miocene/Oligocene ~23.5 My	~10 (0 to 25 possible)	3	10	30
WEATHERED BRINGELLY SHALE (porosity <25%; ρ and velocity increase with depth in top few m of weathered zone WT ~5 to 10 m depth when Br Sh exposed)	early Tertiary weathering? ~65 My	~10	4	15	40
FRACTURED BRINGELLY SHALE (in zones, with fracture porosity ~2%)		varies	20	70	430
UNWEATHERED, DEEP BRINGELLY SHALE	late Triassic ~220 My	max 150m	100	700	1000

Table 1. Lithology Resistivity Distribution (Saturated, ρ_o Ωm) CWMC and Surrounds (This is a simplified distribution based on lab petrophysics).



Inductive Response

The airborne TEM's early channel conductance contours were chosen for presentation in Figure 3 as the channel 0 and 1 data were not too adversely affected by cultural features, especially transmission towers and power lines. The data emphasise conductances in the 2 to 6 siemens band and are considered to reflect relative conductivity in the shallower Tertiary and Quaternary (creeks) sections. Such conductivity would be controlled by water saturation,

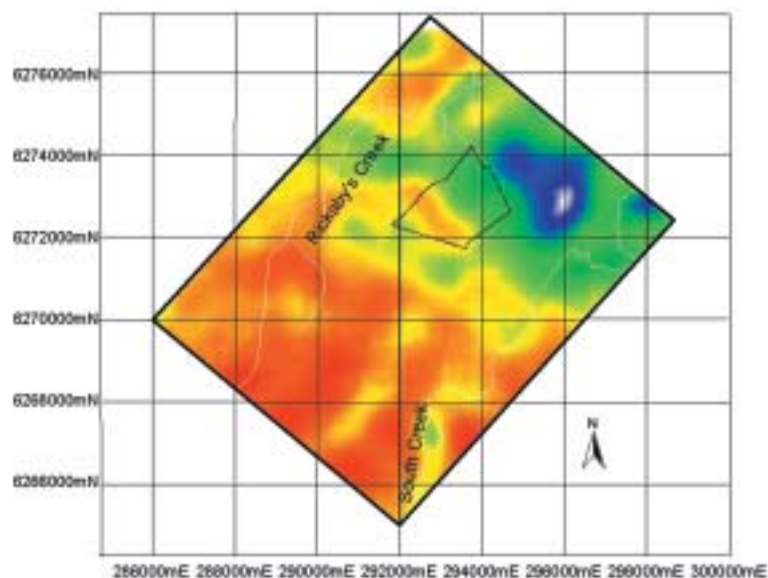


Fig. 4. Image of resistive limit calculated from QUESTEM data shows freshening of groundwater to northeast. The waste site straddles the change.

water salinity, porosity and its texture, and the presence of conductive solids (clays). In contrast to the magnetic map where the salient anomalies are cultural in origin and the waste cells, in aggregate, are prominent, the conductance map appears to be configured by the near surface hydrogeology with the southwestern palaeosalinity high (red/orange/yellow) giving way to a fresher regime to the northeast (blues) and with pondings, soaks and streams indicated by the cooler colours.

Petrophysics

The investigation was supported by a laboratory petrophysical study, some of which was discussed previously by Emerson & Yang (1997). Some relevant data are summarised in Table 1. Saturated-state resistivities (ρ_o , S_w @ 100%) are given for the important lithological units in the geological section and for salty, brackish and fresh saturants. It is clear that the section from the near-surface to (but not including) the low porosity shale acts more or less as a single resistivity unit for each salinity condition i.e. about $3 \pm$, $10 \pm$ and $30 \pm \Omega m$, roughly, for the saline, brackish and fresh conditions, respectively. It may be inferred then that broad lateral changes in salinity regimes in the whole of the Tertiary features (clay to highly weathered shale) might be mappable, but that it would be unrealistic to expect fine and reliable differentiation vertically down the section on the basis either of inductive or galvanic techniques.

There are other possibilities for the resistivity distribution. Locally, the saturant salinity may not be uniform from top to bottom. Also, the water saturation may diminish towards the top of the section. Such variations do occur at CWMC and its surrounds with consequent changes to the electrical profile, but these possibilities will not be addressed here, as the broader features only are being considered.

Resistive Limit Image

Further data processing was undertaken to enhance the electromagnetics. A flight height corrected resistive limit map was imaged and is presented on a 2 km grid in Figure 4. In this colour image warm colours (to red) indicate the higher subsurface conductivities or lower resistivities and cool colours (to purple) indicate the lower conductivities or higher resistivities. The processing procedures and the resistive limit have been discussed by Macnae et al (1991) and Stolz & Macnae (1997). Considerable difficulty was experienced in compensating the data for noise levels that generated spurious apparent conductivities at late delay times. The compensations undertaken resulted in relative rather than absolute conductivities for the images, such that the conductivities estimated from airborne data are likely to underestimate systematically the true conductivity.

The flight height data were used to correct the resistive limit image as this quantity depends inversely on distance to the source, through a power law. The resistive limit is the low frequency, least skin effected inductive response and is the closest approximation to a DC resistivity map that an inductive source can provide. A large value of resistive limit (red) indicates a high ground conductivity near the surface and possibly extending to depth; a small value (blue) indicates a low ground conductivity to a considerable

depth; while intermediate values (yellow, green) could be a high conductivity at depth or a moderate conductivity at shallow depth.

The CWMC processed survey results can only be regarded as a broad brush depiction of subsurface resistivity/conductivity units with averaging of source bodies' responses in a 100 m radius bowl. Nevertheless the results are useful and instructive. For the QUESTEM system as employed at Castlereagh, and in the simple case of a layered sequence with occasional lateral inhomogeneities, it is reasonable to expect the vertical resolution for layered or block conductive features to be about 10 % of the flight height i.e. around 15 m, and the lateral resolution to be around 250 m. Conductivity features that exhibit a reasonable contrast to their surroundings should be readily detectable if their dimensions are of the order of tens of metres vertically and hundreds of metres laterally. Recent developments with the TEMPEST system (Lane et al 1999) show improved vertical resolution can be achieved with better signal to noise ratios and more rapid sampling of the secondary field. Closer line spacing down to 50 m will also improve lateral resolution.

The high cultural noise emanating from the surrounding areas results in a poor signal to noise ratio at Castlereagh meaning that conductance (conductivity x thickness) changes of the order of 50 % are required to highlight features rather than changes of about 10 % which can be detected in good signal to noise ratio surveys. In the case of a ribbon or plate feature which might approximate a tongue of groundwater of contrasting conductivity, e.g. a contaminant plume, the feature would need to be about 100 m long and 10 m wide if it had an excellent conductivity contrast (100 to 1) or about 150 m long and 150 m wide if it had a poor conductivity contrast (2 to 1). Such features have not been interpreted in the data.

More recent surveys with SALTMAP (Pracilio et al, 1998) and TEMPEST (Lane et al, 1999) show that these newer systems are capable of better near-surface resolution.

The resistive limit image in Figure 4 is regarded as a coherent representation of the surveyed region's bulk electrical properties. This interpretation accords well with many salinity measurements from boreholes in the region. It shows a significant change in regional groundwater salinity (down to the tight shale) with a pronounced freshening to the NE. The CWMC site happens to straddle this salinity change. The freshening is considered to be related to the existence of late Tertiary and/or Quaternary drainage and depositional episodes of the proto-Hawkesbury-Nepean that permitted the infiltration of fresh water into a formerly saline subsurface e.g. through lagoons, lakes and flood plains.

Conductivity-Depth

Conductivity depth images were generated but the noise levels were too large for reliable quantification of both conductivity and depth. However, some 'spotty' CDI profiles did show the broad lateral changes in conductivity from SW to NE. On some profiles there was evidence of an increase in conductivity with depth beneath resistive near surface zones suggestive of shallow infiltration of fresh rainwater in saline sections.

Conclusions

The CWMC is set in a thin Tertiary sequence in a high noise environment. The CWMC survey illustrates the use of airborne magnetics mapping technology to locate a major waste site and the use of airborne electromagnetics and petrophysics to investigate salinity-dependent electrical conductivity/resistivity palaeodepositional and palaeodrainage features in which the waste site was set.

The Castlereagh site is in a semi-urban area with high noise from major powerlines and other cultural features. Despite these sources of noise it was possible to resolve adequate detail in the survey. In addition it provided valuable information on the electromagnetic noise expected in semi-urban areas and how it might be avoided or removed from AEM data.

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Petroleum Exploration Offshore: Where Has the Effort Gone?

Paul Williamson and Eugene Petrie - Australian Geological Survey Organisation

Key words:

Petroleum exploration, Australia, wells, seismic surveys, oil & gas discoveries

Abstract

The history of Australian offshore petroleum exploration since the early 1980s has been one of defying the low price of oil to maintain high levels of exploration. During this period, discoveries, promotion of exploration acreage and the public availability of exploration data have contributed in retaining offshore Australia as an attractive petroleum exploration location in worldwide terms.

Recent years to 1998 have seen records broken in Australian petroleum exploration, including in wells drilled, seismic reflection data collected and in the number of discoveries, in any single year. Seismic reflection data are critical to the petroleum exploration industry for defining prospects and siting exploration wells. Since 1996 these data have included multiclient non-exclusive 3D seismic data on Australia's North West Shelf. The low price of oil over the period has seen a dominance of exploration in perceived low risk exploration areas on the North West Shelf and in Gippsland.

Introduction

The Australian petroleum industry produces \$8 billion of oil and gas per year. This allows Australia to be slightly more than self-sufficient in oil and gas. Australia is 70 % self sufficient in liquids but exports of gas more than pay for the imported heavier oil fractions not produced in Australia. Current petroleum production saves Australia the large balance of payments debt that would be incurred if we did not have the domestic exploration and production industry.

Seventy five percent of Australian gas production and ninety three percent of oil production are from offshore (AGSO, 1998). Thus the offshore petroleum exploration industry is nationally important. Offshore petroleum exploration depends heavily on geophysical methods and particularly on seismic reflection data. These data are the main tools for defining prospects and siting exploration wells.

Relatively more seismic reflection data are used for offshore exploration compared to onshore exploration. This largely reflects the greater ease of collection by ship compared to land surveying, and the lower cost per kilometre for data collection.

Increasingly 3D seismic reflection data are being used for exploration along with 2D data. Use of 3D seismic data had previously been well established as a tool for detailed field definition in the development phase. Seismic reflection data have underpinned the wildcat exploration wells shown in Figure 1.

The low price of oil over recent years has led to a greater concentration of petroleum exploration in areas around existing production in the Bonaparte and Carnarvon Basins on the North West Shelf and in the Gippsland Basin. Exploration has also concentrated in regions around discoveries on the North West Shelf and in South Eastern Australia. This has largely been at the expense of frontier exploration.

History of Petroleum Exploration

The history of offshore petroleum exploration in Australia since the late 1980s and into the 1990s has been one of defying the low price of oil to maintain sustained

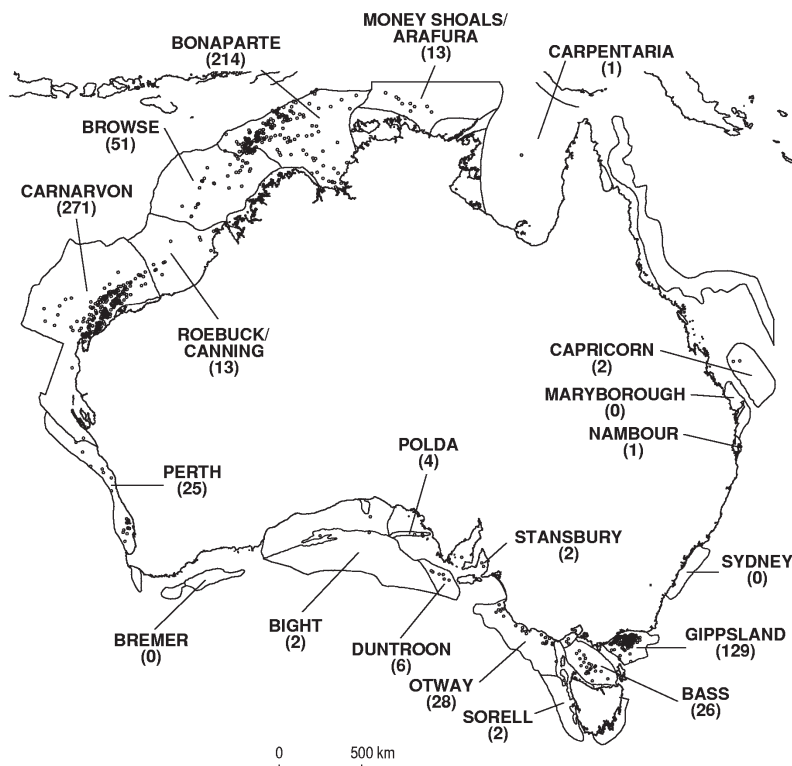


Fig. 1. Australia Offshore Basins - New Field Wildcats to 1998.

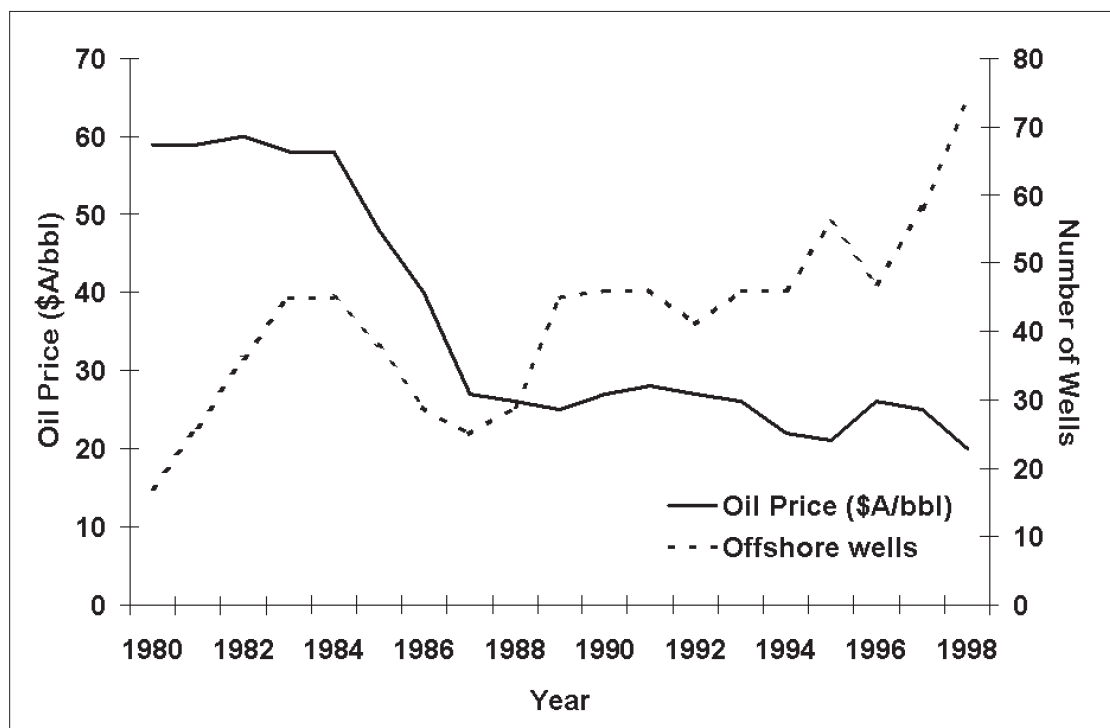


Fig. 2. Offshore Exploration Drilling vs Oil Price.

exploration levels. At the same time the affect of the low price of oil has concentrated exploration activity in areas of perceived low risk.

Figure 2 shows the level of offshore exploration wells and oil prices from 1980 to 1998. From 1984 the level of drilling followed the price of oil down. However, by 1988 the level of drilling was beginning to rise again culminating in a record year of 1998 for both drilling and seismic data acquisition.

Offshore Australia has held international favour as a location for petroleum exploration. Positives for offshore Australia include prospectivity, availability of data, favourable tax regime, stable politics, an open and transparent regulatory regime, and a pleasant place to live (onshore). This has resulted in offshore Australia being rated well as a location for exploration. According to recent press releases a survey of industry carried out by Robertson Research has rated offshore Australia second in the world in attractiveness as an exploration arena outside North America. The United Kingdom was the country most favoured.

Seismic Reflection Surveys

The level of collection of exploration seismic has dramatically increased over the last 5 years. This has coincided with increased drilling activity and has been greatly contributed to by the increased use of 3D seismic in petroleum exploration. 3D seismic data had begun to be heavily used for exploration in the Gulf of Mexico and the North Sea after beginning as a method used to define the structure of fields after discovery as an aid to their development. The value of 3D seismic in saving money through better positioning of exploration wells was subsequently recognised. In Australia, an agreement to extend the confidentiality period for non-exclusive multi-

client 3D seismic data from 5 years for 2D survey to 8 years was achieved between industry, contractors and government. This agreement flagged the beginning of the collection of non-exclusive multi-client 3D surveys on the NW Shelf, which is reflected in the steep increase in 3D survey activity in 1996 (Table 1).

The use of 2D surveys for exploration and to site wells was however retained by operators of some licences. This was in particular the case where exploration was in its early regional stage or where structures were considered to be large and relatively simple as in some deeper water areas. Table 1 shows a summary of offshore 2D and 3D seismic data by State for the years 1994 to 1998. Because of the relatively low price of oil, seismic data have been dominantly collected in regions with established production. A lesser amount has been collected in areas containing commercial discoveries and in frontier areas.

Offshore Exploration Drilling

Over the last 5 years Australia has experienced a period of increased offshore exploration drilling activity which peaked in 1998 as shown in Table 2. This increase can be attributed to a number of factors including aggressive release programs by Governments for offshore areas, the entry of new players, and increasing work commitments by operators.

The number of offshore new field wildcat (NFW) exploration wells drilled during 1998 (57) easily surpassed the previous record of 49 NFW wells drilled in 1990 and followed a record number of 12 offshore new field discoveries (NFD) during 1997. Eleven of the discoveries were located in Northwest Australia in the producing Bonaparte and Carnarvon Basins and one discovery was made in the Bass Basin off Tasmania.



	1994		1995		1996		1997		1998	
STATE	2D	3D	2D	3D	2D	3D	2D	3D	2D	3D
QLD	-	-	-	-	-	-	-	-	-	-
NSW	-	-	-	-	-	-	-	-	-	-
VIC	3852	23 833	2332	8460	379	1536	-	-	-	-
TAS	750	13 780	-	-	2374	-	880	-	3884	-
SA	421	-	872	-	792	-	314	-	4812	-
WA	20 703	60 407	34 351	45 509	29 687	144 461	27 578	352 762	70 736	405 182
NT	400	511	218	57 717	19 560	109 866	21 858	45 798	21 633	403 710
ZOCA	827	27 375	4770	-	867	69 650	6281	5784	3655	47 268
Sub-total	26 953	125 906	42 543	111 686	53 659	325 513	56 911	404 344	104 720	856 160

Table 1. Offshore Seismic Survey Activity 1994-1998, Line-km.

Underpinning the recent high level of offshore exploration drilling has been the acquisition of large amounts of seismic data. Large 2D and 3D Seismic Surveys which collected vast amounts of data were carried out over the last 5 years in offshore Western Australia, Northern Territory and in the Zone of Cooperation Area A (Bonaparte Basin) in the Timor Sea. Details are also shown in Table 1.

Discoveries

The five-year discovery success ratio for Northwest Australia (Carnarvon, Bonaparte, Browse and Money Shoal/Arafura Basins) has been one discovery well per 4.2 new field wildcat wells drilled. These discoveries, some in water depths of over 1,000 m, reflect the trend elsewhere in the world in drilling in deeper waters and the underlying technology required to produce oil and gas from water depths of over 3 km.

Significant discoveries over the last five years include oilfields at Laminaria, Corallina, Elang, Kakatua, Cornea, Wonnich, Buffalo, Woollybutt, Tenacious, Legendre South and Vincent, all off Northwest Australia. During 1999, significant offshore oil discoveries have occurred at Moon

and North Gypsy both located in the Carnarvon Basin. Large increases to current gas reserves have resulted over the last five years following discoveries off Northwest Australia at Chrysaor, Fohn, Bayu, Keast, Kelp Deep and Sunset. During 1999 two giant gas discoveries were made at Geryon and Orthrus near Chrysaor in the Carnarvon Basin.

Government Promotion of Exploration

In the mid-1980's the Commonwealth through AGSO (then the Bureau of Mineral Resources) in cooperation with the now Petroleum and Electricity Division of the Department of Industry Science and Resources, began international promotion of the prospectivity for petroleum exploration of Australian offshore areas. This has contributed to an influx of new entrants to offshore petroleum exploration. From 1995 through 1998 an average of ten new entrants per year took interests in offshore petroleum exploration licences. Of these approximately 50% took up licences in the Bonaparte Basin, in the Ashmore Cartier and the Northern Territory, 35% were in Western Australian licences, 10% in Victorian licences and 5% in Tasmanian licences.

BASIN	YEAR										TOTAL NFW	TOTAL FIELD DISC.	5 YEAR SUCCESS RATIO
	1994		1995		1996		1997		1998				
	NFW	NFD	NFW	NFD	NFW	NFD	NFW	NFD	NFW	NFD			
BASS									1	1	1	1	1:1.0
BONAPARTE	16	4	9	3	8	3	14	5	17	2	64	17	1:3.8
BROWSE	1		1	1			2	2	12	1	16	4	1:4.0
CARNARVON	9	2	17	3	21	3	19	5	21	6	87	19	1:4.6
GIPPSLAND			4	2			2		2		8	2	1:4.0
MONEY SHOAL/ ARAFURA									1		1	0	
OTWAY			3								3	0	
PERTH					1				1		2	0	
STANSBURY									2		2	0	
TOTAL	26	6	34	9	30	6	37	12	57	10	184	43	1:4.3

Table 2. Exploration Activity 1994 To 1998.



Government has promoted the acreage, which is released by the Commonwealth Minister at the Australian Petroleum Production and Exploration (APPEA) Conference each year. The promotion uses data collected via the AGSO continental margins programs, AGSO studies and joint studies with industry, and promotional papers and lectures at conferences and industry forums. AGSO is continuing its effort to promote petroleum exploration in offshore Australia and is currently focussing on the prospectivity of the Bight Basin with new studies and data acquisition programs. Sustained promotion is particularly important in maintaining high levels of exploration when periods of low oil prices occur, as has recently been the case.

Lodgement of Petroleum Data

Petroleum exploration has also been stimulated by the public availability of petroleum exploration data collected under the Petroleum Search Subsidy Act 1959 (PSSA) and subsequently under the Petroleum (Submerged Lands) Act 1967 (P(SL)A). Because the PSSA was formulated at a time when Australia was considered to have very poor prospectivity for oil and gas, exploration was subsidised under the Act on condition that exploration data were made available to assist future exploration. During the term of the PSSA, discoveries of oil and gas were made in the Gippsland Basin (Barracouta and Marlin), the Northwest Shelf (Barrow Island), the Cooper Basin (Gidgealpa), the Bowen/Surat Basin (Moonie, Cabawin) and the Amadeus Basin (East Mereenie). After these discoveries the Australian petroleum exploration and production industry was well underway. As a result the subsidy was removed under the P(SL)A that followed. The P(SL)A administered the offshore area outside the three nautical mile zone from the coast, and not all of Australia as under the PSSA. However, what was retained under the P(SL)A was the requirement to lodge exploration data with the Commonwealth and States and to make available that data as input to subsequent exploration. That arrangement remains to this day.

Access to Data

Seismic data can be obtained as digital field data or processed data from AGSO and from the States/NT Departments of Mines and Energy. Well samples, reports and well logs are also available. These data are all available

for the cost of transfer. Also available are reports giving data from destructive analysis of well samples, for example to investigate source rock potential.

The most recent innovation is the ability to order copies of digital field seismic data from the Chester Hill Archive (formerly Villawood) NSW via the Internet through the AGSO website at www.agso.gov.au. This is part of a National Petroleum Information and Data Strategy endorsed by the ANZMEC Upstream Petroleum Subcommittee. The Strategy aims to make information on how to get copies of publicly available petroleum exploration data from offshore or onshore Australia seamlessly available via the Internet.

In short, Australia's history of petroleum exploration and associated legislation, has left us with a high level of access to petroleum exploration data that is almost unique worldwide. This is part of Australia's competitive advantage and part of the reason why offshore Australia has been so highly regarded as a place to explore.

Conclusion

In recent years the low price of oil has tended to drive offshore petroleum exploration to areas considered to be of low risk. This still leaves Australia highly underexplored with less than eight thousand wells nationwide compared to around three million wells for the North American continent. Thus there is much room for increased exploration particularly if a sustained increase in the oil price occurs, if new discoveries are made in frontier areas or if new gas markets are established for the already discovered supergiant gas fields or for newly discovered gas fields.

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The Importance of Accurate Phase Matching

Time, phase and amplitude balancing are often performed on multi-vintage 2D data. This makes interpretation easier, quicker and more accurate. Time, and therefore depth, structure maps are more reliable. But how accurate do you need to be? Phase misties of up to 45° generally present no hindrance to a rapid interpretation.

Figure 1 shows an unbalanced intersection. The mistie between these two surveys was determined statistically to be 40° and 10 ms, and the corrected sections are shown in Figure 2. From an interpretation viewpoint, there appears little advantage in balancing the data, however, when we come to map the amplitudes we see a different story.

In Figure 3 we see an amplitude extraction on the unbalanced data, the different vintages have different apparent amplitude levels. This difference is not due to the amplitude level of the surveys as they have been normalised using the RMS level of the trace. Rather it is due to the phase change moving energy within the wavelet. After balancing, retracking and re-extracting the amplitudes, we get a much clearer amplitude map in Figure 4.

GeoCom would like to thank the Woodside-Shell Alliance for permission to show their data.

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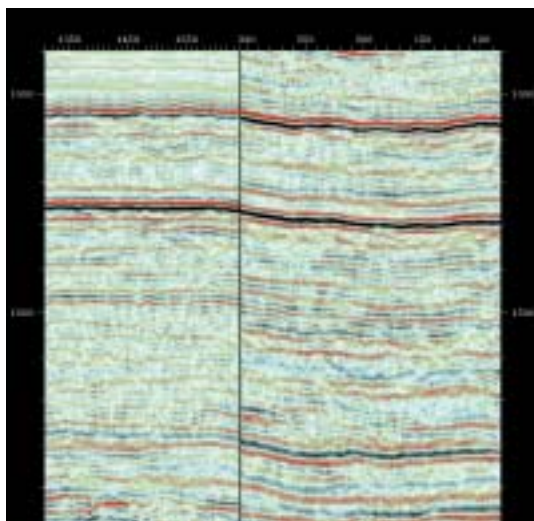


Fig. 1. Intersection between 1980 and 1999 data prior to balancing.

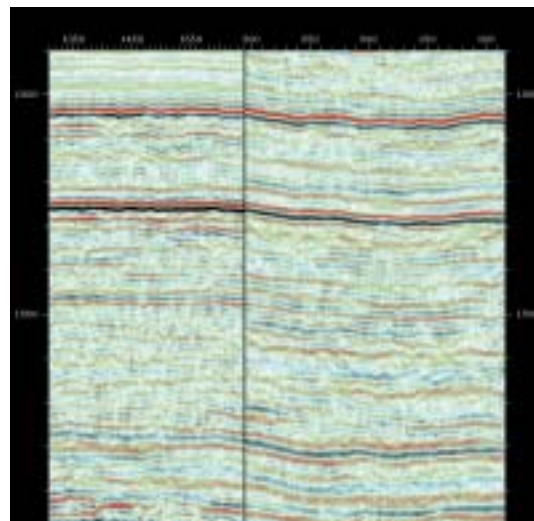


Fig. 2. The same intersection after balancing.

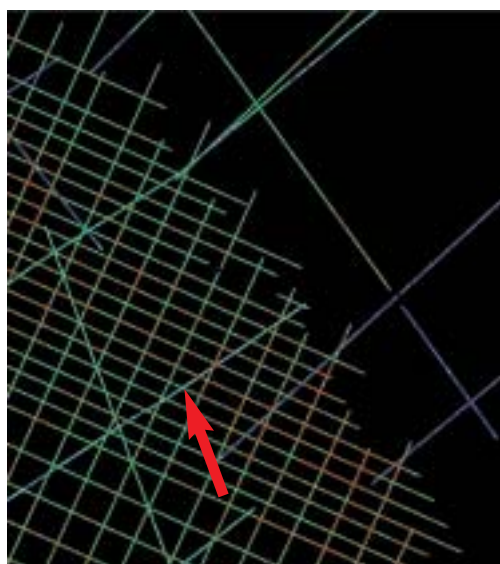


Fig. 3. Normalised amplitude extraction from unbalanced data. Note the footprint of each vintage.



Fig. 4. Normalised amplitude extraction after the application of statistical seismic balancing.



New Data to Increase Exploration in Victoria

While the heady days of Victoria's gold rush are past, its wealth generation is still substantially based on earth resources through our extractive, mineral, and petroleum industries. These three major industries directly contribute around \$3.5 billion annually to Australia's economy.

The Geological Survey of Victoria (GSV) is a business unit of Minerals and Petroleum Victoria (MPV) specialising in earth resource management within the Department of Natural Resources and Environment. Its job is to promote the exploration industry through geological and geophysical mapping, and identify and promote the exploration of prospective mineral, petroleum and stone resources. The GSV works closely with the Petroleum Development Unit of MPV to ensure that the benefits to both industries are captured. GSV's mission is *"To deliver high quality products to generate wealth through the sustainable development of earth resources."* The emphasis is on encouraging effective and responsible exploration and the development of Victoria's earth resources.

The Geophysics Section conducts regional geophysical surveys and interpretations in accordance with the mineral industry's needs in conjunction with the Geological Mapping and Mineral Resources Sections using state-of-the-art resources and facilities. In particular, fully integrating the interpretation of the latest geophysical data into the geological mapping programs has been a high priority. As a result, the GSV has developed new methods and standards for displaying geophysical interpretations.

GSV uses the latest field equipment, including GPS, spectrometers, magnetometers, and gravity, conductivity and susceptibility meters. In addition, it uses the most advanced hardware and software for data and image processing, modelling and GIS applications, to ensure strict data quality control and to provide accurate and reliable products efficiently. Work is regularly outsourced, particularly routine data collection, to optimise the use of latest technology and skills.

Free data to boost exploration

Geoscience digital data for Victoria are now available **FREE** from MPV.

Digital data includes:

- Airborne geophysical data collected under the Victorian Initiative for Minerals and Petroleum (VIMP) program and open-file company surveys (located and gridded data)
- Gravity (located and gridded data)
- GIS data packages
- Geological maps in GIS format

The purpose of this free offer is to make GSV's data more widely available for project generation work. As companies and individuals use the data, the more likely they are to explore in Victoria.

Airborne surveys

The VIMP program and joint projects with the Australian Geological Survey Organisation (AGSO) and a few large industry surveys have enabled the collection of industry standard magnetic and radiometric data over 85% of the State. These data have been collected at line spacings between 200 and 400 m. (Figure 1). All of the MPV surveys have been carried out by airborne survey contractors.

The investment by the government in the VIMP airborne survey program means that there is now a new comprehensive data set (total magnetic intensity (Figure 2), radiometric and digital terrain model) available as a fundamental tool in exploration programs. Companies are now flying high-resolution surveys in their prospective areas using line spacings of 50 m to infill the VIMP surveys. These company datasets provide orders of magnitude more geological detail than the VIMP surveys.

Gravity

Under the VIMP program the GSV and contractors have embarked on a major gravity acquisition program to collect semi-regional gravity data at a station spacing of 1 to 2 km, infilling the previous regional 11 km spaced data. This has resulted in a more detailed Bouguer anomaly gravity image (Figure 3) and a better insight into the geology of Victoria.

Current coverage is approximately 70% of the State (Figure 4) with over 30 000 gravity stations collected across Victoria to date, equivalent to about 1000 stations per 1:100 000 map sheet area. Industry is now becoming more aware of the application of gravity and carrying out detailed gravity surveys as part of their exploration programs.

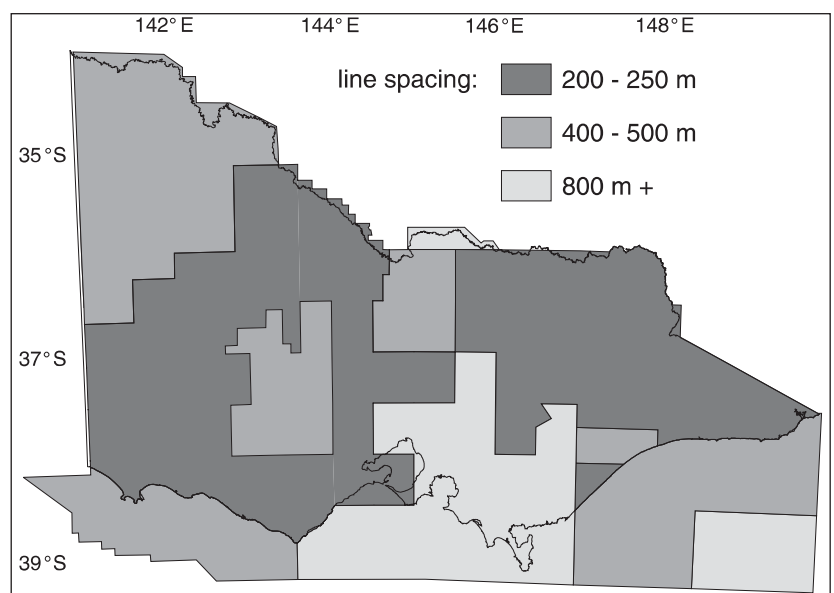


Fig. 1. Victorian airborne survey line spacing.

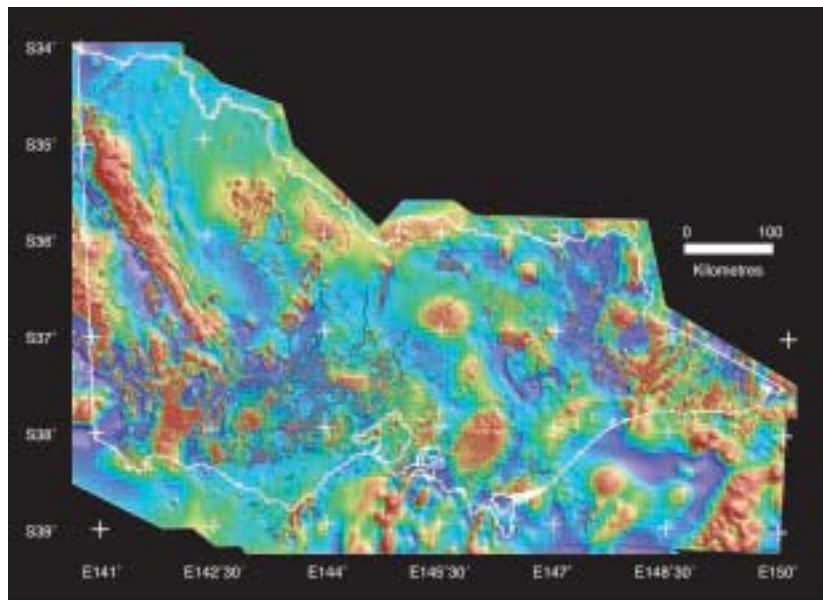


Fig. 2. Total magnetic intensity image of Victoria.

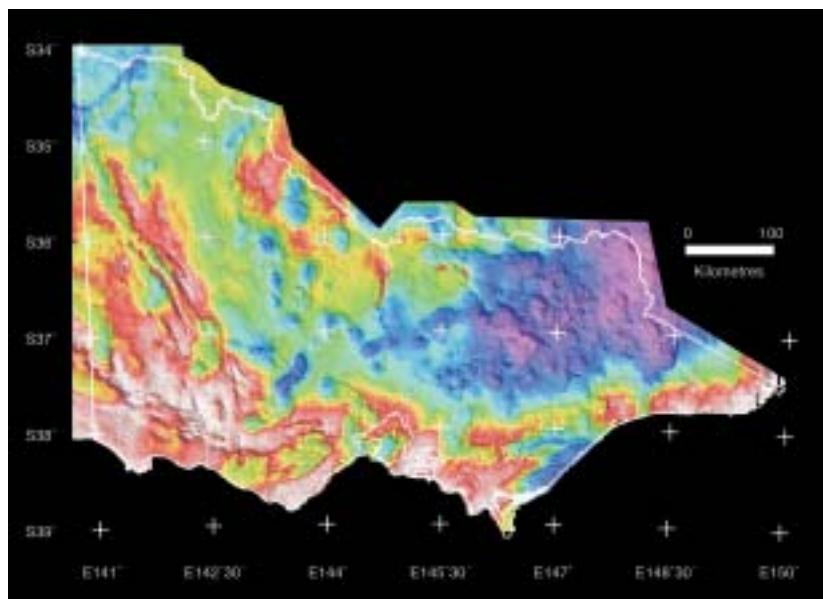


Fig. 3. Bouguer anomaly image of Victoria.

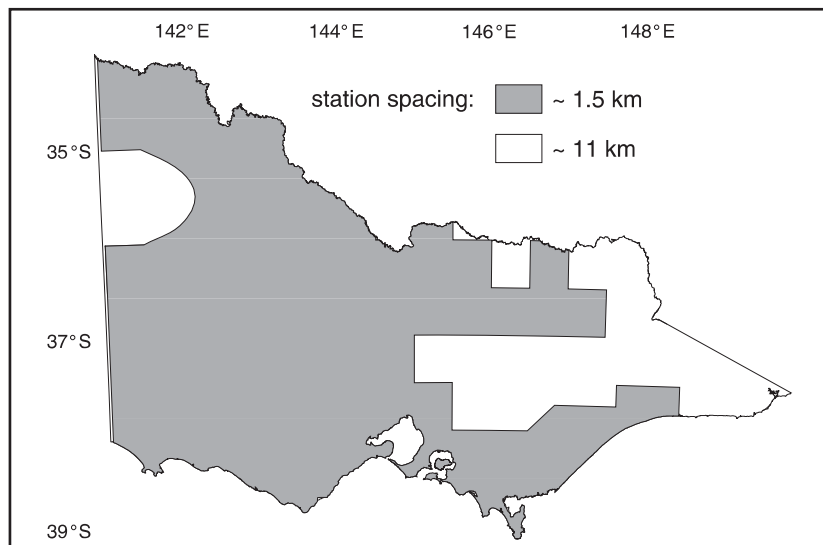


Fig. 4. Victorian gravity station spacing.

Gippsland Deep Water Seismic

In a joint venture with Seismic Australia MPV has jointly acquired 906 line-km of 2D reflection seismic data (Figure 5). These data will assist in the Gippsland Potential Project which is looking at a regional synthesis of this premier petroleum basin using potential field, well and seismic data. The seismic data will also provide a database in the area of proposed future releases of Exploration Licences in this deep water area.

These data are available for purchase from Seismic Australia and may be viewed in the MPV offices.

Palaeozoic Geology of Victoria

The volume *"The Tasman Fold Belt System in Victoria"* is the culmination of a decade of geological work by the GSV that has, for the first time, been supported by high quality airborne geophysical data. It describes the evolution of Victoria through time, from the Neoproterozoic through to the Permian, and covers the development of the Victorian part of the Delamerian and Lachlan Fold Belt as part of the Tasman Fold Belt System. It describes the different styles, timing and controls on mineralisation that developed in Victoria during this period, and makes links to similar styles of mineralisation in both Tasmania and New South Wales.

As part of this publication three new 1:1 000 000 maps have been prepared:

- Surface geology map
- Pre-Permian geology map, showing the interpreted geology of Victoria, with the Permian and younger units stripped off
- Mineralisation map of metallic and major industrial minerals

The pre-Permian geology map was compiled from the surface geology map and interpretation of the extensive new magnetic, radiometric and gravity data, along with seismic profiles where available. The mapped geology has been reconciled with the geophysical data sets, to produce a map that is both geologically and geophysically reasonable. The main background magnetic image and the subsidiary images elsewhere on the map face help support the new interpretation presented for the covered areas. The background image also gives extra information that could not be adequately presented on the map, such as sedimentary or contact metamorphic changes in the magnetic properties of rock packages, dyke swarms, and thick basalt cover.

The volume will be released in early 2000.

Geophysical signatures

GSV has recently released a volume *"Geophysical signatures of base metal deposits in Victoria"*. This volume was produced by the GSV as a joint publication with the ASEG. The case studies of mineralisation in areas of outcrop or shallow cover will help explorers determine appropriate geophysical techniques for exploration in Victoria. Topics covered are:

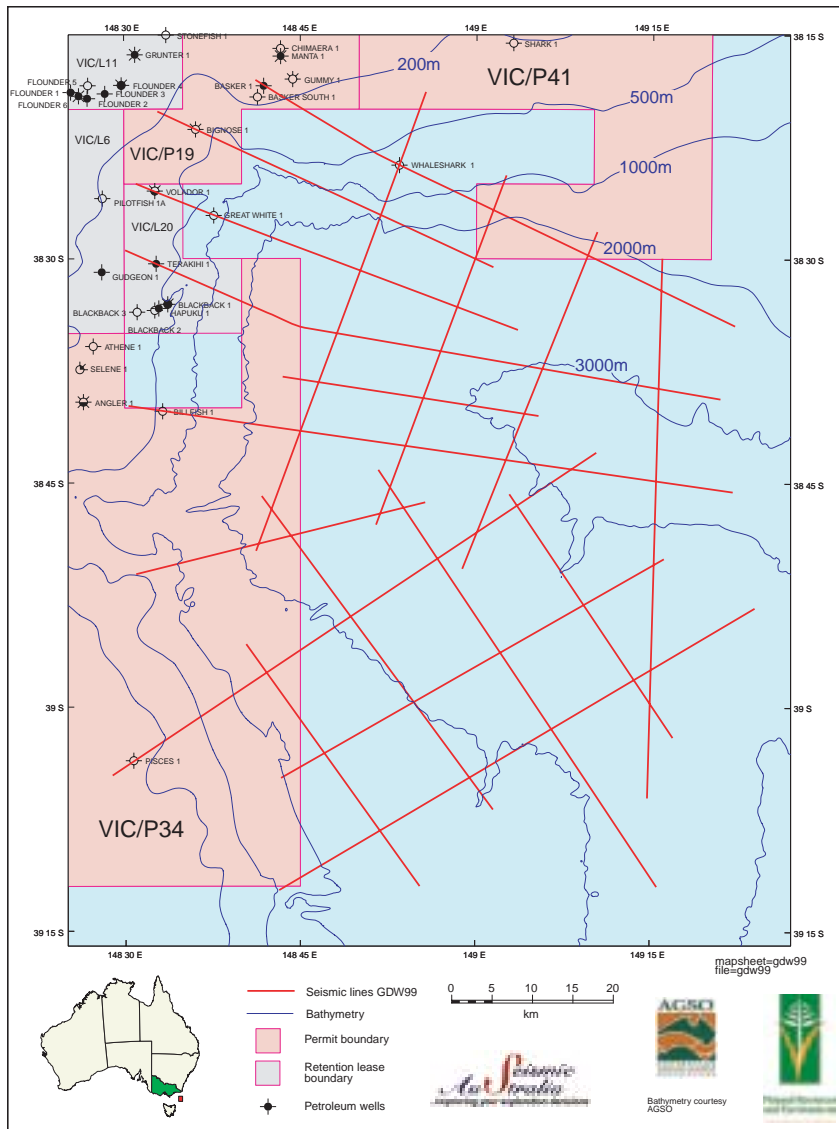


Fig. 5. Gippsland deep water seismic line locations.

- Geology, mineralisation styles and geophysical techniques applied to base-metal exploration in Victoria.
- Volcanic-hosted massive sulphides at Benambra, Hill 800 and Wickliffe
- Porphyry copper mineralisation at Dogwood, Sunday Creek and Thursdays Gossan
- Greenstone hosted Cu-Au at Mount Ararat and Heathcote
- Carbonate hosted Pb-Zn deposits in the Buchan Rift
- Possible Tennant Creek style mineralisation at Nowa Nowa

The volume aims to be a source of reference material for geologists and geophysicists involved in exploring for base metals in Victoria and similar terranes worldwide.

GSV is now working on the second volume which will concentrate on signatures of industrial minerals.

For more information on Geophysics Data contact:

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Geophysics in the Geological Survey of Queensland

Geophysics has always been an integral part of the work of the Queensland Geological Survey (GSQ). Seismic refraction and electrical resistivity methods were applied to engineering and hydrogeological problems, while seismic reflection techniques were applied to marine geological and coal basin studies. I.P. and ground magnetometer methods were applied to mineral investigations. As part of the GSQ stratigraphic-drilling program, borehole geophysical logging was conducted at most sites.

Regulations require the lodgement of geophysical survey data from tenure-related exploration programs by industry. This has resulted in large databases of seismic, wireline logs, airborne geophysical (magnetic, radiometric, and electro-magnetic) and gravity data. These data, when Open-File, are made publicly available in support of exploration in Queensland.

In the early 1990s, geophysical data collection by GSQ changed emphasis from local to region scale investigations in support of geological mapping, mineral potential and basin studies.

In 1989 regional gravity data collection commenced with 400 data points collected in the Charters Towers area,

followed in 1993 with 8000 data points collected in the Normanton and Cloncurry 1:1 000 000 map sheet areas. Gravity data collection continues with the aim of providing coverage where aerial geophysical surveys have been flown in support of GSQ projects.

Small-scale aerial geophysical surveys (magnetic and radiometric) were flown over the Anakie (1990) and Walsh-Red River (1993) areas. In 1994, the Queensland Government provided additional funding for the first of three major initiatives to obtain new geophysical data sets. Specifically this funding was used to acquire new airborne and gravity data in support of geological mapping programs and to arrest the decline in mineral and energy exploration effort in the State.

The second initiative, 'GEOPHYSICAL DATA INITIATIVE', was funded over three years between 1997-1999. Airborne geophysical data (372 800 line-km) were collected over the Drummond-Galilee and Adavale Basins in central Queensland. In addition to supporting on-going geological mapping programs, these surveys provided key data sets to encourage exploration for minerals in the northern Drummond and hydrocarbons in the Galilee and Adavale Basins.

The third, and current initiative, 'PROSPECTIVITY PLUS', provides funding over four years starting in 1998/1999. This initiative will support the acquisition of new regional geophysical data sets, and will promote Queensland's prospectivity with the release of information packages and digital database access and distribution systems to globally based explorers.

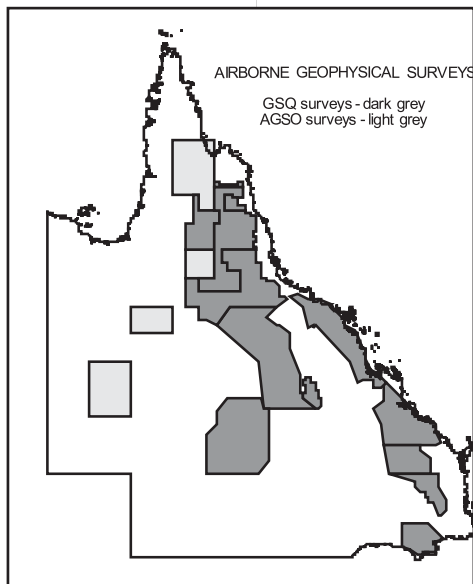
Under 'PROSPECTIVITY PLUS', an airborne geophysical survey is underway over the Hodgkinson, Georgetown, northern Charters Towers and Clark River geological provinces. The northern blocks (230 600 line-km) have been completed, while the southern blocks (167 000 line-km) will be completed after the 1999/2000 wet season. Unlike our earlier airborne surveys where line spacing was 400 m, the Hodgkinson-Georgetown survey has large areas covered with 200 m survey lines.

AGSO has flown the Julia Creek, Boulia and Springvale 1:250 000 Sheet areas with magnetic and radiometric data collection. The current initiative is funding gravity data collection in on a 4 x 4 km station grid to complement the airborne geophysical survey data over the Boulia and Springvale Sheet areas, commencing in April 2000. It is hoped that gravity will also be collected on the Julia Creek Sheet area.

Mineral and energy data, including geophysical survey data, submitted to this Department by regulation will, in future, be in accord with the GGIPAC standards for digital company reporting. The 'PROSPECTIVITY PLUS' initiative is providing funding to set-up a management system for digital company reports. Also funded will be GIS information packages for northwest Queensland, a Queensland mineral resource database (QMIN), and Internet access to mineral and energy databases. Internet access to Open-File aerial geophysical survey data is currently being built and tested in an Intranet environment using Desmond FitzGerald and Associates' GDADS software.

For more information on airborne geophysical and gravity datasets contact:

D. E. Searle, Geological Survey Office
Tel: (07) 3237 1445
Fax: (07) 3235 4074
Email: dsearle@dme.qld.gov.au



The maps above show where GSQ and AGSO have collected modern airborne geophysical and gravity data in Queensland.



The first initiative, 'AIRDATA', with funding provided over three years between 1994-1996, allowed collection of airborne geophysical (320 600 line-km) and gravity data (11 700 stations) over the Ayr-St Lawrence, Rockhampton, Mundubbera, Kingaroy, and Texas areas. Consequent on these surveys was an increase in exploration effort, as measured by uptake of ground under exploration tenure.

Continuous 3D Pre-SDM Velocity Analysis

Ian F. Jones¹, Huibert Baud¹, Keith Ibbotson¹, & Bruno Virlouvet²

Abstract

Presented here is an innovative technique for performing automated continuous and horizon consistent velocity model updating using CRP gathers from 3D pre-stack depth migrated data.

The method employs CRP gathers computed at every CDP position along sparse velocity analysis lines. The velocity error observed in the CRP gathers is analysed along horizons, which are automatically tracked on the basis of lateral consistency of the velocity encountered. Various statistical tests reject inconsistent velocity values, such that all velocity information remaining has some spatial coherence. The residual moveout errors associated with these values are then used as the basis of the velocity updating.

This approach ensures that there is some statistical reliability in those measurements being used as the basis for the velocity update.

The results will be demonstrated on a North Sea 3D pre-stack depth migrated data example.

Introduction

Over the past few years, several authors have presented techniques for updating the velocity depth model required for performing full-volume 3D pre-stack depth migration (pre-SDM). With each technique, there are various theoretical or practical limitations. For example, the post-stack layer-stripping approach (Jones, 1993) presupposes that the velocities are known, and then updates the layer geometries. The Deregowski-loop (Deregowski, 1990) allocates a vertical 1D velocity estimate to an incorrect spatial location; the coherency scan ('inversion') technique supposes constant velocities within the 3D ray-bundle (Reshef, 1994); 3D Tomographic inversion (Diet, et al., 1994) supposes a smooth model. And, more recently, the CRP scanning technique (Audebert & Diet, 1996; Jones et al., 1996) yields a correct velocity estimate, but allocates it to an imprecise spatial location.

Regardless of the technique employed, another limitation to date has been the spatial sampling of the information used to perform the velocity estimation. Typically, pre-stack migrated velocity information (usually in the form of CRP gathers) is output on a coarse grid, at best perhaps 200 m by 200 m, but more typically 500 m by 500 m.

In order to improve on the limitation of spatial sampling, we present here a technique for increasing the statistical reliability of the velocity information to be input to the chosen velocity update scheme in an automated way.

The Methods

The basis of the technique is that described by Doicin et al (1995) wherein a CMP gather is NMO corrected, and then a scan of perturbed residual NMO gathers is created from it. This ensemble of move-out corrected gathers is then input to a coherency analysis routine to determine the 'best' move-out velocity on the basis of say, stack power. This approach results in an estimate of stacking velocity at each CMP location and each time sample. In this regard, their approach was not new, as similar techniques had been previously described (eg. de Bazelaire, 1988). However, the important innovation in Doicin et al., (1995) was related to the statistical analysis of the information produced so as to eliminate picks of peg-leg multiples, and to eliminate velocity information which showed little or no spatial (geological) coherence.

Here we describe two variants of the technique of Doicin et al, adapted to the depth domain:

1. The first variant is based on the CRP-scanning technique of Audebert & Diet (1996). We compute a suite of CRP gathers at each CMP position: each of the gathers in this 'scan' results from a unique 3D pre-SDM performed with a perturbed rendition of the velocity-depth model. These scans are then input to a modified version of Doicin's algorithm. We do not diminish the theoretical limitations of the velocity estimation scheme, but we certainly increase the reliability of the information input to the scheme.
2. Secondly, we use the technique to determine a final residual depth-error correction to be applied to CRP gathers just prior to their being summed to form the final 3D pre-SDM image. This would presuppose that all model building had been done, and would constitute a fine-tuning of the CRP gathers.

Results

We applied the methodologies described above to a North Sea data example. Here, the steeply dipping sediments flanking a salt dome are considered, where the model was built by iterative 3D tomographic inversion (Lanfranchi, et al, 1996; Jones, et al, 1995).

A single line was chosen to demonstrate the details of the continuous velocity analysis process for this paper: an interpretation of the top-chalk event is superimposed to give a geological reference.

Key words:

3-D seismic velocity analysis

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Continued On Page 42



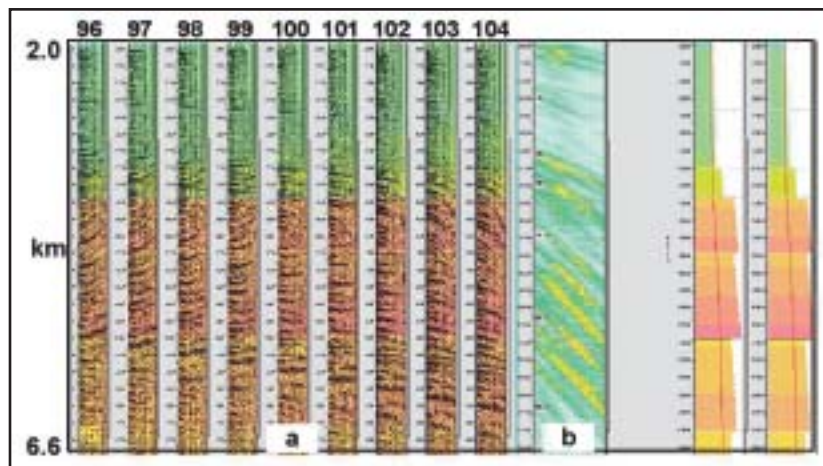


Fig. 1. 3D preSDM CRP scan and spectrum.

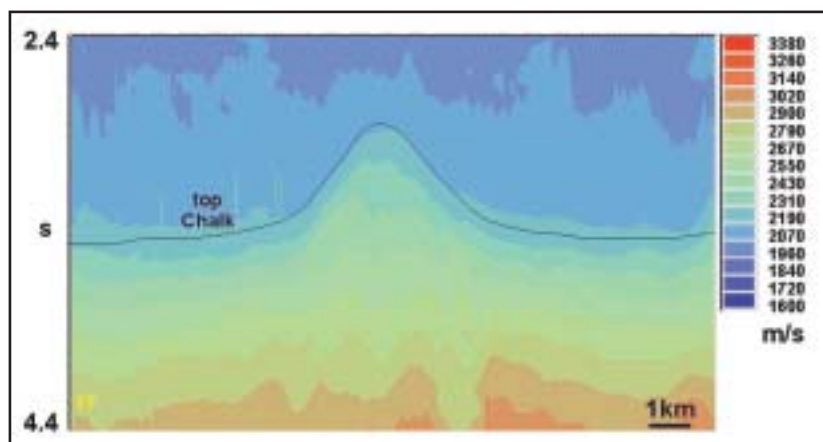


Fig. 2. Perturbation picks from CRC scanned data DEVEL output every 25 m (19 point operator).

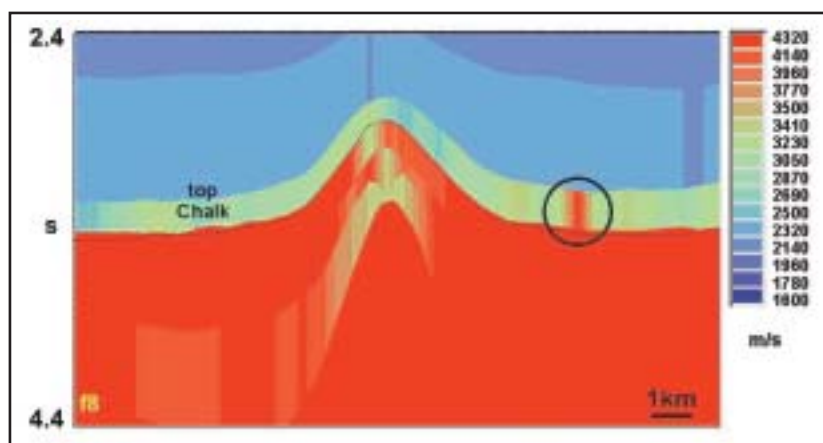


Fig. 3. Interval velocity from CRP scan data manual picking in iso-utility on 500 m grid.



Continued From Page 41

CGG's usual approach to updating this model would be to use CRP-scanning: in figure 1 we see a scan of 9 CRP gathers (corresponding to 96-104% perturbations of the current velocity model, in increments of 1%). Manual picking would be performed either on the gathers (1a) or from the spectrum (1b), typically on a grid of 500*500 m.

For the new technique, these scans would be produced continuously along the velocity lines (spaced for example every 250 m), and then input to the new process for investigation for maximum 'stack' power (for a given depth in the current model) and spatial coherence.

In Figure 2, we see the auto-tracked values of model perturbation, based on continuously produced groups of 9 CRP gathers per CMP location, at 25 m CMP spacing. In this image, we have chosen a spatial coherence gate of 19 consecutive CMP's. Thus with a 25 m CMP interval, we are looking at a velocity coherence scale of about $(19 \times 25 \text{ m}) = 475 \text{ m}$. However, because the tracking for this image was done on the percentage perturbation picks, rather than the velocity, we are not guaranteed a geologically meaningful continuity.

It should be noted that at this stage, no model has been input to the process. The procedure is entirely automatic. It is only when we invert to interval velocities that a model is used.

In Figure 3, we show the results of manual picking of CRP-scan data, with picks being made every 500 m. Here we have converted the picked RMS information to interval velocities with a simple vertical Dix approximation. Towards the centre right of the horizon above the chalk we see an anomalously high velocity in the layer (right hand side). This is not in keeping with the surrounding velocity field. It would appear as a bulls-eye in the velocity map, and probably be edited-out. Thus we would have a hole in the velocity field with associated reduction in reliability.

Compared to the automatic result (Figure 4), we see that the automated procedure did not retain this anomalous value. The value probably arises from small-scale faulting in this horizon, so the CRP gather at this point had the fault plane energy dominating the velocity pick.

Perhaps the most important difference between the two approaches is that whereas the manual picking took one day for this line (which translates to about two to three weeks per iteration for the whole 3D pre-SDM study), the automatic approach took about 90 s of CPU time. Naturally, we have more CPU overhead in computing the continuous CRP scans, but this is more than offset by the saving in manpower time. Following the picking phase of this iteration, (either for the manual or automatic), we would move on to editing/smoothing/QC of the velocity field, model update, and next iteration.

It is this reduction in manpower burden that we see as the main benefit of this technique. Thus, the effort being put into routine picking can now be directed into QC and project speed-up. We envisage using this technique throughout each of the iterations in the model building process.

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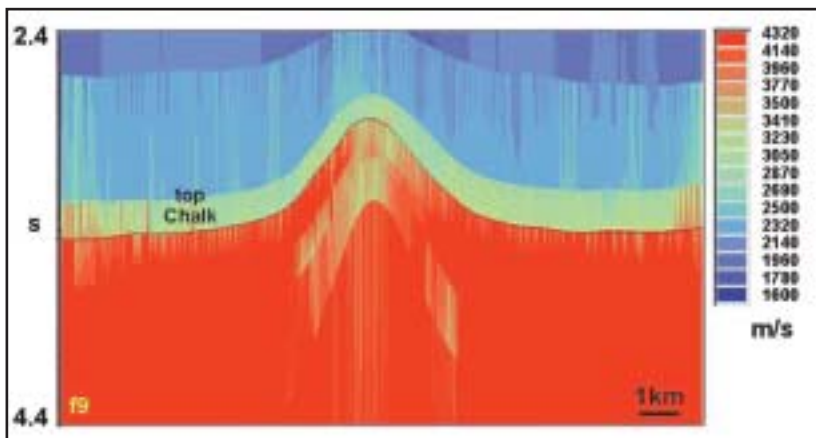


Fig. 4. Interval velocity from CRP scan data DEVEL output tracking horizons every 25 m (19 point operator).

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Analysis of Geophysical Potential Fields A Digital Signal Processing Approach

By P.S. Naidu and M.P. Mathew,

Volume 5 of the Advances in Exploration Geophysics series, Elsevier,

US\$195.50, ISBN 0-444-82801-X. 298 pages

This book presents a detailed account of the application of the classical tools of digital signal processing to aeromagnetic and gravity data. While the authors say in their preface that these tools have not been used as extensively for processing such data as for processing seismic data, my personal experience from working for many years with aeromagnetic data is that digital methods are routinely used, in Australia anyway.

The authors claim that their style of writing lends itself to self-study, or reference. For a reference to support a course on gravity and magnetic exploration at graduate level, or for an advanced course on geophysical data processing, their claim is valid. I found the book easy to read, with detailed explanations, and a level of mathematics appropriate to the subject. It probably fills a place in the market between detailed articles found in journals, and the more specialized texts on digital signal processing.

Chapter 1 provides an overview of potential field surveys both for mineral and for hydrocarbon exploration, and progresses to the role of digital signal processing. It ends with a detailed list of the notation used throughout the book.

Chapter 2 is about potential field signals and models, and covers such topics as the potential field in free space and with sources, satisfying Laplace and Poisson equations. The Fourier transform is fundamental to the analysis of potential fields, and is discussed for one and two dimensions. Other topics covered are the Hilbert transform and singularities of a potential field. The chapter moves on to discuss a potential field in source-filled space, before two very comprehensive sections on two-dimensional and then three-dimensional source models. Finally, the chapter concludes with a discussion of stochastic models, firstly with a random interface, and secondly with random media.

Chapter 3 is devoted to the power spectrum and its applications. While much of this material is covered in many texts, the exposition given here is clear and comprehensive, with examples related to magnetic and gravity data. For example, the chapter discusses depth

estimation from the radial spectrum, and the use of the angular spectrum.

The next two chapters are concerned with the digital filtering of data. Various types of filters, their designs and weaknesses, Gibb's phenomena, continuation filters, reduction to the pole and many other topics are covered in Chapter 4. Chapter 5 discusses inverse filtering, least squares inversion and, lastly, texture analysis. These two chapters are perhaps the most important from a practical point of view, and the ones that will be referred to the most by practitioners in the subject.

The last chapter, Chapter 6, is about parameter estimation, and covers maximum likelihood estimation (MLE), MLE estimation of parameters of simple source models, and non-linear least squares inversion.

The book concludes with a comprehensive subject index. Detailed references are provided at the end of each chapter, and they are complete and up to date.

I have found this book to be particularly useful in clarifying my own knowledge of potential field analysis; it suggests approaches I have not used. It is pitched at a level suitable for undergraduate or graduate studies, as well as being a reference for practising geophysicists. Perhaps an omission is no reference to wavelet transforms, which are now becoming popular as an analysis tool.

There are a few niggling typographical errors, which really should not occur in a book with this price tag. Also, colour images of data examples rather than old-fashioned contour maps would have added a modern dimension to the presentation. Image processing and the value of colour are briefly mentioned in Chapter 1. Colour plates should be supported by the high price, which may limit the distribution of what otherwise is a very worthwhile treatise on the subject.

Reviewer: Peter Milligan
AGSO



People and the Earth

Basic Issues in the Sustainability of Resources and Environment

By J. J. W. Rogers & P. G. Feiss. ISBN 0-521-56872-2. Cambridge University Press, 1998. 338 pp. \$59.95

The authors state that this book was written to provide information about the ways in which the nature of the earth affects and controls human activities: about where (and why) we can utilise air, land and water resources, and where and why we can return the waste products of human activity. Nominally, this is a book by geologists addressed to the overlapping concerns of 'environmentalists, developers, scientists, industrialists, economists, political scientists, sociologists, lawyers'. However, it is clear from the format that this is a textbook, pitched at the matriculation to early undergraduate level student. The basic subject matter is reminiscent of parts of my own matriculation physical geography course.

The volume is divided into nine more or less equally-weighted chapters, dealing with population, agriculture, natural hazards, water, energy, minerals, waste disposal, global change and a general summary. Each chapter is generally self-contained in the material that it treats, making this a difficult cover-to-cover read. The style is more suited to classroom topical use, and to this end, each chapter is also provided with its own set of numerical problems, discussion questions, and references for further reading.

The production is black-and-white, with good use of photos, graphs, tables, maps and diagrams to support and break up the text. Each chapter also contains 'boxes'. These usually contain historical anecdotes which support and reinforce the 'lessons' of the text; these are often entertaining and enlightening vignettes of half a page to a page in length. I found reading these a useful education in itself.

As an example of the level of detail entered into by the authors, consider Chapter 6 – Mineral Resources. There is a brief outline of the ubiquity of mineral products in human activities, an argument that geologists should be seen to be making more of. This is followed by a discussion of the economic definition of 'ore'; definitions of sustainable and non-sustainable resources; and concepts of, and differences between economic resources and reserves. This is followed by a discussion of probability and exploration risk. The 'box' associated with this section discusses some of the social, economic and environmental impacts of Ok Tedi. Section 2 deals with classification and formation of different ore deposit types, and is extremely simplified – perhaps over-simplified, covering all the major types of precious, base and industrial metal deposits in just eight pages! (There are references for further reading, however). The uneven distribution of the major deposit types is discussed in terms of space, but not in time, and again the discussion is oversimplified, with a few inaccuracies e.g. 'Missouri Valley Type' deposits. The next section discusses mining techniques, and mineral processing and refining,

combined with a discussion of the changing balance between labour and capital in these processes. The penultimate section outlines some of the land tenure issues associated with mineral exploration and extraction. Unfortunately, native title is not discussed here, despite being a major issue for miners in many countries. The 'box' in this section contains an entertaining anecdote about claim jumping at Butte, Montana. The chapter concludes with a philosophical look at where mining may be allowed in the future. All of this in just 32 pages!

There are several problems with this book. The first is that the target audience is never clearly defined, so that an assumed body of knowledge is not implicit in the text. This leads to distracting diversions as the authors detail tangential material such as biochemical reactions, the theory of logarithms, chemical theory and topics that could better have been left to an appendix, or omitted. Unfortunately, for a book that hopes to give a wide audience a geological 'take' on environmental issues, most geological terms are poorly defined, if at all. A glossary could have helped here. Because of the overlapping nature of some of the topics, and the likelihood that this is a textbook (and thus not meant to be read sequentially), parts of the text refer to references in separate chapters, which is also distracting. I felt that the book would also have benefited from an 'up-front' discussion of physical processes and principles that implicitly underlie much of the text, but are rarely discussed. These principles include equilibrium, entropy, feedback, thresholds, evolution and reversibility, gravitational potential, and for a geology-based text, timescale. Such a chapter at the start of the book would have freed the individual chapters of much cumbersome explanation, and would have left more space to properly describe some subjects. The book also suffers from an overly Northern Hemisphere and American-centric bias, with the majority of examples derived from the USA and Canada. Seven examples out of 52 deal with Southern Hemisphere countries; none mention Australia, (nor South Africa or even New Zealand) as case studies, despite our resource-based economies and issues of land allocation, water use, native title, the ozone hole, and nuclear waste disposal all being headline material down here.

Overall, I found the book frustrating, as it is clearly not a book that the average professional geophysicist would buy to read or as a reference. College geography/geology teachers would find the book a useful source of discussion points and source material, but at \$60 it is probably too expensive to expect every student to buy a copy. There may be a market here for someone to write a similar, cheaper book for use in colleges, but based on the Southern Hemisphere experience.

Reviewer: Nick Direen



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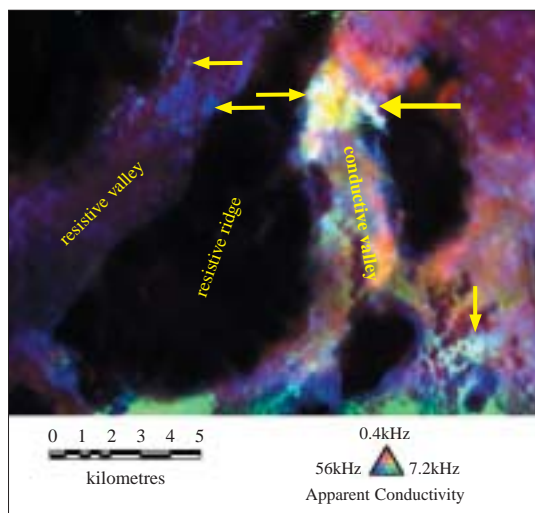


Fig 1. Ternary apparent conductivity (Red=400Hz, Green=7.2kHz, Blue=56kHz) from Liverpool Plains. The yellow arrows indicate previously known saline outbreaks, which correspond well with bright areas on the image. Also note the less conductive valley west of the central resistive ridge compared to the valley to the east, although other saline areas may have been identified in the western valley. Ternary AEM images (such as in Figures 1 and 2) give a good qualitative indication of the three dimensional distribution of conductivity. Analogous to radiometrics ternary images, the deepest (late time or low frequency) response is assigned to the red band, intermediate depth (mid times or middle frequencies) to green and shallow (early time or high frequency) to blue. Thus areas that are resistive from near surface to depth appear as dark areas on the image. Bright parts of the images represent high conductivity from surface to depth. Bluish areas indicate high near surface conductivity with relatively less conductive material at depth – and so on.

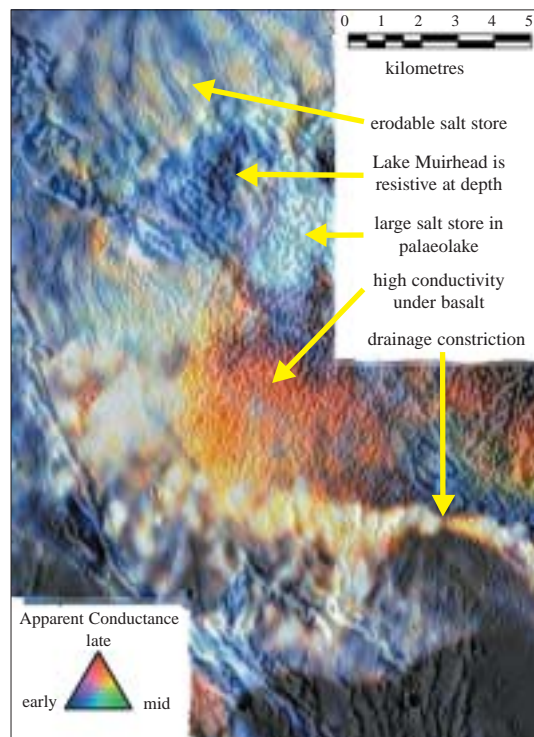


Fig 2. Willaura ternary apparent conductance (Red=Late, Green=Mid, Blue=Early time) overlying the vertical derivative of magnetics. The image shows the spatial relationship of geological structure and salt storage patterns.

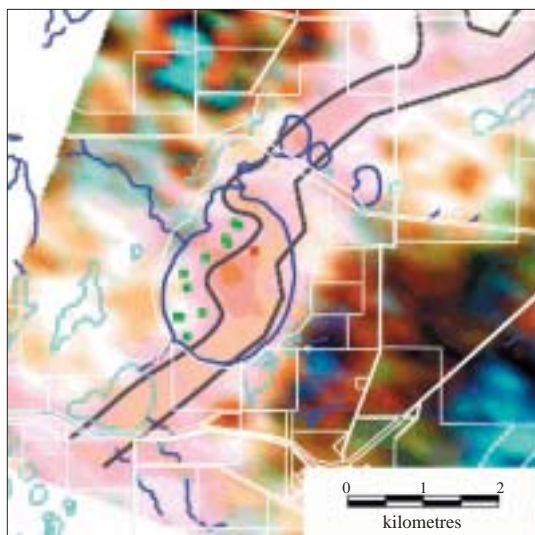


Fig 3. Principal component image of AEM data from Lake Toolibin with an interpreted palaeochannel and bores. The bore in the palaeochannel (red), was positioned on the basis of AEM data and intercepted a high yielding aquifer that is now being pumped to lower the water table. Earlier (green) bores had missed the aquifer. (PC analysis and image prepared and supplied courtesy of World Geoscience Corporation).

In Preview 82 the figure captions in Ross Brodie's article 'Investigating Salinity Using Airborne geophysics' were inadvertently transposed. The correct digital figures with their captions are shown left. A corrected digital copy of the the article can be obtained from:

Ross Brodie at Ross.C.Brodie@agso.gov.au.

On the front cover of Preview 82 the captions for the two images should also be transposed.

