Preview

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

ABN 71 000 876 040 ISSN 1443-2471 August 2004 Issue No.111

CONFERENCE HANDBOOK

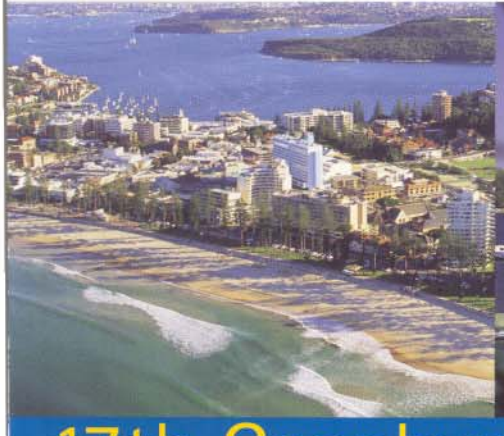
INTEGRATED EXPLORATION IN A CHANGING WORLD

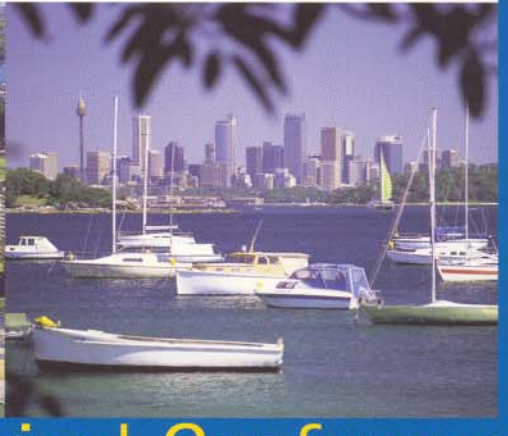
ASEG-PESA SYDNEY 2004

Co-hosted by:

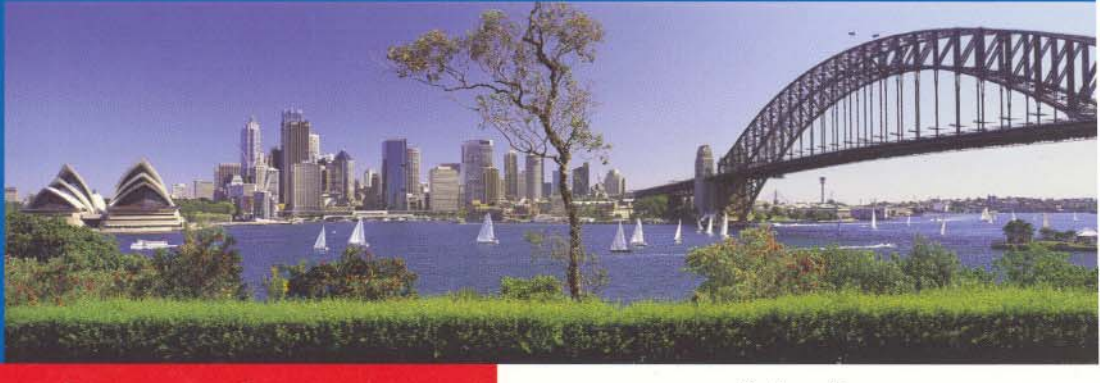
Australian Society of Exploration Geophysicists

Petroleum Exploration Society of Australia (PESA NSW Branch)





17th Geophysical Conference and Exhibition



Sydney Convention & Exhibition Centre
Darling Harbour Sydney, Australia
15 - 19 August 2004

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Best Conference Papers in Exploration Geophysics

If you enjoyed the technical papers at the ***17th ASEG Convention*** and want to examine the results in more detail, or there were good papers that you were not able to hear, then you are in luck. The December issue of ASEG's ***Exploration Geophysics*** journal will contain some of the best papers presented at the meeting, thanks to the generous sponsorship of **BHPBilliton Limited** and **Western Mining Corporation.**

PLACE YOUR ORDER NOW

CONFERENCE HANDBOOK

SECTION 1

Welcome from the Conference Organising Committee

Barry Smith

Tim Pippett

The Sydney 2004 Conference Organising Committee welcomes you to the Australian Society of Exploration Geophysicists 17th Geophysical Conference and Exhibition, co-hosted by the Petroleum Exploration Society of Australia (NSW). A special welcome is extended to attending presidents and representatives of ASEG, PESA, SEG (USA), EAGE (Europe), SEGJ (Japan), KSEG (Korea) and SAGA (South Africa).

During the Conference a number of executive meetings will be taking place and the Committee is pleased to be able to facilitate meetings of the SEG and ASEG executives in Sydney. A list of meetings, venue and times will be posted in the registration area.

The Conference is being held at the award-winning Sydney Convention and Exhibition Centre in spectacular Darling Harbour. It promises to be a most exciting and inspirational four days. Current high prices for oil and base metals will certainly add a motivating backdrop to this event.

Our conference theme is most appropriately titled **"Integrated Exploration in a Changing World"**. This theme brings together the application of state-of-the-art technologies to all phases of resource exploration and development at a time when our profession is influenced by changing economic and political conditions throughout the world. These changes offer enhancing opportunities to those with spirit, adaptability and technical excellence. This final characteristic of technical excellence in particular is an aim of the Conference.

The first class technical program includes 235 papers. These cover exploration case histories, technical innovations, environmental and near surface applications, business aspects of exploration, and research to suit all interests across our profession. Keynote addresses on challenging and inspirational topics will be presented by eminent industry leaders. **Keynote** presenters include; Amos Nur, Tom Whiting, Phil Harman, Ted Tyne, Paolo Dell'Aversana (EAGE DLP), Heloise Lynn, Prame Chopra, Michael Lee, Keiran Wulff and Bob Whiteley. Specialised **Petroleum Forums**, with debate by panellists and featuring audience participation, will involve: Mike Bahorich, Peter Duncan (SEG President), Nader Dutta and Brian Russell.

Technical sessions will occupy the first three days of the conference, with additional technical material on display in the poster section of the Exhibition area. On Thursday you can attend one of two topical symposia or a workshop on deepwater exploration, all of which are included in your registration fee. The symposium on **Inversion in Mineral Exploration** is chaired by Doug Oldenburg and Greg Street is the chairman of the **Salinity Studies** symposium. Paul Weimer, the 2004 SEG DISC, will present a workshop on **Petroleum Systems of Deepwater Settings**, which is particularly relevant today.

The Sydney Committee has also organised a number of workshops and two field excursions; the **Sydney Basin Excursion** has a petroleum and coal seam focus, while the **Lachlan Fold Belt Excursion** will appeal to the minerals fraternity. For students, a sensational program on Tuesday will inform and entice earth science students to consider a career in our profession. The Student Day will be preceded by a reception for Tertiary students on Monday evening.

Corporate and Government bodies active in our industry are providing strong support by participating in a range of events and sponsorship opportunities. In addition, exhibitors offering the latest technical innovations and services to the resource and environmental industries will be demonstrating their capabilities during the three-day Exhibition.

To capitalise on Sydney's fabulous natural beauty, the Ice Breaker, Conference Dinner and Farewell Cocktails are being held in Darling Harbour. Be sure to book your table for the dinner when you register. Golf Day registration forms are available for the Ambrose team event on Friday 20 August, so join with us at the Moore Park Golf Club, located near the heart of the city. For out of town attendees, be sure to allow a few extra days around the time of the Conference to take a trip to the scenic Blue Mountains, the Hunter Valley wine area or perhaps a walking tour of Sydney's Rocks district.

The co-chairmen wish to thank the Organising Committee, which has worked tirelessly and efficiently to assemble an event that the co-hosting societies can be proud. We also thank the companies that employ the Committee members, for without their blessing it would not be possible to devote the time necessary to make the Conference a success. An integral part of our committee is Conference Action, professional conference organisers. Conference Action has carried out secretarial and logistics duties with aplomb and has operated the registration area as well as coordinated production of the actual event. The Geological Survey of NSW is thanked for providing the venue for our committee meetings. The Committee is in turn indebted to many people who have helped in sub committees and we extend our gratitude to them for volunteering their support. Finally, the co-chairs wish to thank Jenny Bauer and Kim Frankcombe of the Conference Advisory Committee, who provided counsel and guidance throughout the lead up to the Conference.

The location, technical program and social activities promise an outstanding event and we're thrilled that so many have chosen to join us in Sydney.

Barry Smith ***Timothy Pippett***

Co-chairs, Organising Committee
ASEG's 17th Conference and Exhibition, co-hosted PESA (NSW),
Sydney, Australia

ASEG

Let's be perfectly honest. Looking over the myriad of conference themes for various organisations over the years, it's easy to be bemused, or amused, or even to simply nod off. But rarely does a theme ring with resonance like the theme of the 2004 17th ASEG International Conference and Exhibition: **Integrated Exploration in a Changing World**. Unless anyone has been off the planet for the past few years, it should be clear to us all that the world is indeed changing.

The inexorable shift toward internationalism is probably the single biggest change that we see every day in the newspapers and in our lives. This means more Australian lamb on American tables, more Coalition forces on the streets of Baghdad, more asylum seekers in detention or at the local supermarket, more university students studying English as a second language, more delays at already crowded international airports, and innumerable other examples of borders seeming more and more transparent all the time.

Another separate but related change in the world is the need to make decisions at many levels with a seemingly endless supply of information from which to choose. Integrating data and making sense of it is critical for making all kinds of decisions. How many types of information should we integrate and verify to make a decision on where to drill a hole? How many to make a decision to mine? Indeed, how many to make a decision to start a family or move jobs or pre-emptively invade a country?

At the end of the day, those involved in Exploration are master decision makers and, in the changing environment in which we work, integration of many and disparate data is one of the challenges that will increase in complexity and importance.

In light of the exquisite level of relevance of this year's conference theme, it gives me particular pleasure to welcome a particularly international group of delegates to Sydney. I look forward to seeing members of ASEG and PESA exchanging ideas with colleagues from SEG, EAGE, SEGJ, KSEG, HAGI and SAGA, as well as visitors whom we would like to count among our membership in future.

The technical sessions, keynote addresses and exhibitions promise to offer a great deal to assist all the delegates in becoming even more effective decision makers as we attempt to succeed in the rapidly changing world integrating vast quantities of data.

Howard Golden
President,
Australian Society of Exploration Geophysicists

SEG

It is with great personal pleasure that I bring to you greetings and best wishes from the Society of Exploration Geophysicists on the occasion of the ASEG-PESA Sydney 2004 Conference and Exhibition.

SEG exists to promote excellence in the science and practice of applied geophysics. While journals, magazines, textbooks and lectures are one way we pursue that goal, an equally important vehicle is through gatherings such as this. At conventions of this sort we can share advances in our science face-to-face, we can build that common sense of community and communication that is so important to the open sharing of new ideas, and we can make life long friends with others who share our love of the earth sciences.

SEG, as a global geophysical community, now has over 22,000 members in more than 130 countries worldwide. It is a growing community with over 2000 new members last year. There are 121 student sections and 40 Associated Societies around the world. More than half the membership now resides outside the USA.

Australia, with more than 600 SEG members and 5 active student sections, is our 6th largest member community and clearly one of our most active. It is your participation that helps us make the claim of being "THE global society of applied geophysics".

I look forward to the events of this week as I make only my second trip to your beautiful country and I look forward to the continuing contributions Australia will make to our science and our community in the future. I hope I will get to meet as many of you as possible at the convention. Drop by the SEG booth to say "Hello".

Peter M. Duncan
President,
Society of Exploration Geophysicists

Howard Golden
ASEG

Peter Duncan
SEG

Oliver Dubrulle
EAGE

Yuzuru Ashida
SEGJ

EAGE

The 17th ASEG/PESA meeting is clearly going to be a major international event, and on behalf of the European Association of Geoscientists and Engineers (EAGE), I would like to wish good luck to ASEG and PESA. Though our roots may be in Europe, our membership is truly global, and we have many members residing in Australia. We are therefore very proud to lend our support to this important conference.

The theme of this year's ASEG/PESA meeting is **"Integrated Exploration in a Changing World"**. This is of particular interest to EAGE. A primary focus for us is the integration of all relevant disciplines, and this integration must happen at every stage of geosciences activity, from exploration through to development and production. In exploration, with the progress of techniques such as pre-stack depth migration, we see more and more that the result of a PSDM exercise depends not only on the quality of the PSDM algorithm, but also on the validity of the initial geological model. It is vital that all interpretations and model-building are the result of combining the input from the various relevant disciplines.

This does not mean that every single geoscientist should be an expert in all disciplines. Geoscientists, whether geologists or geophysicists, must first be strong in their own basic disciplines. But too often, by focusing on their own disciplines in the interpretation workflow, geoscientists tend to be preoccupied with their own issues and ignore the uncertainties attached to models generated by other disciplines. To avoid this common bias, individuals must have an open attitude, companies should encourage the organisation of multidisciplinary teams, and cross-disciplinary training must be a priority.

This brings us to another very important topic of this conference, learning through pre-conference workshops. At the EAGE annual conferences, we always organise pre-conference workshops, where we favour the presentation and discussion of multi-disciplinary topics. The idea of organising a comprehensive Student Day program is to be commended. The oil and gas industry, with its ageing population, must bring a whole new generation up to speed.

EAGE has recently been reorganised into two divisions, one for Near-Surface Geosciences and one for the Oil and Gas. We believe there are many interactions possible between these two divisions, and we welcome the fact that ASEG and PESA are adopting a similar approach by including a significant contribution on mining in the conference program.

On a personal note, I discovered Sydney last year, and I will never forget this fantastic feeling when I saw Sydney Harbour and the Opera House for the first time. Organisers of a conference in such a magical environment can hardly go wrong! I would like to close by thanking you for the opportunity to contribute, and to wish all attendees a most worthwhile and successful ASEG/PESA Conference and Exhibition.

Olivier Dubrule
President,
European Association of Geoscientists and Engineers

SEGJ

It is a great honour for the Society of Exploration Geophysicists of Japan (SEGJ) to participate in the ASEG's 17th Conference and Exhibition. Taking this opportunity, I would like to introduce some recent activities of the SEGJ.

SEGJ was founded in 1948, and we have 1506 members as of May 2004. Its strength is the application of geophysics to civil engineering and natural resource exploration. SEGJ publishes a journal ***"Butsuri-Tansa"*** or ***Geophysical Exploration*** six times a year. We hold two regular conferences every year and publish the proceedings for each of them. Since 1990, we have hosted an International Symposium every second year. Each symposium is dedicated to a special theme, such as Geotomography and Fracture Imaging. Proceedings of these symposiums are issued as special publications of SEGJ.

In November 2004, we will hold the 7th International Symposium at Sendai, in association with four overseas societies. It is a great pleasure to receive assistance from the ASEG for the symposium and we hope to hold a meeting that will be worthwhile for all geophysicists to attend.

The economic recession in Japan has adversely affected the geophysical activities in the last few years. As a consequence, in December 2001, the SEGJ adopted a new incorporated structure, authorised by the Ministry of Education and Science, to encourage growth in the Society. The main aim of the incorporation is to strengthen our activities. The middle to long-term objectives of the new society are to:

1. Expand the journal to respond to members' needs;
2. Enhance conferences and lectures to disseminate geophysical exploration technology;
3. Establish guidelines for geophysical practice responding to the community demand; and
4. Establish the close relationship with foreign Geophysical Societies.

We now have the following activities and projects relating to the geophysical and geo-technical fields in Japan:

1. Exploration and development of methane hydrate;
2. Earthquake prediction;
3. Geo-sequestration;
4. High level radioactive disposal;
5. Public utilisation of shallow subsurface zones in urban areas;
6. Evaluation of landslide hazards; and
7. Studies of the continental shelf.

We organised the consortiums in order to solve the problems relating to these topics.

We address not only domestic issues but also international activities. We have established close relationships with the ASEG, SEG, EAGE, KSEG of Korea and SEG Beijing. There are many geophysicists in Asia, but unfortunately we have not yet developed good communication channels with them. However, we have started discussions with the Vietnamese

society and we hope to extend cooperation with it in the very near future.

With the help of ASEG, we are on the way to publish a translation of "Guidelines of Geophysical Application for Civil Engineering, 2000", which was originally written in Japanese, and very well received among the civil engineering industry, as the book is very handy and comprehensive. Hence, there is a great demand from engineers of other countries, especially from Asia. The book has already been translated into Korean and published by the KSEG.

Responding to this demand, we decided to publish it in English. The contribution from the ASEG in refining the English of our translation has been great. We would like to express our gratitude to the Society, and the English version will be published very soon. In addition to Guidelines of Geophysical Application for Civil Engineering, we will publish the encyclopaedic dictionary of geophysical exploration in Japanese at the end of this year.

ASEG, SEGJ and KSEG discussed the joint publication of a journal on several occasions, with a focus on the Western Pacific region, incorporating practical applications of geophysics to all areas of resource exploration and engineering. Consequently, in January 2004, we published a joint issue of three journals. We appreciate the effort and support of managing editor, Lindsay Thomas. We hope that this new unique publication starts new friendships and extends new fields of application. We will discuss the continuation of this venture during this Conference.

As Australia and Japan are located in the same Western Pacific region, there are many issues we can cooperate on. We would like to collaborate with ASEG on the geophysical issues in our region at all times.

Yuzuru Ashida
President of the Society of Exploration Geophysicists of Japan

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Oil Search Limited is an oil and gas exploration and development company that has been operating in Papua New Guinea since 1929. The company is incorporated in Papua New Guinea and owns approximately 70% of PNG's oil reserves and over 50% of gas reserves dedicated to the Highlands Gas Project. Oil Search took over as operator of the country's producing oil fields in October 2003 from incumbent Chevron Niugini, and now has approximately 800 employees in both Australia and PNG. Our vision is to build a world class petroleum business with an uncompromising focus on HSES performance across all our operations. We have interests in the following licences in PNG: 9 Petroleum Exploration Licences, five as operator, 5 Production Licences, 8 Gas Retention Licences and 3 Pipeline Licences. We also have three exploration licences in Yemen (two as operator) and an exploration licence in Egypt. We owns 20% of the Misima Mines Limited.

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1700–1900 Icebreaker - **SPONSORED BY VERITAS DGC ASIA PACIFIC LTD**

MONDAY AUGUST 16

0830–1010 Welcome and introductions **Barry Smith & Tim Pippett**

Peter Duncan - *SEG Vice President*, **Gareth Williams** – *EAGE President*, **Prof Keisuke Ushijima** – *SEGJ President*, **Howard Golden** – *ASEG President*

KEYNOTE – Falcon: Lessons on the Commercialisation of Technology – **Tom Whiting**, *BHP Billiton*

KEYNOTE – Latest News from the Cassini-Huygens Mission and the MER Robotic Rock-Hounds, plus Plans for Future Far Out Exploration – **Neal Newman**, *NASA*

Close of Plenary Session

SESSION 2	SEISMIC TECHNICAL FORUM I (MAKING THE MOST OF ATTRIBUTES) SPONSORED BY APACHE ENERGY LTD	EM PROCESSING	GRAVITY GRADIOMETRY	ENVIRONMENTAL AND NEAR SURFACE 1
1045–1105	**KEYNOTE** - Useful 3-D Seismic Attributes *Mike Bahorich, Apache Corporation*	AEM target detection in geological noise *A Green, D Hunter*	**KEYNOTE** - Falcon airborne gravity projects *Phil Harman, Gravity Capital*	**KEYNOTE** - Airborne geophysics in environmental management- a European perspective *Michael Lee, British Geological Survey*
1105–1125	3D seismic stratigraphy and seismic attributes analysis: a powerful approach to maximise the characterisation of Palaeozoic depositional systems (Australian Northwest Shelf) *L Langhi*	Footprints of airborne electromagnetic systems over one-dimensional earths *J Reid, J Vrbancich*	Estimating the pre-mining gravity and gravity gradient response of the Broken Hill Ag-Pb-Zn deposit *R Lane, M Peljo*	UXO location using total field magnetics in SE Asia *T Pippett, S Lee*
1125–1145	The advantage of 3D visualization for 2D seismic interpretation *R Weindel, B Smith, C Carty*	An assessment of CSAMT data for location of mineralised targets under glacial cover (Western Tasmania) and basalt cover (Victorian goldfields) *M Asten, M Vicary, H Rutter*	Case histories of high-accuracy land gravity gradient measurements *D DiFrancesco*	Cavity investigations for the Australian marine complex in Western Australia *G Turner, E Wedepohl, J Anning*
1145–1205	Seismically constrained high resolution geological modelling *B Bankhead*	Modelling the electromagnetic response in complex geological structures using the 3D finite-element method based on the hexahedral and the tetrahedral edge-element technique *F Sugeng, A Raiche*	Too old for modern exploration? Old torsion balance observations revisited *H Goetze, G Goltz*	Airborne bathymetric lidar - supporting shallow water exploration and development *R Barker, M Sinclair*
1205–1225	Panel discussion	Discoveries through innovation in applications of airborne and ground TDEM in very conductive environment *J Silic, T Ballantyne*	3D Full Tensor Gradiometry: a high resolution gravity measuring instrument resolving ambiguous geological interpretations *C Murphy, G Mumaw*	Evaluation of 2D resistivity imaging technique for mapping and monitoring of subsurface cavity collapsed into sinkhole *P Sararugsa, D Manjai, W Yangme*

1235–1335 **LUNCH - SPONSORED BY MULTIWAVE GEOPHYSICAL CORPORATION - EXHIBITION HALL 5**

SESSION 3	AVO AND RESERVOIR CHARACTERISATION SPONSORED BY OMV AUSTRALIA PTY LTD	PETROLEUM CASE HISTORIES SPONSORED BY OFFICE OF MINERALS & ENERGY, PIRSA	EM SYSTEMS	ENVIRONMENTAL AND NEAR SURFACE 2
1335–1355	Reservoir property estimation in the carbonate reservoir with AVO Inversion - a case study *S Besheli, S Hendi, J Vali*	Salt tectonics in the Officer Basin, Western Australia: Implications for trap formation and petroleum exploration *A Simeonova, R Iasky*	The Geotech VTEM time domain helicopter EM system *K Witherly, R Irvine, E Morrison*	Seawater depth determination using the helicopter HoisTEM system *J Vrbancich, P Fullagar*
1355–1415	Reservoir characterisation of the Flag Sandstone, Barrow Sub-basin, using an integrated, multi-parameter seismic AVO inversion technique *K Jarvis, A Folkers, P Mesdag*	Improving the resolution of deep-crustal seismic data to study shallow gas hydrates on the Hikurangi Margin, New Zealand *H Zhu, I Pecher, S Henrys, G Maslen*	Enhancing electrical signals with sensor arrays *M Norvill, A Kepic*	Radon effects in ground gamma-ray spectrometric surveys *B Minty, J Wilford*
1415–1435	Azimuthal anisotropy for fractured reservoir characterization in the presence of structural dips *A Grandi, H Lynn*	Cooper Basin workstation data provision - pitfalls and progress *P Hough, D Cockshell, W Seweryn, K Woollard, A Peters*	The emerging role of helicopter time-domain EM systems *S Balch*	Gravity and magnetic tensor data: Possible use in regolith exploration *P Heath, S Greenhalgh*
1435–1455	Azimuthal variation in the PP seismic signature: Display of high-dimensional data, AVO az modelling and interpretation *H Lynn, D Cox*	Australian northwest margin, meteorite impacts and seismic velocities: is there a connection? *A Goncharov, J Kennard, L Becker*	Novel ways to process and model GEOTEM data *D Sattel, R Lane, G Pears, J Vrbancich*	The hydraulic and electrical fractal dimension of regolith *T Dhu, G Heinson, J Joseph*

1455–1525 **AFTERNOON TEA – EXHIBITION HALL 5**

MONDAY AUGUST 16

SESSION 4	THE EFFECTS OF FLUIDS ON SEISMIC RESPONSE	GEOTHERMAL SPONSORED BY OFFICE OF MINERALS & ENERGY, PIRSA	MINERAL EXPLORATION GREENFIELDS SPONSORED BY GPX AIRBORNE PTY LTD	ENVIRONMENTAL AND NEAR SURFACE 3

1455–1525	AFTERNOON TEA – EXHIBITION HALL 5			

MONDAY AUGUST 16

SESSION 4	The Effects of Fluids on Seismic Response	Geothermal Sponsored by Office of Minerals & Energy, PIRSA	Mineral Exploration Greenfields Sponsored by GPX Airborne Pty Ltd	Environmental and Near Surface 3
1525–1545	Numerical rock physics: fluid effects on wave propagation *E Saenger, O Kruger, S Shapiro*	KEYNOTE - Hot dry rock geothermal energy *Prame Chopra, Director, Geodynamics Limited*	The Waterloo and Amorac nickel deposits, Western Australia: A geophysical case history *P Mutton, W Peters*	New airborne compliance monitoring techniques for seismic operations *D Ivic, R Langley, D Cockshell*
1545–1605	Model-based prediction of lithology, pore fluid and porosity *K Spikes, J Dvorkin*	Hot Dry Rock Geothermal Exploration in Australia *R Hillis, M Hand, S Mildren, P Reid, S Reynolds, E Nelson*	Regional target generation for porphyry Cu-Mo systems in the Erdenet area, Mongolia *S Batty, H Hishida, M Kai, D Bold*	Using Geophysics to locate burials and other cultural features, Isle of the Dead, Port Arthur, Tasmania *F Links, M Roach, G Jackman*
1605–1625	A PVT chamber for observing the time-lapse seismic response to pressure *B Evans*	Thermal modelling of the hot dry rock geothermal resource beneath GEL99 in the Cooper Basin, South Australia *G Beardsmore*	Geophysical surveying over VMS deposits in Oman *P Swiridiuk, B Close*	Radiometric stitching *R Clifton*
1625–1645	Time-lapse analog modelling of turbidite channel sands *D Sherlock, L Scoby-Smith, E Montague*	Testing models for bottom of hole temperature recovery, Cooper Basin, South Australia *F Holgate, P Chopra*	HoistEM data processing for discovery of high grade manganese ore under regolith cover *A Hashemi, J Meyers*	Net community benefits and seismic line remediation - a case study *D Cockshell, R Langley*
1645–1705	Quantitative prediction methodology for differential stresses and discrimination between pressure and fluid saturation based on seismic attributes derived from experimentally recorded waveforms *R Ciz, A Siggins, K Dodds, D Dewhurst, M Urosevic*			Anomalous head wave amplitudes over a low velocity shear zone *D Palmer*
1800–1900	MONDAY HAPPY HOUR DRINKS – SPONSORED BY MITCHAM INDUSTRIES – EXHIBITION HALL 5			
1800–2000	POST GRADUATE STUDENT RECEPTION – SPONSORED BY ORIGIN ENERGY LTD – BALLROOM FOYER			

TUESDAY AUGUST 17

SESSION 1	Seismic Technical Forum II (AVO/Inversion Case Histories) Sponsored by WesternGeco	Coal and Coal Bed Methane 1	Regional Mapping	Groundwater
0830–0850	KEYNOTE: Recent Advances in Seismic Inversion and the Road Ahead *Nader Dutta, WesternGeco*	Quantitative geophysical log analysis in coal measure sequences *P Hatherly, R Turner, R Sliwa, T Medhurst*	A virtual national data grid for Australia - current situation and vision for the future *B Spies, K Dodds, S Reymond, D Sutich*	Comparison of shallow seismic and seismoelectric techniques for groundwater surveys: A case study at Narromine NSW *L Jones, C Waring, S Hankin, D Johnstone, T Fomin*
0850–0910	The Boris oil field in the Gulf of Mexico - a geophysical case study *G Duncan, B Little, K Tomich, C Taylor, M Glinsky, D Whittam*	Coalbed methane play and prospect evaluations using GeoGraphix software *P Sari Wisman, B Lyons*	The Shuttle Radar Topography Mission - A new source of near-global digital elevation data *D Cowan, G Cooper*	Gravity monitoring with a CG5 Scintrex autogravimeter *M Sugihara*
0910–0930	Defining the subtle trap - a Bass Basin case history *M Lonergan, A Pauli, R Taylor*	Coal seismic depth conversion for mine data integration: a case study from the Sandy Creek 3D seismic survey *B Zhou, P Hatherly, G Fallon, D Sommer*	A case study using radiometrics as a first pass technique to geological mapping in the Musgrave Province in South Australia *V Stamoulis*	Influence of capillary fringe on the groundwater survey using ground-penetrating radar *K Onishi, S Rokugawa, Y Katoh, T Tokunaga*
0930–0950	Fluid property discrimination from the inversion of AVO attributes *B Russell, D Hampson, L Lines*	Can 1D methods generate useful starting models for tomographic inversion of near surface refraction data? *D Palmer*	Gawler Craton uncovered *L Jones, P Lyons, B Golby, A Shearer, M Schwarz, R Skirrow, R Korsch, J Totterdell, W. Preiss, N. Direen, M. Fairclough, D.Johnstone*	Hydrogeological mapping using the seismoelectric method *M Rosid, A Kepic*
0950–1010	Panel Discussion		The Tanami 3D geological model - Integrating geology and potential field data *L Vandenberg, A Meixner*	Groundwater recharge mapping using airborne radiometric data *G Street, A Harrison*
1010–1045	MORNING TEA - SPONSORED BY STUART PETROLEUM LIMITED – EXHIBITION HALL 5			

TUESDAY AUGUST 17

SESSION 2	SEISMIC ACQUISITION (MARINE) SPONSORED BY WESTERNGECO	COAL AND COAL BED METHANE 2	MINERAL EXPLORATION - BROWNFIELDS SPONSORED BY WESTERN MINING CORPORATION	GEOTECHNICAL 1
1045–1105	A strategy for optimal marine 4D acquisition *M Widmaier, S Hegner, F Smit, E Tijdens*	Utilisation of fracture patterns for optimising CBM production in the southern Sydney Basin, Australia *I Wang, J Choudhury, W Barker, S McNally*	Borehole logging and automated interpretation of drill hole lithology from the Murowa Kimberlites, Zimbabwe *D Hinks, P Fullagar, S McIntosh*	**KEYNOTE** - Contribution of geophysics to major engineering projects ***Bob Whiteley, Coffey Geoscience***
1105–1125	The revolution in seismic resolution: High density 3D spatial sampling developments and results *A Long*	Geophysical studies in the Bowen Basin: a collaborative approach *J Draper, A Aoki, N Okamoto, H Karashima, H Aoyama, M Tanoue, T Aizawa, K Yamazaki, M Covington*	The use of borehole radar for the delineation of thin tabular orebodies ahead of mining *P du Pisani, D Vogt*	Tomo-statics approach to reflection prospecting of urban active faults *Y Zhuoxin, L Baojin, Z Xiankang*
1125–1145	Sensor positioning and data orientation methods for fixed geophone ocean bottom cables in shallow water surveys *D Lamb, C Massacand*	The artificial intelligence and the lithological evaluation - a case study of the Jiu coal basin, Romania *M Radulescu*	***Borehole radar application to kimberlite delineation at Finsch diamond mine*** *A Wolmarans, J Cloete, P Jordaan, I Mason*	The Effect of Different Attenuation Models on Earthquake Hazard in the Newcastle and Lake Macquarie Region, Australia *D Robinson, T Dhu, J Schneider*
1145–1205	Numerical modelling of sea wave movement on seismic streamers in relation to swell noise on data *A Shepherd, J McDonald*	Shallow, high-resolution converted-wave seismology for coal exploration *S Hearn*	Sub-audio magnetic survey experiments for high-resolution, subsurface mapping of regolith and mineralisation over a blind gold discovery near Agnew in Western Australia *J Meyers, N Cantwell, P Nguyen, M Donaldson*	Utilization of seismic surface waves (ground roll) for near-surface investigation *C Park, J Ivanov*
1205–1225	Imaging beneath the Taranaki Fault, New Zealand - A feasibility study for wide-angle seismic surveys *G Maslen, I Pecher, V Stagpoole, D Woodward, A Gorman*		Reflection seismic surveys at St Ives gold mine, WA *E Stolz, M Urosevic, K Connors*	
1235–1335	LUNCH - EXHIBITION HALL 5			
SESSION 3	SEISMIC INTERPRETATION SPONSORED BY WOODSIDE ENERGY LTD	TECHNOLOGY CASE STUDIES SPONSORED BY BHPBILLITON LIMITED	EULER DEPTH DETERMINATIONS	GEOTECHNICAL 2
1335–1355	Automated event picking in prestack hyperspace *T Thompson, M Lamont, B Hartley, M Glinsky*	3D SRME applications in the Gulf of Mexico *J Young, D Lin, D Pham, S Xu*	Towards automated mapping of depth to magnetic basement - examples using new extensions to old methods *P Milligan, G Reed, T Meixner, D Fitzgerald*	Passive seismic methods using the microtremor wave field *M Asten*
1355–1415	Tuning seismic resolution by frequency shifting *B Zhou, I Mason, P Hatherly*	Lithology and fluid prediction in lightly explored basins *G Duncan, M Jamieson, A Morrison, M Glinsky*	Yumbarra - a case study in geophysical 3D magnetic modelling *D Calandro, G Reed, C Foss*	Resolving a velocity inversion at the geotechnical scale using the microtremor (passive seismic) survey method *J Roberts, M Asten*
1415–1435	Automatic 3D fault extraction and fault surface separation *I Cohen, A Vassiliou, N Coult*	Industrial evolution of depth imaging model building techniques - A Timor Sea case study *P Plasterie, L Vincent, P Guillaume, V Dirks*	A multilevel generalization of Euler deconvolution and its comparison with the Continuous Wavelet Transform *M Fedi, G Florio, T Quarta*	Anti-disturbance high-resolution shallow seismic exploration for surveying of urban active faults *Y Zhouxin, L Baojin, Z Xiankang*
1435–1455	Interpretation advances in noisy data areas *A Long*	Implementation of volume interpretation in revealing upside potential in a mature field, the Sangatta Oilfield: A case study *B Murti, B Toha, S Nugroho*		Generating shear wave models of the near surface *D Palmer, A Spyrou*
1455–1525	AFTERNOON TEA - EXHIBITION HALL 5			

TUESDAY AUGUST 17

SESSION 4	ANISOTROPY: THE EFFECTS OF FRACTURES ON SEISMIC RESPONSE SPONSORED BY WOODSIDE ENERGY LTD	SEISMIC PROCESSING I SPONSORED BY VERITAS DGC ASIA PACIFIC LTD	PROCESSING MAGNETIC DATA

TUESDAY AUGUST 17				
SESSION 4	ANISOTROPY: THE EFFECTS OF FRACTURES ON SEISMIC RESPONSE SPONSORED BY WOODSIDE ENERGY LTD	SEISMIC PROCESSING I SPONSORED BY VERITAS DGC ASIA PACIFIC LTD	PROCESSING MAGNETIC DATA	
1525–1545	**KEYNOTE**: The winds of change: Anisotropic rocks, their preferred direction of fluid flow and their associated seismic signatures *Heloise Lynn, Lynn Incorporated (SEG/AAPG Distinguished Lecturer)*	Hybrid velocity model prestack imaging *B Muller, M Lamont*	Minimising noise problems when downward continuing potential field data *G Cooper, D Cowan*	
1545–1605	The in situ stress field of the West Tuna area, Gippsland Basin: implications for natural fracture-enhanced permeability and wellbore stability *E Nelson, R Hillis, S Mildren, J Meyer*	3D seismic trace interpolation using noncausal spatial filters *B Hung, C Notfors*	A new set of magnetic field derivatives for mapping mineral prospects *D Fairhead, C Green, B Veruzco, C MacKenzie*	
1605–1625	Fluid effect on shear wave splitting in a porous fractured reservoir *R Galvin, B Gurevich*	An efficient explicit 3D prestack depth migration *A Long, J Ren, C Gerrard, J McClean, M Orlovich*	Contact mapping from gridded magnetic data - a comparison of techniques *M Pilkington, P Keating*	
1625–1645	Evaluating the impact of fracture-induced anisotropy on reservoir rock property estimates made from seismic data *B Hansen, B Gurevich, K Lawson, K Koster*	Practical evaluation of P and S-wave separation via elastic wavefield decomposition *N Hendrick, E Brand*	Separation filtering using fractional order gradients *D Cowan, G Cooper*	
1645–1705	Attenuation of compressional waves in porous rocks with aligned fractures - Comparison of the theory with the numerical experiments *M Brajanovski, B Gurevich, G Lambert, K Koster*	Inversion for Thomsen's anistropy parameters *P Elapavuluri, J Bancroft*		

WEDNESDAY AUGUST 18				
SESSION 1	PNG CASE STUDIES SPONSORED BY OIL SEARCH LTD	EXPLORATION IN NSW 1	GENERAL STUDIES TED LILLEY STREAM	GRAVITY AND MAGNETIC STUDIES
0830–0850	**KEYNOTE** - Oil Search – Building a New Future *Mark Wilson, Oil Search Ltd*	**KEYNOTE** - Geological Survey activities aiding exploration *Ted Tyne, Geological Survey of NSW*	Regional-residual gravity field separation in the Central Andes using global geopotential models *R Hackney, W Featherstone, H Goetze*	The textural analysis of potential field data *G Cooper, D Cowan*
0850–0910	Seismic delineation of near-field exploration opportunities in the Papuan thrust belt: examples from the SE Gobe Area *M Parish*	HyMap of Broken Hill - Imaging spectrometry for rock and mineral abundance mapping *G Taylor, P Hansford, B Stevens, R Barratt, D Robson*	Enhancement of magnetic signatures of impact structures *D Cowan, G Cooper*	Underground gravity exploration at the Cannington mines *G Liu, D Boggs, P Stone*
0910–0930	Integrated use of seismic, ground and airborne gravity/gravity gradiometer, and ground geological mapping methods in the eastern Papuan Basin, PNG *A Nelson, D Holland, O'Karo Yogi, R Heidorn, D Leech*	An improved pseudo-gravity magnetic transform technique for investigation of deep magnetic source rocks *D Pratt, Z Shi*	Rigidity of the Andes from flexural modelling and admittance and coherence techniques *R Hackney, A Tassara, J Kirby H Goetze*	Minimisation of the gravity response from mine infrastructure: an example from Sons of Gwalia Mine, WA *J Jackson, G Pears, P Fullagar*
0930–0950	Case Study: NW Moran 1 - Extension of Moran Field, Papuan Fold Belt, Papua New Guinea *K Bale, K Bradey*	Use of potential field data and modelling to complement detailed geological mapping in the Braidwood - Goulburn area, New South Wales *S Webster, O Thomas, A Johnston, G Burton*	Three dimensional EM modelling of Antarctic sea ice pressure ridges *J Vrbancich, J Reid, D Annetts, A Pfaffling, T Worby*	Exploration and modelling of basaltic rocks and a Maar depression *H Lindner, R Kaeppler, C Pretzschner*
0950–1010		New enhancement filters for geological mapping *Z Shi, G Butt*	AVO and AI in PNG: Hydrocarbon prospect evaluation in a foreland basin *D Bennett*	
1010–1045	MORNING TEA - EXHIBITION HALL 5			

WEDNESDAY AUGUST 18

SESSION 2	INNOVATIVE SEISMIC METHODS SPONSORED BY ENI AUSTRALIA	EXPLORATION IN NSW 2	LITHOSPHERE TED LILLEY STREAM	EM/ELECTRICAL MAPPINGS
1045–1105	KEYNOTE 1 - Passive seismic: when, where and why *Peter Duncan, Microseismic, USA* *(SEG President)*	Interpretation of the petroleum potential of the Darling Basin, a process of integration and iteration *P Cooney, R Mantaring*	Lithospheric structure in the Australian region - A synthesis of surface wave and body wave studies *B Kennett, S Fishwick, M Heintz*	Rapid estimation of seawater depth from airborne electromagnetics *J Macnae, M Catalano, B Young, A Howard, T Robb, J Vrbancich*
1105–1125	KEYNOTE 2 - Time-depth processing of global offset data: a new perspective for seismic imaging in thrust belt *Paolo Dell'Aversana, Eni S.p.A.* *(EAGE Distinguished Lecturer)*	Overview interpretation of the Murray-Riverina exploration, NSW airborne magnetic / Radiometric Survey and regional Bouguer gravity *M Hallett, S Webster*	Constraints on Australian lithosphere structure using magnetotellurics *G Heinson, K Broxholme, R Gill, S Thiel, N Direen, A White, P Milligan*	Inversion of data from electrical imaging surveys in water-covered areas *M Loke, J Lane*
1125–1145	A nodal approach to wide aperture seismic - using more information from the seismic wave field *J Leven, J Makris, D Illinksi*	Geophysical and geological interpretation of the Junee - Narromine Volcanic Belt *V David, R Glen, R Spencer*	The integration of geophysics and geochemistry reveals the nature of the lithosphere beneath the Slave craton (Canada) *Y Djomani, S O'Reilly, W Griffin, L Natapov, N Pearson, B Doyle*	Post-processing calibration of frequency-domain electromagnetic data for sea ice thickness measurements *J Reid, J Bishop, A Munro, A Worby, P Pfaffling, K Tateyama*
1145–1205	Kirchhoff and wave-equation anisotropic migration in thrustbelt areas *F Aubin*	Isostatic correction of NSW Bouguer gravity data *R Spencer, R Glen*	Lithospheric magnetotelluric imaging in Canada: significance to diamond exploration *I Ferguson, X Wu, J Craven, A Jones*	The time-domain electromagnetic response of wedge-like structures *D Annetts, F Sugeng, A Raiche*
1205–1225		Panel Discussion	The Andean gravity field, forward modelling and determination of lithospheric rigidity *H Goetze, Z Tasarova, S Wienecke, A Tassara, S Schmidt, R Hackney*	Theoretical treatment of amplitude calibration problems in HEM data *Y Ley-Cooper, J Macnae*
1235–1335	LUNCH - EXHIBITION HALL 5			

SESSION 3	NON-SEISMIC FOR PETROLEUM	SEISMIC TECHNICAL FORUM III (LAND ACQUISITION; CHOOSING THE BEST SOURCE) SPONSORED BY MOSAIC OIL N.L.	MT AND EM TED LILLEY STREAM	ELECTRICAL & EM STUDIES
1335–1355	FalconTM airborne gravity gradiometer results from three areas in the East Gippsland Basin, Victoria and the implications for further exploration *H Rutter, P Harman*	Introduction *John Hughes, Santos Ltd*	The use of Mohr circles in the interpretation of magnetotelluric data *J Weaver*	B-Field TEM Data Acquisition for Nickel Exploration *C Annison*
1355–1415	Global mapping deep-water hydrocarbon plays of the continental margins *D Fairhead, C Green, K Fletcher*	Vibroseis or dynamite: Investigating source characteristics *K Driml, B Smith, J Saunders, R Taylor*	Marine electromagnetics in Australia: Ted Lilley's contributions to the understanding of the role of the magnetic field in the marine environment *A White*	SNMR signal contribution in conductive terrains *D Hunter, A Kepic*
1415–1435	Structural imaging of Esh El-Mallaha area, Gulf of Suez, Egypt using Euler Method *E Aboud, A Salem, K Ushijima*	Seismic source modelling and 3D survey parameter design, Surat Basin, Australia *G Beresford, R Taylor*	The marine magnetotelluric method for fun and profit *S Constable, K Key*	Crosshole electric scanning and profiling of a cylindrical conductor: laboratory investigations *S Greenhalgh, B Zhou*
1435–1455	Using the HyMap airborne hyperspectral sensor for offshore seepage mapping *P Hausknecht, B Martini*	Numerical modelling of pseudo-random land seismic sources *S Strong, S Hearn*	Mapping groundwater in regolith and fractured bedrock using ground and airborne geophysics: case studies from Malawi and Brazil *R Kellett, G Steensma, P Bauman*	Monitoring electrical properties of rocks in target zone of CO2-sequestration site *B Singer, K Dodds*
1445–1455		Panel Discussion		
1445–1455	AFTERNOON TEA - EXHIBITION HALL 5			

ASEG-PESA SYDNEY 2004
ASEG 17th International Geophysical Conference and Exhibition

WEDNESDAY AUGUST 18

SESSION 4	SEISMIC PROCESSING II SPONSORED BY VERITAS DGC ASIA PACIFIC LTD	RESERVOIR MODELLING SPONSORED BY SANTOS LTD	MAGNETIC STUDIES TED LILLEY STREAM	DATA MANAGEMENT AND EVALUATION
1535–1545	Practical 3D surface related multiple prediction (SRMP)	Lithological characterization and multiple-point		

THURSDAY SYMPOSIA

THURSDAY AUGUST 19

	INVERSION IN MINERAL EXPLORATION - TUMBALONG MEETING ROOM 1	SALINITY STUDIES - TUMBALONG AUDITORIUM
	Session Chair: Doug Oldenburg, Professor: Earth and Ocean Science, University of British Columbia	**Session Chair: Greg Street, Principal, GeoAg Pty Ltd**
	The morning session will be focused upon non-uniqueness and how we can help ourselves by incorporating other information	Review of methods for mapping dryland salinity *B Spies, P Woodgate*
0830	KEYNOTE: Incorporating geological information into geophysical inversions *D Oldenburg, C Hewson, E Haber*	Some observations on the sedimentary framework of the Loxton-Bookpurnong region, South Australia as defined by borehole, ground and airborne geophysical data - implications for informing the development of groundwater interception schemes *T Munday, T Hill, B Hopkins, T Wilson A Green, A Telfer*
	Towards 3D maps of alteration under cover: regional constrained 3D inversion of potential field data from the Olympic Cu-Au province, South Australia *N Williams, R Lane, P Lyons*	Investigation into salinisation in south-west Queensland *K Wilkinson, T Chamberlain, M Grundy*
	Drilling-constrained 3D inversion of potential field data *P Fullagar*	Airborne geophysics for natural resource management, Angas Bremer Plains, SA *D Gibson*
1010–1045	MORNING TEA	MORNING TEA
	Exploring through cover - 3D inversion of potential field data over the Prominent Hill discovery in South Australia *C Moore*	Interpretation of helicopter AEM data of the Riverland area, South Australia *A Green, R Brodie, T Munday*
	3D joint inversion of electrical and magnetometric resistivity data *J Chen, D Oldenburg*	The validation of RESOLVE AEM data in the Riverland, South Australia, to determine their value in mapping a regionally significant, near surface hydrogeological unit *K Tan, T Munday, A Fitzpatrick, S Barnett, A Green*
	Human interaction in geophysical inversion *C Wijns, P Kowalczyk*	Hydrogeology around Jamestown, South Australia, revealed through airborne geophysics *R Cresswell*
		Mapping "nested" groundwater flow systems, aquifers and salinity systems in the Lower Balonne, SW Queensland *A Fitzpatrick K Lawrie, J Clarke, A Kernich, C Pain, J Coram, P Please, K Wilkinson, B Pearce*
1235–1335	LUNCH	LUNCH
	The afternoon session will focus on new processing/inversion methodologies	
	The BRGM 3DWEG gravity/magnetic inversion software *A Guillen, G Courrioux, P Calcagno, R Lane, T Lees, P McInerney*	Constrained inversion of helicopter AEM data for mapping the Blanchetown Clay *A Green, R Brodie, T Munday*
	Unravelling source spatial parameters and magnetization direction from inversion of TMI, vector component and tensor magnetic field data *C Foss*	River-borne nanoTEM survey for salt-load detection at Loxton South Australia *V Berens, M Hatch*
	Practical 3D airborne EM inversion in complex terrains *A Raiche*	Reducing the costs of AEM and surveys for salinity and ground water mapping *M Gray, K Lawrie, A Fitzpatrick, P Wilkes, R Lane*
1525–1700	AFTERNOON TEA	AFTERNOON TEA
	Three-dimensional quasi-analytical inversion of electromagnetic fields in models with inhomogeneous background conductivity *M Zhdanov, G Wilson*	3D 3C seismic refraction imaging of shear zone sources of dryland salination *D Palmer, R Nikrouz*
	Holistically calibrating, processing and inverting frequency domain AEM surveys *R Brodie, M Sambridge*	Seismoelectric survey results from the SA Riverland near Loxton *C Waring, S Hankin, T Perl*
	A revised inversion model parameter formulation for fixed wing transmitter loop - towed bird receiver coil time-domain airborne electromagnetic data *R Lane, R Brodie, A Fitzpatrick*	

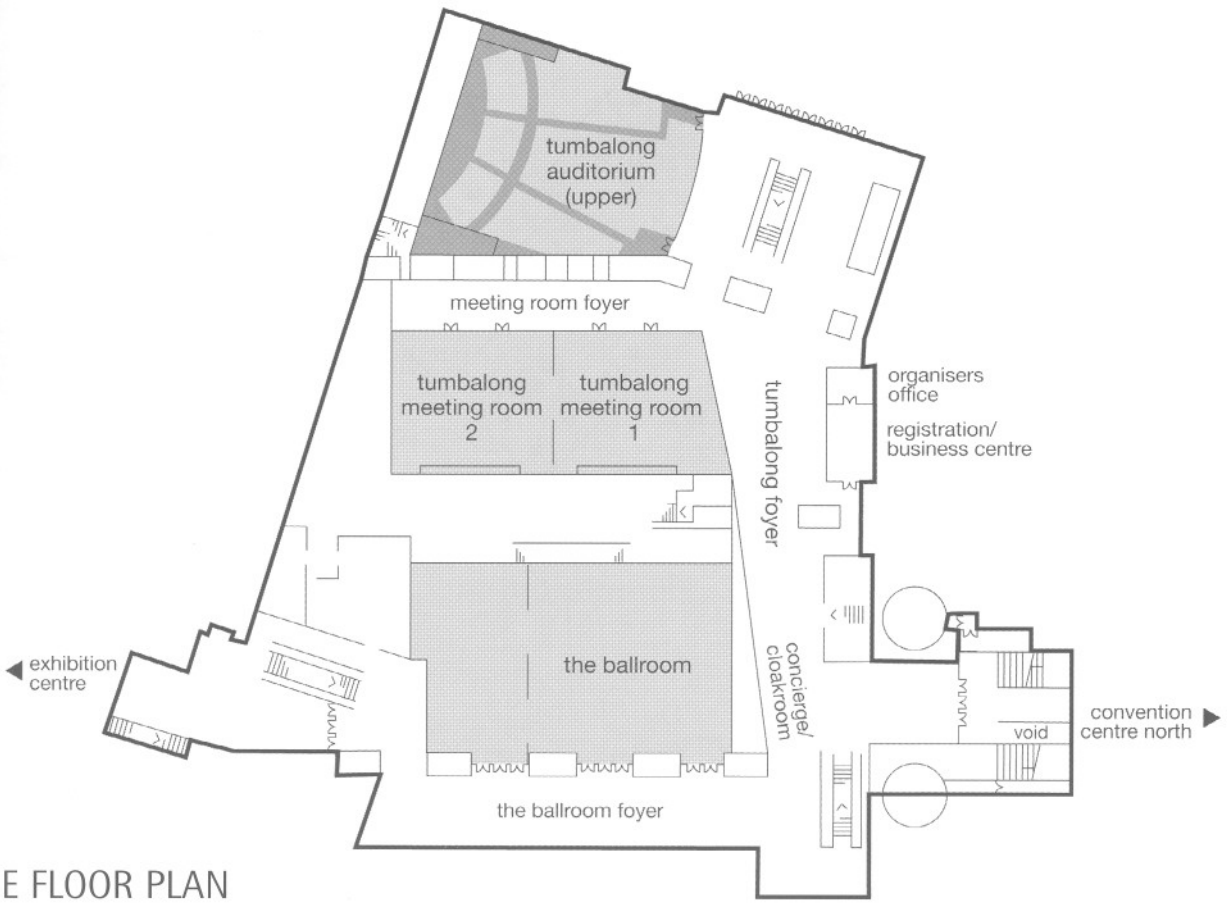
0830–1730 SEG/EAGE DISTINGUISHED INSTRUCTOR SHORT COURSE – TUMBALONG MEETING ROOM 2 – *Paul Weimar*

(Paul Weimer has been a professor at the University of Colorado at Boulder since 1990. He holds the Bruce D. Benson Endowed Chair in Geological Sciences, and serves as Director of the Energy and Minerals Applied Research Center).

The course will provide an overview of the geology of deep-water systems, past, present and future. The review covers recent trends in deep-water exploration, including drilling results and elements of petroleum systems; reservoirs, traps, seals, source rock, migration, and timing. The seismic stratigraphic expression of these systems is integrated with the wireline log expression and information from outcrops, cores, and biostratigraphy. Examples from several producing basins around the world illustrate these points. The production history and the reservoir challenges in developing each of these fields is discussed. Participants are introduced to the basic occurrences of turbidite systems in a sequence stratigraphic framework. Many different kinds of basins produce from turbidite systems. A review of these basins shows the different tectonic settings and associated structural styles. The review also demonstrates that most reservoirs are pure stratigraphic traps or combined traps. A review of seals, source rocks and modeling principles gives the geophysicist practical techniques for understanding deep-water systems. The course concludes with a summary of what is important in the exploration for and development of deep-water systems. The application of these techniques to each geophysicist's current projects is key, as is the difference between frontier exploration and exploration in mature basins with deeper potential. Examples are used to illustrate the principles. These examples will also demonstrate that there is deep-water potential in most basins globally.

TUESDAY AUGUST 17TH 2004 – BALLROOM 2

0900–1000	REGISTRATION	
1000–1145	**MORNING SESSION: "Geoscience in Society"**	
	Chairperson:	Eve Howell
	1. Welcome - Role of Geosciences in Society	Marita Bradshaw
	2. Petroleum Exploration	Mike Bahorich
	3. Minerals Exploration	Andrea Rutley
	4. Geophysics in Society	Roger Henderson
1145–1230	LUNCH	
1230–1330	**PANEL DISCUSSION: " Employment Trends"**	(open to Conference Delegates)
	Chairperson:	Barry Goldstein
	Panel:	Mike Smith
		Karina Chapman
		Jenny Bauer
		Carina Simmat
		Bryce Kelly
1330–1500	**AFTERNOON SESSION: "Careers and Training"**	
	Chairperson:	Dave Pratt
	1. Careers in the Geosciences	Barry Goldstein
	2. A Career in Management of Land & Natural Resources	Bryce Kelly
	3. A Career in Seismic Exploration	Natasha Hendrick
	4. Graduating to Exploration	Roxey Sutherland
	5. A Career in Coal Bed Methane	Mal Bunny
	6. Professional Training	Paul Lennox
1500–1600	**TOUR OF EXHIBITIONS & POSTER PRESENTATIONS**	

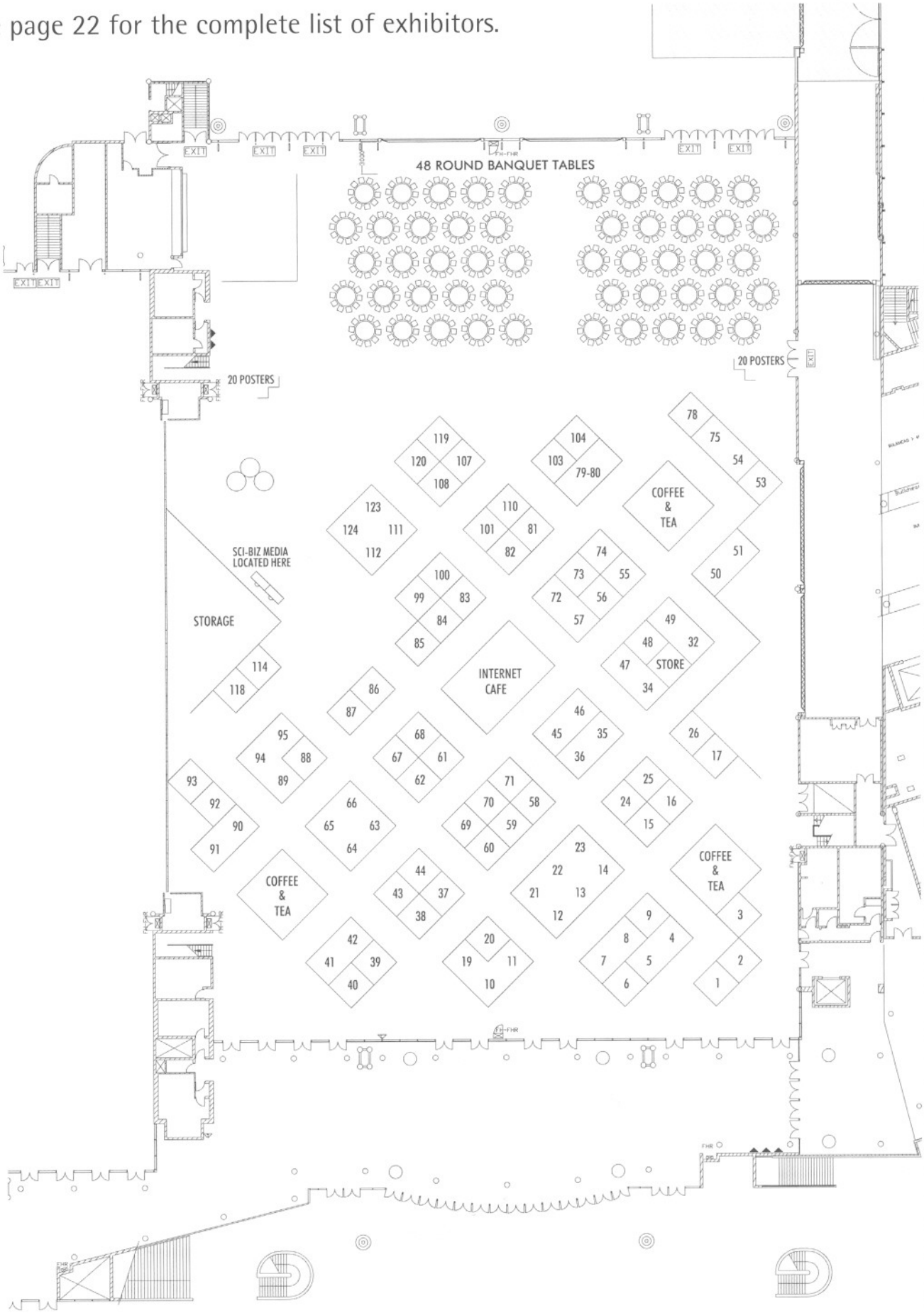


VENUE FLOOR PLAN

timing. The seismic stratigraphic expression of these systems is integrated with the wireline log expression and information from outcrops, cores, and biostratigraphy. Examples from several producing basins around the world illustrate these points. The production history and the reservoir challenges in developing each of these fields is discussed. Participants are introduced to the basic occurrences of turbidite systems in a sequence stratigraphic framework. Many different kinds of basins produce from turbidite systems. A review of these basins shows the different tectonic settings and associated structural styles. The review also demonstrates that most reservoirs are pure stratigraphic traps or combined traps. A review of seals, source rocks and modeling principles gives the geophysicist practical techniques for understanding deep-water systems. The course concludes with a summary of what is important in the exploration for and development of deep-water systems. The application of these techniques to each geophysicist's current projects is key, as is the difference between frontier exploration and exploration in mature basins with deeper potential. Examples are used to illustrate the principles. These examples will also demonstrate that there is deep-water potential in most basins globally.

Exhibition Floor Plan

See page 22 for the complete list of exhibitors.



EXHIBITOR CATALOGUE

SECTION 2

BOOTH NO(S)	ORGANISATION	PAGE NO.
59,60	Alpha Geo Instruments	
108	Archimedes	
92	ASEG	
54,75	Auslog	
2	Australian Seismic Brokers	
110	Baigent Geosciences	
111	Bell Geospace	
39	Ceanet Pty Ltd	
41, 42	CGG Australia + VS Fusion	
17	Condor Consulting – Geotech ltd	
107	CRC LEME	
98,99	CSIRO	
48	Curtin University of Technology	
26	Daishsat Geodetic Surveyors	
104	Dept of Industry & Resources, WA	
69	Dept. of Natural Resources, Qld	
118	EAGE	
49,32	Earth Resource Mapping	
44	Electromagnetic Imaging Technology	
57,72	Encom Technology Pty Ltd	
6	ESRI	
101	Fractal Technologies	
63,64,65,66	Fugro Airborne Surveys Pty Ltd	
45,46	Fugro Instruments	
1	Geo - X Systems, Inc.	
81	Geophysical Software Solutions	
40	GeoPro GMBH	
70,71	Geoscience Australia	
84,85	Geoscience Victoria	
74	Geosoft Australia Pty Ltd	
82	GNS, NZ	
89,94,95	GPX Systems	
3	Grant Geophysical	
78	G-Tek Australia Pty Ltd	
15	Intrepid Geophysics	
56	Kelman Technologies Inc.	
7,8	Landmark	
79,80	Minerals & Energy, SA	
62	Mineral Resources, NSW	
73	Mira Geoscience	
50,51	Mitcham Industries	
61,68	Multiwave Geophysical Company	
83	Northern Territory Geological Survey	
16	Outer-Rim Exploration Services Pty Ltd	
93	PESA	
111,112,123,124	Schlumberger Oilfield Services	
55	Software Advanced Logic Technology	
86,87	Petroysys Pty Ltd	
37,38	PGS Australia Pty Ltd	
58	Professional Investment Services Pty Ltd	
20	RackSaver	
43	Rock Solid Images	
88	SDI	
91	SEG	
90	SEGJapan / Korean SEG	
24	SERCEL Australia	
114	Supersonic Geophysical LLC	
67	Tenix-LADs Corp	
120	Total Depth	
35,36	UTS Geophysics	
20	Verari Systems	
34,47	Velseis Pty Ltd	
12,13,14,21,22,23	Veritas DGC	
10,11,19	WesternGeco	
4,5	Zonge Engineering & Research Organisation	

PLATINUM

WESTERNGECO — STANDS 10,11,19

Level 5, 256 St Georges Terrace
PERTH WA 6000
Tel: 08 9420 4622
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Email: mgiles@perth.westerngeco.slb.com
Contact person: Mike Giles

WesternGeco provides comprehensive worldwide reservoir imaging, monitoring, and development services. We operate the most extensive range of seismic crews and data processing centers in the industry, as well as holding the largest multiclient seismic library. Our unsurpassed array and distribution of resources is ready to meet any geophysical challenge. Our Reservoir Services group is moving advanced seismic technologies into the reservoir - to serve not only explorationists, but also reservoir and petroleum engineers, appraisal and production teams.

GOLD SPONSORS

VERITAS DGC — STANDS 12, 13, 14, 21, 22, 23

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Tel: 08 8214 6228
Fax: 08 9214 6222
Email: wendy.mobley@veritasdgc.com
Contact person: Wendy Mobley

At Veritas, our mission is to acquire, process and sell seismic data to the oil and gas industry. We offer a comprehensive suite of integrated geophysical services designed to enhance drilling and production success. These include seismic survey planning and design, seismic data acquisition in all environments, data processing, data visualisation and an explorationist's toolbox of interpretive and reservoir characterisation services. Veritas also has one of the largest seismic data libraries in the industry today. Veritas employees are one of the most experienced teams of energy explorationists in the industry. All of whom are committed to the principles of 'geophysical integrity', which means we strive to deliver value and consistent, accurate results to our customers on every project we undertake.

EXHIBITORS

ALPHA GEO INSTRUMENTS — STANDS 59, 60

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SUTHERLAND NSW 2232
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Fax: 02 9542 5263
Email: tpippett@alpha-geo.com
Contact person: Timothy Pippett

Alpha Geoinstruments, a division of Alpha GeoScience Pty. Ltd. distributes a wide range of geophysical instruments into the Australian and New Zealand markets. The following manufacturers are represented by Alpha Geoinstruments :

- Mala Geoscience (Sweden) – Ground Penetrating Radar systems with frequencies from 25 to 1000 MHz.
- ABEM Instruments (Sweden) – a range of Resistivity Instruments and Seismograph recorders.
- GEM Systems (Canada) – total field Magnetometers, proton precession, overhauser and potassium vapour sensors.
- Geovista – Borehole Logging Systems
- Dualem – Electro-magnetic System

A range of software programs for geophysical application. Alpha Geoinstruments also have a range of geophysical instruments for rental; see us at stand 59 & 60 for details.

ARCHIMEDES — STAND 108

PO Box 423
GLENSIDE SA 5065
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Email: ikivior@archimedes-consulting.com.au
Contact person: Tereska Kropinski

Archimedes Consulting is an Australian based company that specialises in advanced processing and analysis of aeromagnetic and gravity data over onshore and offshore sedimentary basins. The company provides cutting edge technology for petroleum exploration detecting uniquely: faults and fracture patterns in sediments, litho-stratigraphic boundaries, hydrocarbon alteration zones, palaeochannels, igneous bodies, basement configuration and deep crustal structures. Archimedes conducts extensive research work on the application of potential field data to hydrocarbon exploration. The company has developed proprietary software for special processing and interpretation of magnetic data, which has been applied over Australian Basins, as well as basins in PNG, New Zealand and the Middle East.

ASEG — STAND 92

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PERTH BUSINESS CENTRE WA 6849
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Contact person: Louise Middleton

The ASEG is a not-for-profit company founded in 1970. Its aims are;

- to promote the science of geophysics, and specifically exploration geophysics, throughout Australia
- to foster fellowship and co-operation between geophysicists
- to encourage closer understanding and co-operation with other earth scientists
- to assist in the design and teaching of courses in geophysics and to sponsor student sections where appropriate.

The Federal Executive assists in the formation of local branches of the society throughout Australia and will publish any material considered desirable for the promotion of its objectives. Activities The ASEG's main activities are publication of the technical journal Exploration Geophysics and the bi-monthly magazine *Preview* and occasional Special Publications. The ASEG organises a Geophysical Conference and Exhibition every 18 months. The ASEG also conducts continuing education courses and supports research in exploration geophysics. Membership The ASEG's current Membership is over 1400 and increasing at a rate of 10 percent a year. Research Foundation The ASEG has a Research Foundation which helps fund specific research projects at Australian tertiary institutions. Up to $5,000 can be made available to help pay research costs incurred by each project. Technical Standards Committee The ASEG's Technical Standards Committee is responsible for implementing industry wide standards to aid in data transfer and data quality. Current chairman is Paul Wilkes and members include most Chief Geophysicists of state geological surveys.

AUSLOG — STAND 54, 75

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Auslog, Scintrex, Lacoste and Romberg and Micro G operate under the L&R-Scintrex Inc group of companies. Auslog is a world leading supplier of Borehole Geophysical systems based in Brisbane. Our sister company Australian Logging Services provides borehole Services Australia wide. New advancement in data transmission and tool development is providing a bright future in years to come. Whatever the borehole requirement, Auslog can help. Scintrex, L&R and Micro G are the worlds leading suppliers of land Gravity instrumentation with continuous efforts in development and new products. Gravity, Magnetics, resistivity and integrated airborne systems provide the basis of manufacturing while also supplying a wide range of geophysical tools.

AUSTRALIAN SEISMIC BROKERS — STAND 2

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Email: s.jeffrey@asb.com.au
Contact person: Steve Jeffrey

Australian Seismic Brokers market non-exclusive data throughout South East Asia. The available data base has currently available over 3 million kms of seismic data for sale. within Australia we are also able to supply Well Completion Reports and composite logs. The seismic data base comprises new speculative shoots,reprocessed data both pre stack and post stack, scanned data and original open file segY or hardcopy data. We can also undertake data searches on the clients behalf to find legacy data sets or scan client hardcopy data to segY for further processing or workstation loading.

BAIGENT GEOSCIENCES — STAND 110

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Contact person: Mark Baigent

Baigent Geosciences specialises in the processing of airborne geophysical data. The company is devoted to high quality results and services in the processing of magnetic, radiometric, dtm and helicopter EM data sets. The company has an extensive knowledge base in the processing of fixed and helicopter acquired data. The company has he ability to incorporate the horizontal gradients in the magnetic total field to enhance structural resolution. In house software development keeps abreast of industry innovation to make sure that only the best processing solutions are used to maximise the usefulness and interpretability of the data. With over twenty years involved in the exploration arena Baigent Geosciences ensures the highest quality and rapid turn around of geophysical data

BELL GEOSPACE LIMITED — STAND 111

Aberdeen SCOTLAND
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Bell Geospace is the sole commercial provider of the Full Tensor Gradiometry technology, acquiring all components of the gravity gradient field on both marine and airborne platforms. The company offers high precision gravity solutions to the mining and oil & gas industries and government sectors worldwide. BGL, the wholly owned subsidiary of Bell Geospace Inc, were formed in 1998 and based in Aberdeen, UK. Marine 3D-FTG has been operational in the Gulf of Mexico and offshore Europe since 1998 and the Air-FTG™ system since late 2002. Over 60,000 line km of Air-FTG™ data has been acquired in the Africa, Canada and the USA to date.

CEANET PTY LTD — STAND 39

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Ceanet is a leading supplier and developer of innovative software solutions and services for research and development in all industries including the Geophysical Sciences. MathWorks products, MATLAB and Simulink, play a fundamental role in the research, design, and product development for geologic and oceanographic research including data analysis, algorithm development, modeling, and simulation. With offices in Sydney and Brisbane we offer the following services:

- Software sales and customisation;
- Application development;
- Training and support;
- System installation and integration;
- Modelling and other specialised consulting services;
- Project Management.

For information about our software products and technical support contact our representatives 1800 628 320 or email your enquiry on info@ceanet.com.au

CGG AUSTRALIA AND VS FUSION — STAND 41, 42

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Compagnie Generale de Geophysique (CGG) is a leading supplier of geophysical products and services to the worldwide oil and gas industry, mainly in geophysical equipment, seismic acquisition and processing and reservoir geophysics. CGG Australia offers state-of-the-art seismic processing in time and depth, land and marine domains. The Perth centre is connected to the Kuala Lumpur processing hub through Linux PC clusters using the latest release of CGG's Geocluster seismic data processing package. The hub follows the same model used in the CGG Group's London and Houston regional hubs which include huge Linux PC clusters and fast links to the data processing centres. This move is intended to boost the group's regional computing power and shorten processing turnaround time through the enhanced speed of specific applications and ultimately provide a better structural image. VSFusion offers borehole seismic application design, data processing and interpretation services. By using calibration information and parameters derived from borehole seismic measurements to enhance surface seismic imaging and attribute processing, reduced uncertainty is achieved in surface seismic interpretation. VSFusion serves as a bridge between well log information, surface-seismic and reservoir geophysics, and offers a specialization in complex and special processes such as 3-D VSP, AVO, fracture monitoring and delineation and time-lapse VSP.

CONDOR CONSULTING, INC - GEOTECH LTD — STAND 17

Suite 150. 2201 Kipling Street
LAKEWOOD CO 80215
Email: ken@condorconsult.com
Contact person: Ken Witherly

The VTEM Heli-Time Domain EM system is a state-of-the-art airborne EM prospecting system designed for application to a wide range of nature resource problems. The VTEM technology was introduced commercially in late 2002 and quickly became top of it's class in terms of dipole power and overall system versatility, with the Mk III "TRex" class operating at over 0.5M dipole moment and the "Raptor" class single turn, light weight system designed for high resolution mapping applications. VTEM is built and operated by Geotech Ltd., Toronto Canada with global marketing, processing and interpretation supported by Condor Consulting, Inc.

CRC LEME — STAND 107

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Contact person: Susan Game

Cooperative Research Centre for Landscape Environments and Mineral Exploration. CRC LEME is in its second seven-year term. It applies regolith science to the Australia's problems in mineral and natural resource management. It is strongly committed to addressing the challenges of mineral exploration in areas of transported regolith. It is undertaking and developing a wide range of integrated projects that use multi-disciplinary approaches to look at three-dimensional architecture of the regolith. The projects focus on the time-dependent physical, chemical, biological and hydrological processes that control geochemical dispersion of the minerals in the regolith. We refer you to our website: http://crcleme.org.au for information of LEME research activities, news, publications and regolith landform maps. LEME is an unincorporated joint venture between its eight participants: Australian National University, CSIRO Divisions of Exploration & Mining and Land & Water, Curtin University of Technology, Geoscience Australia, Minerals Council of Australia, NSW Dept Mineral Resources, Primary Industries and Resources SA, University of Adelaide, established and supported by the Australian Government's Cooperative Research Centres program.

CSIRO — STANDS 98, 99

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With 368 research and scientific staff in Perth, Melbourne and Sydney, CSIRO through its Divisions of Petroleum Resources, Exploration and Mining and Industrial Physics, provides strategic, world class R&D - plus related technology services and solutions - to address the changing needs of the mining, mineral exploration, oil and gas industries in Australia and around the world. CSIRO has a reputation for world-class, creative and industry-focused research, based on experience, project management capability, diversity of scientific disciplines and comprehensive, leading-edge facilities. These considerable attributes enable scientists to help industry resolve complex, multi-faceted issues and problems within commercially acceptable time frames. CSIRO is the largest supplier of strategic R&D to the Australian exploration and mining industry. Focusing on research aimed at increasing the competitive advantage of the industry, CSIRO has established an enviable track record in the delivery of innovative science and engineering.

CURTIN UNIVERSITY OF TECHNOLOGY — STAND 48

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Contact person: Nicole Judge

The DEPARTMENT OF EXPLORATION GEOPHYSICS specialises in education and research in Minerals, Groundwater and Petroleum Geophysics. In 2004 the Department has 13 Staff and 82 Students. Since the inception of a geophysics program at Curtin, over 550 persons have been awarded degrees at all levels. The Department is currently a member of two CRC programs, CO2CRC and CRCLEME and has been a State nominated Centre of Excellence for Exploration and Production Geophysics. The petroleum arm of the research program is the Curtin Reservoir Geophysics Consortium which has been awarded the SEG's Distinguished Achievement Award for 2004. The annual operating budget of the Department is approx. $2 million, most of which is received via research grants.

DAISHSAT GEODETIC SURVEYORS — STAND 26

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Tel: 08 8531 0349
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Email: david.daish@daishsat.com
Contact person: David Daish

Daishsat is the leading provider of GPS positioned gravity surveys in Australia, surveying in excess of 500,000 gravity stations in Australia and around the world over the last 12 years. Having recently taken delivery of the latest in gravity acquisition equipment, the Scintrex CG5 gravity meter and Leica GPS1200 RTK units, we are the only operators of this new equipment in Australia. Utilising the latest equipment and employing the most experienced staff, our clients can expect production, accuracy and reliability gains over previous surveys and all competition. Contact David Daish or Leon Mathews for your next high quality gravity survey !

DEPARTMENT OF INDUSTRY & RESOURCES WA — STAND 104

100 Plain Street
EAST PERTH WA 6004
Tel: 08 9222 3635
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Contact person: Arthur Hoffman

The Department of Natural Resources, Mines and Energy (NRM&E) is responsible for supporting, promoting and monitoring the State's mining and energy industries. NRM&E promotes the State's potential by encouraging investment, attracting explorers and developers, and assisting in land access negotiations. The department collates an extensive range of geological data gathered by government and the private sector and makes it available. It administers the management of, and dealings in, all Queensland exploration and production tenure, ensuring compliance with petroleum and Native title legislation. NRM&E manages petroleum and gas safety and health standards and practices. The department develops legislation and policy to ensure a sustainable industry. The Department is also responsible for natural resource management including salinity management.

DEPARTMENT OF NATURAL RESOURCES, QLD — STAND 69

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Contact person: John Draper

The Department of Natural Resources, Mines and Energy (NRM&E) is responsible for supporting, promoting and monitoring the State's mining and energy industries. NRM&E promotes the State's potential by encouraging investment, attracting explorers and developers, and assisting in land access negotiations. The department collates an extensive range of geological data gathered by government and the private sector and makes it available. It administers the management of, and dealings in, all Queensland exploration and production tenure, ensuring compliance with petroleum and Native title legislation. NRM&E manages petroleum and gas safety and health standards and practices. The department develops legislation and policy to ensure a sustainable industry. The Department is also responsible for natural resource management including salinity management.

EAGE — STAND 118

Contact person: Arno Smits

EAGE (European Association of Geoscientists & Engineers) is the leading European based international organisation of geoscientists and engineers. The objectives of the Association are to promote the application of geosciences and related engineering subjects and to foster the communication, fellowship and co-operation between those working in, studying or being otherwise interested in these fields. The Association achieves its objectives through publications, conferences, workshops, education programmes and exhibitions. Today EAGE has 2 divisions, the Oil & Gas Geoscience Division and the Near Surface Geoscience Division. In addition to the annual EAGE Conference and Exhibition in Madrid (13-16 June 2005), the 2nd North African/Mediterranean Petroleum & Geosciences Conference and Exhibition will be held in Algiers from 10-13 April 2005. Information regarding all EAGE organised conferences and workshops is available at www.eage.org

EARTH RESOURCE MAPPING — STANDS 32, 49

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Contact person: Darren Mottolini

Earth Resource Mapping is proud to be the leading image processing and Internet distribution software developer. Earth Resource Mapping produce a suite of imaging solutions for the processing, display and serving of digital raster imagery. The flagship product ER Mapper has gained considerable usage amongst the remote sensing community of the world. It features the innovative dynamic algorithm compiler allowing the easy handling of very large image datasets. Research into wavelet compression methods has lead to the development of the ECW (enhanced compressed wavelet) format and associated Image Web Server product. This enables the delivery of large processed datasets over the Internet or secure intranets.

ELECTROMAGNETIC IMAGING TECHNOLOGY — STAND 44

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Contact person: Andrew Duncan

ElectroMagnetic Imaging Technology (EMIT) develops instrumentation and software for electrical geophysics. The EMIT SMARTem receiver system is now in widespread use, especially in surveys where low noise measurements are required in the presence of electrical interference. SMARTem is a PC-based 8-channel system for any type of electrical geophysics including EM and IP, with full time-series recording and Windows graphic interface. EMIT's Maxwell is software for the visualisation, processing, modelling and plotting of EM data of any type - time or frequency domain, airborne, ground, borehole. EMIT's Atlantis 3-component borehole magnetometer system is perfectly matched with the SMARTem system for borehole B-field TEM surveys.

ENCOM TECHNOLOGY PTY LTD — STANDS 57, 72

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Encom Technology is celebrating its 20th year as a supplier of advanced geoscience software and services and is proud to be a Silver Sponsor of the ASEG-PESA 2004 Conference and Exhibition. Encom has offices in Sydney and Melbourne and works with an international support network of resellers for its geophysical products and services. Encom develops integrated geoscience software applications, and provides advanced interpretation, research and software engineering services to exploration and engineering geophysical organisations. Popular Encom products include Discover for MapInfo Professional, Discover 3D, Discover Mobile, Profile Analyst, ModelVision, AutoMag and QuickMag. Encom also develops products under licence including EM Flow, EM Vision and NODDY. It is also a distributes and value adds to ER Mapper, Image Web Server and the UBC products MAG3D, GRAV3D, EM1DFEM, DCIP2D and DCIP3D. Encom's Advanced Technology Services Division provides training, innovative interpretation services, R&D facilities, and software engineering for customization of client R&D or workflow optimization. Encom uses state of the art 3D software technology for interactive interpretation applications that are designed to integrate GIS, geological, geochemical, geophysical interpretation and processing needs in a single 1D, 2D and 3D environment. Encom Petroleum Information provides the definitive petroleum permit information service GPINFO for petroleum explorers, services companies and government organizations and incorporates spatial information on permits, wells, pipelines and a wide array of related spatial data. Each year, Encom produces an industry sponsored GPinfo Petroleum Permits Map of Australasia for the annual APPEA conference.

ESRI — STAND 6

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ESRI Australia has been operating since 1979, and is the leading provider of Geographic Information Systems (GIS) solutions in Australia. ESRI Australia markets and supports ESRI GIS software and imaging GIS software from Leica Geosystems. ESRI Australia offers GIS solutions that scale from small, single-user projects to departmental and corporate-wide systems where data and processing are shared over local area, wide area and Internet/intranet networks. By combining experienced staff with a passion for GIS and the world's leading GIS software, ESRI Australia delivers quality geospatial solutions... every day.

FRACTAL TECHNOLOGIES — STAND 101

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Contact person: Tamara Ziere

Fractal Technologies develop 3-dimensional data management and visualisation software for the geosciences. Their mission is to provide the resource industry with 3D spatial information management and interrogation products. By partnering with other software vendors and system integrators, they deliver Best of Breed solutions that enhance business processes, thereby adding value to the industry_s data assets. Their products include:

- FracSIS Visualisation _ a data integration suite that stores different forms of geological, geophysical, geochemical and drilling data in a single spatial database and allows that data to be presented in a unified 3D visualisation environment.
- FracSIS Spatial Data Manager _ a comprehensive data management and collaboration application that provides data translation, audit trail, security, version control and publication services for exploration and mining data. It is a vendor-independent storage and management solution allowing everyone in an organisation to access data in whichever format they require in a controlled, managed environment.
- The group also provides services in the areas of custom software development, training, database creation, and data validation. Future directions for the group include increasing its global deployment of software and products, the development of a 3D GIS software package, and the fast tracking of the world_s first truly 4-dimensional spatial information system.

FUGRO AIRBORNE SURVEYS PTY LTD — STANDS 63, 64, 65, 66

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Fugro Airborne Surveys is a multi-disciplinary geoscience service company. Its core business of airborne geophysical data acquisition, processing and interpretation services includes applications for mineral and petroleum exploration, geological mapping, environmental and engineering solutions for both government and private sectors in the Asia-Pacific region and around the world. FAS also has a successful record in developing new exploration technologies through joint venture R&D programs. A comprehensive range of the latest geophysical survey technologies is available including: – Fixed wing time domain and helicopter frequency domain electromagnetics – Fixed wing and helicopter high-resolution magnetics and radiometrics – Fixed wing gradient magnetics – Airborne gravity and airborne gravity gradiometry (Falcon). FAS has an extensive fleet of aircraft, enabling surveys to be undertaken safely and cost effectively in a wide variety of terrains in almost any location on any continent. The company is certified to AS/NZ ISO9001:2000 and is a founding member of IAGSA.

FUGRO INSTRUMENTS — STANDS 45, 46

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The successor to Geo Instruments, FUGRO INSTRUMENTS is a leading supplier of high-quality geophysical instrumentation and software to the exploration, geotechnical, engineering, environmental and agricultural sectors. We promote Australian-made instruments internationally, and represent the major North American (AGI, Bartington, Exploranium, Geometrics, Geonics, Geostuff, Interpex, Iris, PetRos Eikon, Phoenix, RMS, and Sensors & Software), and European (DMT & Robertson Geologging) suppliers in the Australasia-Pacific region. Our competitive advantage comes from a strong customer focus offering leading-edge and innovative solutions, backed by reliability in our products and outstanding after-sales technical support. With an established background and knowledge of all types of geophysical technologies, FUGRO INSTRUMENTS has the expertise and dedication to be preferred choice for geophysical instrumentation

sales, rentals and repairs for land, marine and airborne applications. FUGRO GROUND GEOPHYSICS, provide high quality ground geophysical data acquisition, processing and interpretation services for clients throughout the world, from offices in Perth, Sydney and Lima, Peru. We are a member of the Fugro worldwide group: Utilising this extensive network allows us to work efficiently and competitively across the globe. FGG are experts in a full suite of geophysical techniques including;

- TEM - high powered, high resolution, full time series - dB/dt and B-Field - surface and downhole
- DGPS gravity - ground, vehicle, and helicopter supported - sea floor gravity
- Induced Polarisation - high powered 3300V transmitters - standard or 3D arrays
- DGPS magnetics - 10Hz sampling, decimetre positioning and FEM, NMR, Radiometrics, MIP/MMR, Resistivity, CSAMT

GEO-X SYSTEMS, INC — STAND 1

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Geo-X Systems Ltd., with ARAM ARIES seismic recording systems provides the latest in seismic acquisition technology. Our field proven UNI-RAM acquisition module creates a universal solution for seismic crews working in Mountains, Deserts, Jungles and Transition Zones with water depths up to 50 meters. The ARAM Lithium Ion battery technology provides high efficient, light weight, power for more than 120 hours of crew operation without recharging. In areas where cables are difficult to deploy ARAM ARIES Net-Link is a highly portable wireless data transmission system. ARAM also developed the SPM-Lite portable CRU recorder, for use in difficult terrain.

GEOPHYSICAL SOFTWARE SOLUTIONS — STAND 81

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Geophysical Software Solutions (GSS) specializes in geoscientific software development, particularly in the area of potential fields; and in the modeling and interpretation of gravity and magnetic data acquired in the course of mineral exploration surveys. GSS is particularly experienced in the simultaneous modeling of multi-component down-hole magnetic data with ground or airborne TMI data. GSS has developed a number of software products to assist in exploration. Potent provides a highly interactive framework for 3-D modelling of magnetic and gravity data, in both minerals and petroleum exploration contexts. PotentQ is a streamlined version of Potent that provides rapid semi-automatic modelling of a single magnetic and/or gravity anomaly. EM-Q uses an interface similar to PotentQ to model EM moment data.

GEOPRO GMBH — STAND 40

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GeoPro GmbH is an international exploration service company offering a range of seismic services for both onshore and offshore data acquisition and processing. Its head office and processing centre is located in Hamburg, Germany, and a subsidiary office has been established in Perth. GeoPro's key service is marine surveys using ocean bottom seismometers (OBS). OBS acquire high quality compressional and shear wave data either in conjunction with a standard marine reflection survey to acquire near-vertical compressional and shear data for PP or PS reflection processing, or for a wide aperture survey using WARRP techniques. The benefits of using OBS technology include the quieter ambient seafloor environment, and the ability to record both P and S wave energy using 3-component seismometers.

GEOSCIENCE AUSTRALIA — STANDS 70, 71

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Geoscience Australia is Australia's national geoscience research and spatial information agency. Geoscience Australia provides independent geoscientific information and knowledge to enable the government and the community it serves to make informed decisions about exploring for and developing resources, the management of the environment and the safety and wellbeing of Australians. Our range of products includes:

- geological and geophysical maps and field and processed data (including minerals databases);
- petroleum prospectivity studies and marine data;
- digital elevation data;
- topographic and thematic maps;
- geohazards reports;
- geodetic datasets; and
- remotely sensed data.

Most of our products are now available free online or for the cost of transfer.

GEOSCIENCE VICTORIA — STANDS 84, 85

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Contact person: Paul McDonald

Victoria's Minerals and Petroleum Division (MPD) is responsible for promoting and regulating the Victorian oil and gas, extractive and mineral exploration and mining industries. Statewide pre-competitive geoscientific products are provided from a program that combines new geological data with maintained corporate data. These high quality products aim to generate wealth through the sustainable development of earth resources by attracting hydrocarbon and mineral explorers to Victoria. The geoscientific information include geological maps and accompanying reports, airborne geophysical surveys and GIS data packages covering mineral occurrences and production, geochemistry, geology and geophysical data and interpretation.

GEOSOFT AUSTRALIA PTY LTD — STAND 74

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Established in 1986, Geosoft stands for integrity and best practice in earth science mapping and exploration technology. Today, Geosoft software is

helping to simplify geospatial data access and analysis for improved understanding, knowledge development and business decision-making in industries such as mineral exploration, oil and gas, government, and in environmental investigations and UXO (Unexploded Ordnance) detection. The company is headquartered in Toronto, Canada, with offices in South America, Europe, South Africa and Australia. Geosoft's partner network provides additional coverage throughout the United States and across the globe, in Russia, India and China.

GNS - NEW ZEALAND — STAND 82

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GNS is New Zealand's primary geological organisation, with 300 staff. Our hydrocarbon exploration consulting group combines an established reputation in research with industry standard software and highly experienced professionals. Our multi-disciplinary teams are experts in seismic processing, seismic interpretation, sedimentology, biostratigraphy, organic geochemistry and basin modelling. We provide innovative solutions for exploration and development problems throughout the Asia Pacific. Visit our booth to find out how we can help you with your seismic imaging. Our geophysicists can discuss how we can solve your processing problems and demonstrate our seismic processing software, Globe Claritas.

GPX SYSTEMS — STANDS 89, 94, 95

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Contact person: Ron Creagh

GPX Airborne Pty Ltd

GPX Airborne Pty Ltd provides airborne services to the mineral, groundwater and environmental geophysical industries. GPX Airborne was formed as a subsidiary of GPX Services Pty Ltd in 2001 in order to commercialize Newmont Mining Corporation's helicopter-borne Time-Domain Electromagnetic system (HoistEM). As a natural growth GPX Airborne now also operates fixed wing and helicopter borne magnetic and radiometric systems worldwide. The Directors of GPX Airborne Pty Ltd are Mr Pat Cunneen, Managing Director, Mr Greg Reudavey, Chairman and Mr Ron Creagh, Director Operations. Each Board Member has more than 25 years experience at a senior level in the airborne geophysical industry.

GPX Services Pty Ltd

GPX Services Pty Ltd provides ground geophysical services to the mineral, groundwater and environmental geophysical industries. GPX's main area of expertise is in electrical geophysical surveys for mineral exploration, groundwater exploration and environmental applications. Core personnel comprise Lindsay Greenham, Francis Thomson, Ron Creagh and Gerard McNeill who together have a combined total of 75 years experience in the Geophysical contracting industry. GPX has extensive Australian and international experience.

GRANT GEOPHYSICAL — STAND 3

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Grant Geophysical is an international geophysical contractor providing specialized land, transition zone and shallow water (OBC) seismic data acquisition and processing services to petroleum and mining industries around the world. Grant actively researches and implements emerging technologies with conventional 2D, 3D and in reservoir monitoring applications, repeatable 4D surveys. Grant acquires data utilizing single component, dual sensor, 3C or 4C multi-component technologies with fixed axis or fully gimbled sensors. Grant has experience operating in North America, Canada, South America, Europe, Africa, the Middle East, Far East and Asia with projects in some of the world's most challenging environments (mountains, plains, desert, heavy forest, jungle, marsh, swamp, rivers and coast) using the latest technology available in the marketplace for all terrain, man-portable and heli-portable operations. Grant will acquire consistently superior seismic, with faster mobilization (customized proprietary vessels) and survey completion together with exceptional operational safety so that seismic exploration is managed with care in order to leave a minimal environmental footprint.

G-TEK AUSTRALIA PTY LIMITED — STAND 78

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G-tek is recognized around the world as leaders and pioneers of advanced Geophysical Technologies for sub-surface mapping and detection of metallic or non-metallic objects on or below the earth surface. Core markets include Mineral Exploration, Environmental Services and Engineering Services. Mineral Exploration Sector, G-tek provides high definition geophysics, using G-tek's patented technology Sub Audio Magnetics (SAM), this permits the simultaneous measurement of high definition magnetic, electromagnetic, electrical resistivity and induced polarization data. Key Benefits include; simultaneous multi dimensional data, high resolution, reduced interpretation time, increased confidence levels and the main key benefit is being able to reduce drilling expenditures. Environmental Services the core activity is the detection and mapping of sub-surface chemicals and metals, both military and industrial. G-tek is highly regarded internationally as world leader in its technology and provision of service in this specialty. Engineering Service market, we assist engineers with planning and costing of their projects. Projects that require our services include mine development, highway construction and other tasks that involve the knowledge of geological structure, geological hazard, and ground competency.

INTREPID GEOPHYSICS — STAND 15

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Intrepid Geophysics has 20 years experience in providing specialist services to the resource exploration and production industry, including consulting, software development and support services. Intrepid's premier products are: Intrepid (v3.7) - comprehensive suite of geophysical data processing

and interpretation software - specialising in magnetics, gravity, radiometrics and bathymetry data. Now with new gradient enhanced gridding! JetStream - powerful web-data-delivery, without data-loss! Full user control to select and download a subset, with re-projection, and delivery in standard file formats. Geological Modelling(3D-WEG) - Intrepid is collaborating with the BRGM to integrate geophysical processing solutions with the BRGM's innovative 3D geological modelling and potential field inversion software, 3D-WEG.

KELMAN TECHNOLOGIES INC. STAND 56

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Kelman Technologies Inc. (KTI) offers a full suite of seismic data processing and data management services through four offices: In Canada: Calgary, Alberta - Head Office, In the U.S.A.: Houston (Texas), Oklahoma City (Oklahoma) and Denver (Colorado). Seismic Processing Division: land and marine 2D and 3D seismic processing, OBC technology, applications R&D, depth / time / high-resolution imaging, Stretch-Free Stacking (SFS), anisotropy, Kirchhoff and Wave-Equation prestack depth migration. Data Management and Archives Division: 24-hour on-line data storage and retrieval services, data and database management, reconciliation and work flow management, data analysis and reformatting, workstation rentals, and mapping and graphic services. KT International Division: business services include: wholly owned KT International offices, Joint Ventures with other geophysical service providers, dedicated centres for National Oil Companies, R&D co-development projects, technology transfer and applications skills training.

LANDMARK STAND 78

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Leveraging on a standard E&P platform, Landmark designs, develops and deploys innovative and integrated technology systems that provide for all aspects of the upstream oil and gas industry while improving efficiency. From Rapid Prospect Generation to Production Optimization, Landmark's offerings are focused on key decision points in the oil and gas lifecycle, facilitating greater teamwork and enabling companies around the world to lower their finding, lifting and production costs, significantly reducing cycle times and boosting productivity and profitability. Landmark Graphics is division of Halliburton Energy Services, which provides products, services and integrated solutions for oil and gas exploration, development and production. Their capabilities range from initial evaluation of producing formations to drilling, completion, production enhancement and well maintenance.

MINERALS & ENERGY SA STANDS 79, 80

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The Minerals & Energy Division, Primary Industries & Resources South Australia facilitates mineral and petroleum exploration and development. The division is focused on increasing the prosperity of South Australians by ensuring responsible development of South Australia's mineral and petroleum resources within a sustainable framework. It provides geoscientific and specialist services as part of a process to acquire and update geological, geophysical and engineering data. The group is also responsible for industry regulation, legislative development and review, policy development and provision of advice. South Australia was recently ranked No.1 in the world (Fraser Report) in the Geoscientific databases category, with all explorers considering that our data encourages exploration investment. Many of these databases including geophysical data can be accessed and downloaded through the South Australian Resources Information Geoserver(SARIG) a world leader in online geoscientific data availability. No third party software is required, simply access SARIG through the website www.minerals.pir.sa.gov.au/sarig or visit the Minerals and Energy Division, PIRSA booth for a live demonstration.

MINERAL RESOURCES, NSW STAND 62

(formerly the NSW Department of Mineral Resources)

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Key Outcomes of the Geological Survey of New South Wales are a competitive position for New South Wales in attracting mineral and petroleum exploration and the creation of opportunities for investment to advance regional and State development; improved knowledge of the geology and mineral resources of the State; geoscience and resources information meets the Government and industry's needs for resource planning, development and utilization; increased petroleum exploration leading to the supply of competitively priced clean energy; informed and improved land-use decisions, leading to the protection of mineral resources; and, clients are satisfied with availability, quality, timeliness and delivery of geoscience and resource assessment information.

MIRA GEOSCIENCE LTD STAND 73

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Mira Geoscience offers software products and consulting services in 3D earth modelling. Our work is focused on applications of the Gocad 3D-GIS software suite, available to the global mining industry exclusively through Mira Geoscience. Gocad offers the most advanced modelling technology available today in the domains of 3D surface and volume modelling, 3D visualisation, geophysical forward modelling and inversion, geostatistics and resource estimation, risk modelling and uncertainty analysis, and multi-disciplinary decision support. Mira offers Gocad software sales, support, and training, the development and sale of Gocad modular plug-ins for mining applications, as well as interpretational consulting services from its offices in Canada and Australia.

MITCHAM INDUSTRIES STANDS 50, 51

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Mitcham Industries, Inc., a geophysical equipment supplier, offers for lease or sale, new and "experienced" seismic equipment to the oil and gas industry, seismic contractors, environmental agencies, government

agencies and universities. Headquartered in Texas, with sales and services offices in Calgary, Canada, Brisbane, Australia and associates throughout Europe, South America and Asia, Mitcham conducts operations on a global scale and is the largest independent exploration equipment lessor in the industry. SAP (Seismic Asia Pacific Ltd - a wholly owned subsidiary), headquartered in Brisbane, Australia, sells equipment, consumables, systems integration, engineering hardware and software maintenance support services to the seismic, hydrographic, oceanographic, environmental and defense industries throughout South East Asia and Australia. SAP is a manufacturers representative for an array of equipment lines. SAP also supplies and services hydrographic, and radio and satellite positioning equipment for government and private entities.

MULTIWAVE GEOPHYSICAL COMPANY — STANDS 61, 68

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Multiwave is a global, specialized and client focused upstream service company. Located with its Headquarter in Bergen, Norway. Multiwave Geophysical Company was set up in 1998 to develop and provide 4-component marine seismic data together with towed streamer techniques focusing on specific products to the marine E&P world. Today Multiwave is in operations world wide with a range of services, but still keeping focus on the main product; Multi-component Seabed Seismic. With our unique near seabed deployment system we are tackling the three main limiting factors normally associated with marine 4C acquisition; cost, depth capability and data quality. Our technology also provides the client with the possibility to perform 4D4C surveys at both deep and shallow water fields. Further our 4C technology also offers services for permanent installation of seabed sensor for reservoir monitoring. Since 2002 the company also took on the challenge to bring the unique new exploration tool, EM SBL, a new marine electromagnetic surveying technology proprietary owned by the Norwegian company EMGS AS. The company's aim is to provide risk reducing tools for exploration and reservoir monitoring, and to make the "electronic oilfield" concept an accessible reality world-wide. Multiwave is today established world wide with regional offices in London, Singapore and Houston.

NORTHERN TERRITORY GEOLOGICAL SURVEY — STAND 83

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The Northern Territory Geological Survey (NTGS) collects, interprets, synthesises and disseminates geoscientific data to attract and render more effective mineral and onshore petroleum exploration. NTGS undertakes regional geoscience programs, mineral resource assessments, metalliferous deposit studies, petroleum system studies, exploration reviews and extensive airborne geophysical surveys. This year the NTGS unveils its web mapping system, STRIKE

OUTER-RIM EXPLORATION SERVICES PTY LTD — STAND 16

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Outer-Rim Exploration Services has been servicing the EM needs of the exploration and mining industry in Australia and overseas for more than ten years. Our reputation is based on providing reliable, consistent and repeatable EM surveys, both surface and downhole, using the Crone PEM system. Over the years, ORE has concentrated on improving the equipment and service to the highest standard, leading the market in safety and data quality. Recently, Outer-Rim Development secured a licence agreement with the CSIRO to manufacture and market the exciting, state of the art, LANDTEM receiver. Using high temperature (HT) superconducting magnetic sensors (rF SQUIDs - Superconducting Quantum Interference Devices), it accurately measures magnetic (B) fields which are one hundred millionth smaller than the earth's magnetic field.

PESA — STAND 93

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The Petroleum Exploration Society of Australia (PESA) is a national organisation representing the interests of all professionals and practitioners in the upstream petroleum industry. Details of the Federal and Branch Committee members are located on the Committees Page. The purpose and objectives of the Society are as follows:-

- to promote professional and technical excellence in the upstream petroleum industry throughout Australia. This is fostered by providing forums to communicate technical innovations and lessons learnt to individuals on a national basis;
- to present views and facilitate discussion of technical and professional matters pertinent to the upstream petroleum industry;
- to foster and provide continuing education for the benefit of PESA members and students progressing towards a career choice;
- to nurture the spirit of research on matters pertinent to PESA members and their upstream petroleum industry colleagues; and
- to maintain a high standard of professional conduct on the part of its members.

The emphasis of the Society is primarily geoscientific although most aspects of the upstream industry are catered for.

The Society is governed by a Federal Executive with local Branches in Queensland, New South Wales, Victoria/Tasmania, the ACT, South Australia and Western Australia responsible for much of the organisation of technical and social events.

Activities

PESA's main activities are:

- Publication of the PESA News (a bi-monthly newsletter) and topical research in the PESA Journal (annual).
- Convening the most focused technical symposiums and conferences for petroleum E&P in Australia.
- Proceedings of PESA Basin Symposiums represent essential references for petroleum exploration and development in Australia.

Key upcoming events are:-

- EABS II - Sept. 19th-22nd, 2004
- Continuing education courses - to deliver cost-effective, world-class training to PESA members in all branches. A number are held every year on a wide range of geoscientific topics.
- Branch monthly luncheons and less frequent evening seminars with notable and topical speakers. These are commonly run in collaboration with key universities and cognate professional societies (such as SPE, SEG and AAPG).
- Annual report on significant activities and breakthroughs in Australian exploration which is presented at each APPEA Conference (PESA Industry Review) and published both by PESA and APPEA.

- Major annual farmout seminar covering acreage in Australasia/NZ at which companies can advertise, promote and gather information on farmouts.
- Local social functions for members and their guests including participation sports events and annual galas.

Support for the Future of Petroleum Exploration

- Education: PESA provides both scholarships and financial awards for deserving university geoscience students.
- PESA is the regional affiliate of the American Association of Petroleum Geologists (AAPG) - the peak international profession association for petroleum geoscience.
- PESA frequently collaborates with AAPG, APPEA, SPE, ASEG, universities and high school science teachers associations to deliver education to its members and future members.

PETROSYS PTY LTD — STANDS 86, 87

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Petrosys provides software that focuses on the creation of maps and the underlying management and analysis of geotechnical information. The software is widely applied in the petroleum exploration and production industry. Maps are the main way in which geoscientists and engineers synthesise knowledge from a variety of disciplines. Petrosys automates this process by providing powerful and user friendly links to a very wide range of more specialised third party systems and running in an open environment. Specific functions of the systems include presentation quality mapping, gridding and contouring, volumetrics, data management, analysis of interpreted seismic, and digitizing.

PGS AUSTRALIA PTY LTD — STANDS 37, 38

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Petroleum Geo-Services is a technologically focused oilfield service company covering the complete value chain from exploration, via field development to production. Our two primary business units are PGS Production Group and PGS Geophysical Group. In addition, PGS Reservoir Consultants provides reservoir expertise and exploits synergies across the product lines. The company employs approximately 5500 people and has offices and operations in more than 20 countries worldwide. Our revenues for 2001 were approximately 1 billion USD.

PROFESSIONAL INVESTMENT SERVICES PTY LTD — STAND 58

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Professional Investment Services Pty Ltd is one of Australia's largest Financial Planning organisations. It is a privately owned Australian company, holding Australian Financial Services Licence Number 234951. Specialist Expertise areas include:

- Wealth creation planning
- Debt management
- Do-it-yourself superannuation
- Corporate superannuation
- Mortgage broking & finance
- Personal insurances
- Tax planning strategies
- Securities & Derivatives

ROCK SOLID IMAGES — STAND 43

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Rock Solid Images is the industry leader in the application of rock-physics for integrating and calibrating seismic and borehole data to provide geologic insight and reservoir understanding at all stages of the oilfield lifecycle. Simply put, we help our customers drill better wells. Rock Solid Images is based in Houston, Texas and Oslo, Norway. We provide a broad range of integrated service products spanning detailed petrophysical and seismic model analysis on individual wells (MOSS), attribute-driven data-mining of large 3D seismic volumes (LITHANN) and detailed reservoir characterization using tightly integrated seismic and well data-sets. In addition to providing turn-key seismic reservoir studies, Rock Solid Images develops software for rock-physics modeling and seismic attribute calculation and classification via industry funded consortia.

SCHLUMBERGER OILFIELD SERVICES — STANDS 111, 112, 123, 124

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Schlumberger Limited (NYSE:SLB) is the leading oilfield services company supplying technology, project management and information solutions that optimize performance for customers working in the international oil and gas industry. The company comprises two primary business segments - Schlumberger Oilfield Services and WesternGeco. Reflecting our belief that diversity spurs creativity, collaboration, and understanding of customers' needs, we employ over 50,000 people of more than 140 nationalities working in 100 countries. Our principal offices are in New York, Paris and The Hague. Revenue in 2003 was $11.5 billion. We are committed to excellence in technical innovation, teamwork and creating value for our customers, our shareholders and our employees. At the wellsite, in our global connectivity centers and in our R&E facilities, we are working to optimize customer performance in a safe and environmentally sound manner.

SOFTWARE ADVANCED LOGIC TECHNOLOGY — STAND 55

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Advanced Logic Technology develops and delivers software and hardware products to the Geoscience industry since 1993. The company is known for its leading edge imaging probes and data logging system. WellCAD software combines excellent display, editing and analysis capabilities for

well log data. A number of add-on modules can be activated to meet user specific requirements. We continually invest in the development of new applications. At ASEG, we feature the ABI85 (acoustic televiewer for geothermal industry), the ABI40 casing inspection mode, a WellCAD module specialized for core description and well site geology.

SDI — STAND 88

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SDI develops graphics software products for GEO & CAD applications. Products include:- SDI Montage, SDI PrintMaster, CGM Editor, CGM Office, SDI Convert, SDI Print To File, CGM_LibV4, CGM Parse, SDI_DGN. Formats handled include:- CGM/CGM+/CGM*PIP, PostScript, PDF, HPGL, EMF, DXF/DWG, DGN, TIFF, JPEG & PNG. Platforms supported: Windows: NT, 2000, XP; Unix: SOLARIS, AIX, HP-UX, IRIX; LINUX: 7.x, 8.x, 9.x, Enterprise 2.x, 3.x. Headquartered in Houston, Texas with regional sales/support offices in London & Beijing, SDI has been specializing in Computer Graphics Metafile technology since 1988. As a technology driven company, SDI focuses its development efforts on utilities for graphic print processing, format conversion, publishing tools, and graphic development kits.

SEG — STAND 91

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SEG JAPAN/KOREAN SEG — STAND 90

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The Society of Exploration Geophysicists of Japan (SEGJ) was established in 1948 with the objectives to promote the science and technology of geophysical and geochemical exploration as well as to encourage mutual communication among the members. SEGJ publishes the official journal, holds the meetings, and leads other geophysical activities in Japan. Butsuri-Tansa (Geophysical Exploration) which is the official journal published bi-monthly contains original papers, lectures, reviews, news and announcements of the Society. In 2004, SEGJ, ASEG and Korean SEG (KESG) were jointly published their journals entitled "Geophysics in the Western Pacific Environment". The issue carries sixteen papers from three societies, and highly evaluated by the members of each societies. SEGJ holds domestic technical meetings twice a year in spring and fall. A meeting consists of approximately 80-100 oral presentations together with invited lectures and/or symposium. We also have international symposium every two years, and we will have the 7th international symposium at Sendai City in this November. More than one hundred presenter will come from twenty countries

SERCEL AUSTRALIA — STAND 24

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Sercel designs and manufactures advanced electronic systems and components for acquisition and positioning of geophysical 3-D surveys for the worldwide petroleum industry. Sercel Australia specialises in the design and manufacture of marine solid streamers and nodal based 4C systems.

SUPERSONIC GEOPHYSICAL LLC — STAND 114

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SuperSonic Geophysical processes all commercially available full wave acoustic logs; both wireline and LWD. Endorsed by practitioners and theoreticians worldwide, SuperSonic Geophysical provides high quality physics based processing in all of the world's major petroleum provinces on many of the world's most significant appraisal and discovery wells. A superior and independent alternative to service company processing, SuperSonic Geophysical provides the best quality sonic log processing available on the market at prices below service company prices. Turnaround is also superior to that of the service companies.

TENIX-LADS CORP — STAND 67

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Tenix LADS Corporation is the world leader in the provision of lidar hydrographic services. This emerging technology is ideally suited for collecting hydrographic data in areas where traditional acoustic methods are either inefficient or impossible. Shallow and complex areas can potentially be surveyed to a maximum depth of 70 meters. Tenix LADS Corporation produces digital survey data to clients using it's LADS MKII survey system. The Laser Airborne Depths Sounder (LADS) system uses state of the art laser technology mounted in a De Havilland Dash-8 aircraft to provide a worldwide contract survey service.

TOTAL DEPTH PTY LTD — STAND 120

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Total Depth is a Geophysical Consultancy, which has provided services within Australia and overseas since 1993. Our clientele include companies from the Petroleum and Minerals sector as well as those involved with R&D and software development. Our objective is to help address specific technical challenges using hybrid workflows created from existing and newly developed technology. The aim is to use these workflows to independently validate existing models and to help address elements of non-uniqueness. Our services typically involve aspects of attribute processing, analysis, interpretation and integration with geological data in time, depth or frequency domains.

UTS GEOPHYSICS — STANDS 35, 36

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UTS Geophysics is a 100% Australian owned airborne geophysical survey company. UTS Geophysics has been successful in the development of many new airborne geophysical techniques and has acquired and processed more than 3.0 million line kilometres of ultra-high resolution airborne geophysical data in Australia and around the world since founding in 1991. UTS Geophysics currently offers the following services:

- fixed wing magnetics and radiometrics and fixed-wing gravity using specialised low level aircraft;
- helicopter magnetics and radiometrics and frequency domain electromagnetics; and
- high quality data processing, enhancement, mapping, imaging and presentation.

Currently UTS Geophysics acquire and process more than 500,000 line-kms of airborne geophysical data, with surveys ranging from regional (400m line spacing, 80m height) to ultra-detailed surveys pioneered by UTS Geophysics (from 10m line spacing and 10m height). UTS Geophysics survey experience encompasses a range of geographic terrain from flat desert country, to rugged mountainous and inaccessible regions.

VELSEIS PTY LTD — STANDS 34, 47

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Velseis Pty Ltd has built a reputation as the leading Australian seismic contractor, providing integrated expertise in survey design, drilling, acquisition, processing and interpretation. Velseis provides dynamite, Mini-SOSIE, Vibroseis and airgun sources, conventional 3D and 2D crews, as well as portable, helicopter, shallow marine, and multi-component recording. In 2001 Velseis established Seisdrill to ensure efficient scheduling of shothole drilling for dynamite surveys. Velseis provides extensive experience in processing and interpretation of high-resolution seismic data, and has a growing oil and gas processing division. Velseis maintains its competitiveness with a proactive commitment to research and development. The extensive experience of Velseis' key personnel ensures reliable and technically-innovative solutions tailored to meet the needs of individual clients.

VERARI SYSTEMS — STAND 20

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Verari Systems, previously RackSaver Inc., is the premier developer of powerful, flexible, and scalable platform-independent systems that are defining a new era in high performance utility computing. Enterprises such as Boeing, ConocoPhillips, Industrial Light and Magic, Lockheed Martin, Microsoft, Motorola, NASA, NVIDIA, Northrop Grumman, Novartis, Pixar, and Shell, as well as top universities and research institutions worldwide, are among the 4000+ customers who have chosen Verari Systems' line of high-density blade server clusters, rack-optimized servers and high-performance technical workstations.

ZONGE ENGINEERING & RESEARCH ORGANISATION — STANDS 4, 5

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Zonge Engineering and Research Organization specialise in manufacturing and providing field services for all aspects of electrical and electromagnetic geophysics. Applications include:

- Minerals exploration
- Subsurface structural mapping
- Environmental studies
- Engineering surveys
- Salinity mapping
- Groundwater mapping

For these we offer a comprehensive service including:

- survey design
- data collection
- processing
- consulting
- interpretation

All Zonge manufactured equipment is available for sale or rent, and can be used for

- IP techniques
- CSAMT
- TEM
- NanoTEM
- Downhole MMR, TEM and IP.

PREVIEW

SECTION 3

ASEG's 17th International Conference and Exhibition

Welcome to ASEG's 17th International Conference and Exhibition, particularly our overseas visitors. This meeting makes a major contribution to Australia's resource industries by providing a showcase for the latest geophysical techniques that are now available to achieve more effective exploration.

The impact of geophysics on mineral and petroleum exploration, as well as on land management and land degradation issues is continuing to increase. The mineral and petroleum industries are the main export earners for Australia; minerals and energy underpin our wealth. In 2002/2003 for example we earned $55 billion, comparable to the combined exports from the farming and the manufacturing sectors.

Exploration is the lifeblood of the resource industries; without exploration they cannot be sustained. Furthermore, as the easier-to-find ore bodies and petroleum reservoirs are developed, we need more sophisticated methods to find the prizes hidden within the earth, either beneath the land or the sea. The search is getting harder and as exploration geophysicists we have to meet the challenges.

In recent years exploration geophysics techniques have also been applied to environmental problems such as land degradation, dry land salinity and groundwater resources. In fact this area of the geosciences has been a growth sector in the last few years and there are five sessions covering these topics at this meeting to reflect this situation. There are also sessions on engineering geophysics and hazard assessment programs, which are also using the techniques developed to find new resources.

We are fortunate that geophysics can be applied to many of the socioeconomic problems facing humankind today. It therefore behoves us, as practising geophysicists, to use our skills and knowledge to tackle these issues, and more importantly to make sure that the key decision makers are aware that these capabilities are available.

It is crucial that the light is not hidden under the bushel, particularly to our political masters. Politicians are usually on the look-out for new ideas and attractive policies, so we have much to offer and we should put a little time into trying to make a difference. We may feel that the outcomes from the Minerals Exploration Action Agenda are disappointing but we shouldn't give up. We now have access to government and we should 'maintain the rage'.

We also have an obligation to enhance the importance of the geosciences so that the teaching facilities at schools and tertiary institutions are appropriately developed. Without good teachers and curricula in the schools, the source of quality geoscientists will dry up and the effectiveness of our industries and our profession will be threatened.

The conference organisers have recognized this issue, and as part of the broader promotion of geophysics the now-traditional Student Day is being complemented by an evening reception for all postgraduate students attending the Conference. These events will offer opportunities to promote our exciting profession; we must all aim to participate.

This issue of Preview focuses on the Conference and Exhibition. During the few days we will be in Sydney, I will be searching the exhibition and the lecture rooms for future contributors who can provide articles of general interest to our members, particularly case histories or review papers. If anyone can contribute, or can identify someone else who can, please let me know.

Enjoy Sydney, and make your visit worthwhile.

David Denham

Aims and Scope

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

Contents

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Contributions

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

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

References

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

Blackburn, G. J., 1981, Seismic static corrections in irregular or steeply dipping water-bottom environments: Explor. Geophys., **12**, 93–100.

Abbreviations and units

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

Deadlines

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

Advertisers

Please contact Con Giannas **(con@resolutions group.com.au)** at RESolutions Resource and Energy Services, for advertising rates and information. The ASEG reserves the right to reject advertising, which is not in keeping with its publication standards.

Advertising copy deadline is the 22nd of the month prior to issue date. Therefore, the advertising copy deadline for the **October 2004 issue will be 15 September 2004**. A summary of the deadlines is shown below:

Preview Issue	Text & articles	Advertisements
112 Oct 2004	***15 Sep 2004***	***22 Sep 2004***
113 Dec 2004	15 Nov 2004	22 Nov 2004
114 Feb 2005	15 Jan 2005	22 Jan 2005
115 Apr 2005	15 Mar 2005	22 Mar 2005

New Members

The ASEG welcomes the following new members to the Society. Their membership was approved at the Federal Executive Meetings on 26 May and 30 June 2004.

Name	Organisation	State
Bradley T. Bailey	Macquarie University	NSW
Karl Heinz Bauer	BHP Petroleum	WA
Matthew Cain Gray	Geoscience Australia	ACT
Daniel Peter Howes	Curtin University	WA
David Lacey	University of Sydney	NSW
Mark Allan McLean	Melbourne University	Vic
Richard T Osmond	Anglo American	Canada
Claire Robertson	Geoscience Australia	ACT
Malcolm Sambridge	ANU	ACT
Patrick A. Tyrrell	University of NSW	NSW
Brian S. Williams	Anglo American Exploration	UK

Print Post Approved – PP3272687 / 0052.

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

Calendar of Events

Melbourne 2006

In 2006 the 18th ASEG International Conference and Exhibition will be held in conjunction with the Geological Society of Australia's 18th Australian Geological Convention. The joint event is named:

The Australian Earth Sciences Convention 2006

(AESC2006) and will held in Melbourne on July 2-7 2006 at the Melbourne Convention Centre.

The AESC2006 will combine the major elements from GSA and ASEG conferences including scientific and technical sessions, trade exhibition, workshops and excursions, and social events.

For more information and to register your interest in the AESC2006 please visit the website: ***www.earth2006.org***

or contact the Conference Office:

The Meeting Planners
91-97 Islington St
Collingwood, Vic., 3066
Tel +61 3 9417 0888
Fax +61 3 9417 0899
Email earth2006@meetingplanners.com.au

See you in Melbourne!

Suzanne Haydon and Peter Pritchard

AESC2006 Co-Chairs

2004

September 19-22
PESA Eastern Australasian Basins Symposium
Venue: Adelaide Convention Centre, Adelaide
Website: www.eabs.info
and
Pacrim 2004
Theme: Hi Tech and World Competitive – Mineral Success Stories Around the Pacific Rim
Venue: Adelaide Convention Centre, Adelaide
Website: www.ausimm.com/pacrim2004
Note, both the above events will take place at the same time at the same venue.

September 27 - October 1
SEG 2004
Theme: Predictive Mineral Discovery under Cover
Sponsored by: Society of Economic Geologists, Society of Geology Applied to Mineral Deposits and Geoconferences (WA) Inc.
Venue: Perth, WA
Website: http://www.cgm.uwa.edu.au/geoconferences/seg2004/index.asp

October 10-15
SEG International Exposition & 74th Annual Meeting
Venue: Denver, Colorado, USA
Website: www.seg.org

November 22-23
Theme: Orebody Modelling and Strategic Mine Planning Uncertainty and Risk Management
Sponsored by: AusIMM
Venue: Hyatt Regency, Perth, WA
Website: http://www.ausimm.com/ommp2004/home.html
Email: conference@ausimm.com.au

24-26 November
7th SEGJ International Symposium - Imaging Technology
Theme: Interdisciplinary integration of the geosciences for better understanding and Modelling
Venue: Sendai, Japan
Sponsors: SEG Japan, SEG, Australian SEG, EAGE, Korean SEG, EEGS
Website: http://www.segj.org/is7/

13-17 December
2004 AGU Fall Meeting
Venue: San Francisco, California, USA
Website: www.agu.org/meetings

2005

January 31 - February 4
The 16th Biennial Congress of the Australian Institute of Physics
Theme: Physics for the Nation
Venue: The Australian National University, Canberra ACT, Australia
Website: http://aipcongress2005.anu.edu.au/

2005

April 4-7
SAGEEP
Atlanta Airport Hilton Hotel, Atlanta, USA

April 10-13
2005 APPEA Conference & Exhibition
Venue: Perth, WA (at the new Convention Centre facility)
Contact: Julie Hood
Email: jhood@appea.com.au

May 23-27
2005 AGU Joint Assembly
Venue: New Orleans, Louisiana, USA
Website: www.agu.org

June 13-16
67th EAGE Conference & Exhibition
Venue: Madrid, Spain
Website: http://www.eage.nl/conferences/

August 16-17
Central Australian Basins Symposium (CABS) 2005
Theme: Minerals and petroleum potential
Venue: Alice Springs (details TBA)
Contact: Greg Ambrose, Northern Territory Geological Survey
Email: greg.ambrose@nt.gov.au

September 19-23
22nd International Geochemical Exploration Symposium
Sponsors: The Association of Exploration Geochemists
Theme: From Tropics to Tundra
Venue: Sheraton Hotel, Perth, WA
Website: www.promaco.com.au/conference/2005/iges

November 6-11
SEG International Exposition & 75th Annual Meeting
Venue: Houston, Texas, USA
Website: www.seg.org

December 5-9
2005 AGU Fall Meeting
Venue: San Francisco, California, USA
Website: www.agu.org/meetings

2006

July 2-7
- The Australian Earth Sciences Convention 2006
- ASEG, in collaboration with GSA
- ASEG's 18th International Conference and Exhibition,

and

- GSA's 18th Australian Geological Convention

Venue: Melbourne, Vic.
Website: www.earth2006.org

Published for ASEG by:

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[1] *Members and chairpeople of ASEG's Standing and ad hoc Committees can be found on the ASEG website:* **www.aseg.org.au**

By Lisa Vella and Koya Suto

ASEG - SEGJ - KSEG Joint Publication

By now, many of you will have had the opportunity to peruse the recent volume of Exploration Geophysics (Vol. 35, no. 1), which represents our first joint publication with the geophysical societies of Japan and Korea, the SEGJ and the KSEG, respectively. Accompanying this joint publication was a questionnaire, seeking the opinions of the membership, regarding the publication and whether or not we should participate in joint issues in the future (see below). This was organised by Koya Suto (ASEG), Toshiyuki Yokota (SEGJ) & Yoonho Song (KSEG) and all the responses and comments in full are posted in the ASEG website:

http://www.aseg.org.au/forms/Joint-Journal_Questionnaire_ Result.pdf

Almost unanimously, people felt that the joint publication was a good idea and that our societies and members benefit from such joint activities. Members were asked to consider if some of the benefits were, for example, related to improving the status of the societies in the world community, or having papers by our authors reaching a wider audience. Approximately half of the questionnaire respondents agreed that these were some of the benefits, in addition to the advantage of good will between neighbours.

Other benefits suggested by members include improving research strengths between countries, learning of the work of others (knowledge transfer) and expanding the range of topics covered by Exploration Geophysics.

In summary, the comments of the questionnaire respondents were overwhelmingly positive, with the majority wanting to see future joint publications, preferably on an annual basis.

Results of the Questionnaire

	Question	Choices	ASEG	SEGJ	KSEG	Total
A	Do you like the idea of joint issue?	1 Good idea	34	83	36	153
		2 Not good	0	3	0	3
		3 Don't care	2	9	0	11
B	Do you think our society benefits from the joint issue?	1 Yes	31	86	35	152
		2 No	1	3	1	5
		3 Don't care	2	7	0	9
C	What do you think the benefit of this joint-issue to our society?	1 We can improve its status in the world community	20	49	9	78
		2 Papers by our authors will reach more readers	11	59	14	84
		3 Good will to the neighbours	10	64	19	93
		4 Advertisements spread wider abroad	3	8	1	12
		5 Other	5	3	0	8
D	Do you think our members benefit from the joint issue?	1 Yes	32	74	35	141
		2 No	2	3	1	6
		3 Don't care	2	12	0	21
E	Do you want to see joint-issues again?	1 Yes	34	78	36	148
		How often?				
		(a) more often than annual	11	5	11	27
		(b) once a year	16	62	16	94
		(c) once every 2 years	6	19	9	32
		(d) less often	1	1	0	2
		2 No	0	4	0	4
		3 Don't care	1	8	0	9
	Number of Responses		36	96	36	168

"Other" in Question C ASEG

- Improves research strengths between countries
- Establishes Exploration Geophysics as the main journal in the Asia-Pacific region, with the inherent feedback response to ASEG
- We learn of the work of others. "Urban" geophysics is the growing importance
- We see good papers from other societies
- Knowledge transfer
- Non-resource applications

The Road to Discovery, or how to encourage mineral exploration without new money

The Road to Discovery, which was launched by Ian Macfarlane the Minister for Industry, Tourism and Resources on 2 July 2004, is the Government's response to the Mineral Exploration Action Agenda (MEAA) and the House of Representatives (Prosser) Inquiry. Both these studies were asked to develop strategies to encourage resource exploration. Clearly, without an effective and efficient exploration industry, there will be fewer resources discovered and Australia's economy will suffer accordingly.

The MEAA and the Prosser Inquiry produced a total of 40 excellent recommendations on ways to make resource exploration more innovation and effective. These recommendations cover four main areas: ***Access to Land, Financial Incentives, Geoscience Information, and Human and Intellectual Capital***.

Unfortunately, in the 2004 Budget the only new money was the ~$5 million/year to provide a 150% tax deduction for offshore petroleum exploration in frontier areas. No additional money was provided for any onshore exploration, either for minerals or petroleum. I understand that the Commonwealth was reluctant to provide any new money for onshore actions, in spite of the national importance of the wealth generated by the resource industries, because of the States' responsibilities for land and mining in the Constitution. .

Consequently ***The Road to Discovery*** is a somewhat toothless tiger. For example, the first action in the ***Finance*** strategy is: "The Australian Government to consider taxation options that support and facilitate industry efforts to raise capital for minerals and petroleum exploration".

One would have hoped that this could have been done in the context of the 2004 Budget, because several options had been outlined in the initial reports, which were tabled in mid-2003, rather than drag the issue out for at least another year. So it really is almost back to square one.

Because of the absence of any new money, the ***Land Access*** strategy looks likely to be the most effective. Meetings and workshops can usually be carried out under existing departmental core budgets and the payoffs for improving the present system could very large indeed.

The aim here is to resolve impediments to land access by developing protocols covering mineral tenure, native title, heritage, environment and conservation estate. In particular to:

- Amend the Aboriginal Land Rights (Northern Territory) Act 1976;
- Provide increased awareness of the expedited procedure provisions under the 1993 Native Title Act;
- Facilitate the development of regional agreements; and
- Improve community engagement to promote community acceptance of the mining industry.

Details of the ***Pre-competitive Geoscience*** strategy, which will be of interest to most members, are listed below.

Goal: To encourage exploration investment and cost-effective recovery through improved pre-competitive geoscience information available under nation-wide protocols, standards and systems

ACTIONS	WHO
(a) *Governments to consider a major pre-competitive geoscience survey program to achieve national coverage of basic geoscience datasets to modern standards*	
• Obtain in-principle agreement to undertake a four year collaborative program of geophysical data acquisition	Ministerial Council on Mineral and Petroleum Resources (MCMPR)
• Consult with State/NT Geological Survey agencies on current geoscientific gaps and priority needs to identify target areas for data collection	GA and States/NT Geological Surveys
• Develop a four year program of geoscience data acquisition, on a cooperative basis between the governments	GA and States/NT Geosurveys, with overall program endorsed by MCMPR
• Subject to funding negotiate purchase of geophysical datasets; call tenders for geoscience survey program	GA and State agencies

ACTIONS	WHO
• Annual review of 2003/04 program and endorsement of next year's program.	GA and Chief Government Geologists Committee in consultation with industry
(b) *Governments in consultation with industry, to develop and implement nation-wide protocols, standards and systems that provide internet -based access to, and effective storage and archiving of geoscience datasets and industry-generated exploration data*	
• Development of on-line delivery of GA and agreed State/NT Geophysical data	GA and commercial software company
• Endorse and adopt standards for company exploration data submitted to Mines Departments	GA in partnership with State/NT Geosurveys through Chief Government
• Develop and endorse a 2 year plan to upgrade and expand the GA Portal to include new on-line datasets	Geologists Committee, in consultation with industry
• Implement web-based services for on-line access	Chief Government Geologists
• Develop and endorse plan for implementation of an Australian earth science grid.	Committee in consultation with CSIRO, universities and industry

However, as far as the Commonwealth is concerned no new money has been provided to Geoscience Australia to increase the Commonwealth commitment in this work.

In the fourth area, ***Human and Intellectual Capital***, the goal is to maintain, cooperatively, an appropriate skills base and adequate public and private research and development to ensure that innovation continues to drive minerals exploration in Australia. However, all the actions are to be carried out under the current Backing Australia's Ability and Backing Australia's Future programs. Perhaps the best action in this area is a commitment by the Government to consider reclassifying earth sciences into a higher cluster in the context of Government contributions for university courses. This would be a very good outcome if it can be achieved.

The Minister has appointed a very strong implementation team. It comprises an industry-led group, led by John Dow, Newmont Managing Director, and assisted by:

- Mitch Hooke – Chief Executive of the Minerals Council of Australia;
- Tim Shanahan – CEO of the Chamber of Minerals and Energy of WA Inc;
- Ian Gould – President of the AusIMM;
- John Hartwell – Head of Resources Division, Dept. of Industry – Tourism and Resources;
- Neil Williams – CEO Geoscience Australia;
- Jim Limerick – Director General, WA Dept. of Industry and Resources; and
- Malcolm Cremer – Deputy Director General, Qld. Dept. of Natural Resources & Mines.

Surprisingly, at the time of writing, the Shadow Minister for Mining, Energy and Forestry, Joel Fitzgibbon, has not issued any comments on the report or the actions planned. The report can be accessed from the following website: http://www.industry.gov.au/assets/documents/itrinternet/Road_to_Discovery20040702155050.pdf?CFID=1391649&CFTOKEN=87789984.

Prime Minister launches Energy White Paper

In contrast to the minimal response to the Minerals Exploration Action Agenda, the Energy White Paper (Securing Australia's Energy Future), launched by the Prime Minister in June raised hackles in State Governments and the Opposition Parties in the Parliament. There is not space to fully discuss the report here. It can be accessed from the following website: http://www.dpmc.gov.au/energy_future/.

Energy is clearly a very important issue. Australia relies heavily on cheap energy and we spend ~$50 billion/year on energy. In the White Paper it is expected that demand will grow by 50 percent by 2020. What that will do to our

greenhouse gas emissions is not assessed. We already produce 28 tonnes of greenhouse gas each year per person, compared to 21 tonnes for the average American (figures from CSIRO).

In terms of exploration perhaps the main change will be fuel excise reform. Starting in 2006 and concluding in 2015 the fuel excise system will be modernised and simplified. The net result is that all fuels used for off road business purposes will become effectively excise free. In other words exploration on the ground should be cheaper.

There are no new initiatives to specifically encourage petroleum exploration. The ~$5 million/year to provide a 150% tax deduction for offshore petroleum exploration in frontier areas, and the additional funding provided to Geoscience Australia in the 2003 Budget to undertake seismic surveys offshore and preserve some of the old seismic tapes have been listed as though they are new actions. In fact these programs were funded well before the White Paper was written.

It is best for members read the paper to make up their own mind, but it seems to me that not enough emphasis has been put on improving energy efficiency. I believe that if governments are serious about issues then they will legislate appropriately. However, when the only encouragement to buy more fuel efficient cars is a commitment to producing a "Green Vehicles Guide" and making it widely available, one has to wonder.

Peter Høj new CEO of Australian Research Council

Minister Nelson has announced the appointment of Peter Høj to the position of Chief Executive Officer (CEO) at the Australian Research Council (ARC). Professor Høj will start a five year term from 1 October 2004. He takes over from Vicki Sara who retired earlier this year.

Peter Høj was educated at the University of Copenhagen majoring in Biochemistry and Chemistry. He has an MSc in biochemistry and genetics and a PhD in photosynthesis. Professor Høj has received fellowships from Denmark and Australia for post-doctoral studies in biochemistry at La Trobe University and Professor of Viticultural Science and Oenology at the University of Adelaide. In 1992 he was awarded the Boehringer-Mannheim medal by the Australian Society for Biochemistry and Molecular Biology.

Since becoming Managing Director of the Australian Wine Research Institute in 1997 he has implemented a cross-disciplinary approach to strategic research and development. The success of the Institute was recognised by an Australian Wine Industry Award in 2002.

He has extensive experience as a member of various science and research committees, including the Steering Committee for the McGauchie Review in 2003 on collaboration between universities and publicly funded research agencies and the Prime Minister's Science, Engineering and Innovation Council.

New South Wales – by Naomi Osman

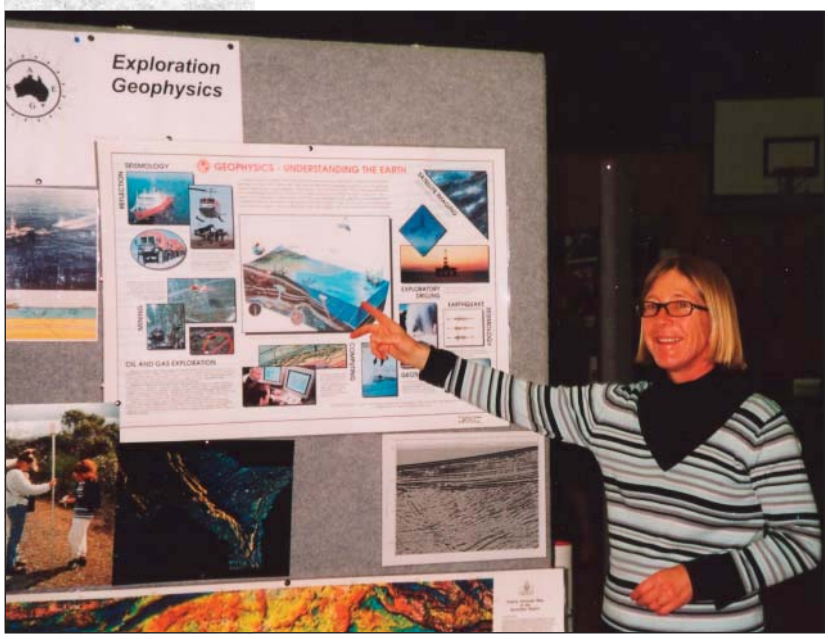
At our May meeting, Derecke Palmer (UNSW) gave an update on 3D shallow, seismic refraction methods with the talk drawing on results from recent test surveys over faulted terrain in the central west of NSW. Derecke left us pondering why resources similar to that invested in detailed 3D reflection surveys have not been applied to refraction work. Accordingly what our earnest speaker suggested was that 3D seismic refraction required significant and innovative development to re-establish it as a preferred method in the tool kit of today's geoscientists. In June, Phil Schmidt and Keith Leslie, (CSIRO Industrial Physics) presented new developments in magnetic tensor gradiometry. The "GETMAG" project has significant potential as an innovative magnetic exploration technique. CSIRO are aiming to have an airborne prototype ready for testing by the years end.

Abstracts for these and other prior presentations are available on our Branch's website. The NSW Branch generally holds meetings on the third Wednesday of each month at the Rugby Club – Rugby Place, near Pitt and Alfred Streets, Sydney, starting at around 5:30 pm.

In other news, the Branch is providing financial support to a number of student members to attend the ASEG-PESA conference, in August. It is hoped that attendance at the conference will assist these students in their study, research interests and future career development. Finally, the ASEG NSW Branch is planning to run a hands-on display with a geophysical theme at GeoFest 2004. GeoFest is an event run during Earth Science Week (Oct. 17–22) focusing on the earth, atmosphere and oceans of the planet and provides school students with the opportunity to interact with Geoscientists and their work.

Western Australia – Anita Heath

The ASEG WA has set up a careers information booth in conjunction with Curtin University Geophysics Department. The aim is to promote geophysics to high school students. The booth was at All Saints College careers night in July followed by a Careers Expo at Burswood in August. The display has been popular with students and contains a number of "toys", thanks to Domenic Howman, including various magnets, ore samples, geophone plus oscilloscope and posters. Environmental geophysics posters were provided by Greg Street.



Anita Heath enthusing over a career in geophysics at the WA Branch Geophysics Roadshow during the Careers Night at All Saints College.

Winter has been a time for technical workshops. SEG Spring Distinguished lecturer, Bill Abriel was present at a July workshop entitled *Risk Assessment in prospect Evaluation from a Geophysical Perspective*. We are now looking forward to the SEG/EAGE Distinguished Instructor Short Course: *Petroleum Systems of Deep Water Settings*, by Dr. Paul Weimer, to be held in Perth on 17th August 2004.

The Branch held a very successful winter social night at the Trots in July and are making it a regular annual event. Technical meetings are now held monthly at the Irish Club in Subiaco. The Society acknowledges Intrepid and Downunder Geosolutions for sponsoring recent meetings. Andrew Duncan is presenting his findings on DHEM in August and an Environmental theme is planned for September.

South Australia – Graham Heinson

The SA Branch of the ASEG hosted a technical meeting on 16th June entitled *Hot Rock Geothermal Exploration in Australia: all it's cracked up to be?* by Richard Hillis of the University of Adelaide. Over 45 people attended the talk at the Duke of York Hotel, at which Richard presented some of the exciting new developments in hot rock geothermal resources in South Australia.

By the time of publication of this edition of Preview, the ASEG SA Branch will have been involved with two lunchtime talks. On 21st July, we host the SEG 2004 Spring Distinguished Lecture by William L. Abriel on *Earth Model Complexity and Risk Description in Resource Exploration and Development*. The meeting will be held at a new venue for the SA Branch, the recently renovated Medina Grand Treasury Adelaide. The following week, on 29th July, PESA and ASEG co-host the ESSO Distinguished Lecturer Presentation on *Recent Advances in Deepwater Sequence Stratigraphy and Reservoir Prediction* by Stephen Flint of the University of Liverpool, at the Mercure Grosvenor Hotel. Finally, the SA ASEG Committee, sponsors and friends tasted over fifty wines on Friday 16th July to choose the best white and red for the annual ASEG Wine Offer. The event was held at the Jerusalem Sheshkabab House, an Adelaide institution for fine Lebanese food along Hindley Street. We thank the owners of the Jerusalem Sheshkabab restaurant for their kind hospitality and Selina Donnelley of Santos and Emma Nelson of the Australian School of Petroleum for organising the event.

Victoria – Jim Cull and Ashley Grant

Members of the Victorian Branch have commenced planning for the 2006 National Conference. There have been extensive discussions with GSA and PESA concerning the options and formats available for collaboration. In view of competition for sponsors and shortages of suitable

Continued on page 12

James Creswell Dooley AM, 1919 - 2004

James Creswell Dooley AM died of cancer on 26 May 2004. The citation for his Order of Australia says "For services to the science of geophysics and to the Bureau of Mineral Resources, Geology and Geophysics." This was a truly prestigious award. Many people thought it well deserved, although Jim was fairly modest about it. He seemed more proud when his wife and soul mate Nanette was also awarded the Order of Australia several years later.

Why was such a self effacing person given such a significant award, and why for services to a science and to the organisation he served most of his working life? The answer is that for Jim, geophysics and the BMR were synonymous. BMR brought geophysics to Australia, and Jim played a big role in making it happen.

Jim was one of seven children born in Melbourne on 30 January 1919 to Norval and Olive Dooley. We have a vision of Jim growing up in a large, caring and supportive family. Jim won a scholarship to Wesley College, and then went on to study Physics at The Melbourne University, where he lived at Queen's College. After graduating, and armed with a Masters Degree, Jim headed for Mt Stromlo. Australia was at war, and he worked on the war effort developing optics systems. Physicists were exempt from military service, but somehow Jim managed to join up and go to New Guinea where he served in the Anti-aircraft Division. When the army discovered he was a physicist he was packed up and sent back to Australia.

By 1944, the government was starting to look beyond the end of hostilities to post war reconstruction. Australia's mining industry was in a mess. Australia had just fought a war without any notion of its inventory of strategic minerals. The Mineral Resources Survey was established, and Jim joined it. One of his earliest tasks was to look for uranium. Soon after, he was looking for asbestos in South Australia, and then working on delineating the limits of coal at Collie in Western Australia. In 1946, the Bureau of Mineral Resources Geology and Geophysics (BMR) was formed. It subsumed the Mineral Resources Survey, and Jim became a founding member of the BMR.

Jim met Nanette during the wedding preparations for her friend Molly's wedding to Jim's brother David. Jim and Nanette were married in 1949, and were inseparable for fifty-five years. After they were married, they moved into and renovated an old hotel for gold miners on a bend in the Yarra River in Warrandyte. They were probably the original hobby farmers, with fruit trees, a goat and a growing family. Jim and Nanette spoke lovingly of this time in their lives. Nanette immersed herself in the local community. There was music in the house, cubs and brownies to attend, and the local church. They learned the value of a close knit, loving community. They were transferred to Canberra in 1965, where they resumed their work with their local community, with Jim active in Legacy. Both he and Nanette were accomplished pianists. Jim played organ at their local church, and Nanette played piano at the local pre-schools.

Jim's career was remarkably multidisciplinary considering the depth to which he studied each topic. In 1951 he led the first seismic reflection survey for oil and gas in Australia in the Roma area of Queensland. It was such a technical success that another was conducted soon afterwards in the Carnarvon Basin. The further success of that survey led to the acceptance of seismic reflection as a cost effective tool in the petroleum industry in Australia. In those days Jim and his peers weren't just being geophysicists. They were helping to invent the science of modern geophysics as they went along. Half the time they had to build the instruments before they began their field work.

Between 1954 and 1957 Jim led several successful gravity surveys, on the islands of the Barrier Reef, and using a gravity meter in a pressure vessel lowered to the bottom of Port Philip Bay. The success of these surveys, and of a gravity survey of the South West Pacific using a submarine, generated confidence in the BMR to begin routine studies of the continental margins of offshore Australia. These first tentative steps ultimately established Geoscience Australia, the organisation that grew from the BMR, as the lead scientific agency in mapping the boundaries of Australia's marine jurisdiction to support Australia's claim under the UN Convention on the Law of the Sea.

In 1956 Jim selected the site for the Port Moresby Geophysical Observatory, which was designed as a seismological, magnetic and ionospheric observatory. In the 1960s he moved on to seismic refraction imaging of the crust. He was part of a program using explosions at sea and

Continued on page 12

Jim Dooley, Armistice Day, 1970

Continued from page 11

recorded on seismographs deployed on land to find out the structure of the crust in Australia. Acronyms like BUMP, for Bass Straight Upper Mantle Project, CRUMP (Carpentaria Region Upper Mantle Project) and FRUMP (Fremantle Upper Mantle Project) started to appear in the literature. Jim liked acronyms. His 94 publications are testimony to research into radiometrics, gravity, magnetics and geomagnetism, seismic refraction and seismic reflection. He worked on asbestos, uranium, coal, oil and gas. He worked at the scale of coal beds, sedimentary basins, the Earth's crust and the mantle. For Jim, geophysics was geophysics, and so long as one was comfortable with the basic disciplines of physics, mathematics, and a bit of geology, there was nothing a good geophysicist couldn't do if he put his mind to it. He instilled this belief in those who worked with him.

Jim retired from the BMR in 1983. Afterwards he lectured for a year at the University of Queensland, and then at the University of Papua New Guinea. He was an Honorary Member of the Australian Society of Exploration Geophysicists. Apart from his contribution to the science of geophysics, Jim had served the society in various capacities, including as Associate Editor and then Guest Editor of Exploration Geophysics. He joined the ASEG in 1971 and was awarded Honorary Membership in 1983. He was founding editor of the newsletter of the Specialist Group on Solid Earth Geophysics in the Geological Society of Australia. He was also a member of the Australian Institute of Physics, the Society of Exploration Geophysics, and the American Geophysical Union. He was still reading his journals two weeks before he died.

Jim's work helped lay the foundations for mapping out Australia's boundaries and natural resources. For example, Australia is the first continent to be covered by seamless geophysical datasets. It took 50 years to do the first pass. Jim always gave credit to those who did the work and finished the job. But younger generations can't finish a job that takes 50 years unless someone else starts it. By showing that the job could be done, people like Jim Dooley, with his scientific brilliance, gave the early visionaries the confidence to begin the job.

Jim outlived Nanette by only two months. They are survived by their five children and eight grandchildren. They were two wonderfully genuine and caring people who gave so much of themselves and in doing so enriched the lives of many.

Barry Drummond

Jim Dooley's scientific journals looking for homes

Ted Lilley (ted.lilley@anu.edu.au) is helping the Dooley family find good homes for Jim's journals on a gratis basis. Jim held comprehensive sets of many geoscience journals. About a third of the holdings are listed below and Ted has the complete list.

While in the first instance it is hoped that the long runs will not be broken up, interest in individual copies etc. is also welcome. Expressions of interest can be lodged without delay, and at any rate before mid-September 2004.

Jim Dooley; Part Holdings, July 2004

1. Geophysics, vol.18, 1953 – 2004
2. ASEG Bulletin, vol.1, 1970 – 1983 became Exploration Geophysics, vol.15, 1984 – 2004
3. Preview, 1988 – 2004
4. Leading Edge (SEG Newsletter), vol.1, 1982 – 2004
5. Reviews of Geophysics and Space Physics – became Reviews of Geophysics, vol.1, 1963 – 2004
6. EOS magazine extensive holdings, ~1957 – 2004
7. Journal of the Geological Society of Australia, vol. 17, 1970 – 1983, Australian Journal of Earth Sciences, vol. 31, 1984 – 2004
8. Geophysics Down Under, SGSEG Newsletter (GSA) vol. 1, 1985 – 2004

Continued from page 10

venues close to the period of the Commonwealth games the Federal Executive have now approved a joint conference with the GSA. Members of PESA have agreed to assist with organisation but in view of the potential for overlap with subsequent symposia in WA will not participate in a JV for Melbourne. A joint COC has been formed with Suzanne Haydon as ASEG Conference Co-Chair.

As part of the general discussion on conference planning several broader issues were raised in relation to potential mergers or collaboration between professional societies. GSA is currently considering similar issues.

In view of the workloads associated with conference planning there have been few opportunities to arrange local technical meetings. One exception was the presentation of the 3D-WEG Geological Modelling Workshop applied to the geology of Broken Hill. This event was arranged by Phil McInerney with assistance from Patrick Ledru and Antonio Guillen (BRGM); the results indicate the potential for additional numerical tools assisting with future capacities for visualisation, modelling and conceptual exploration.

Branch newsletters are distributed by email. If you are not receiving newsletters then please visit our website http://www.aseg.org/ to check that your details are current.

Bernie Eric Milton, 1920-2004

Bernie Milton, former Supervising Geophysicist with the South Australian Department of Mines and Energy, died on 4 May 2004 aged 84 years.

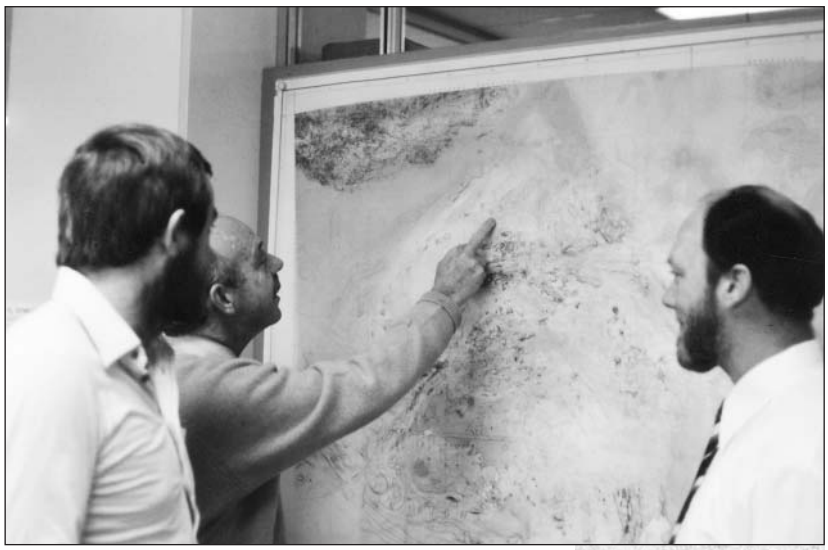
During World War II, Bernie served with the 2nd Australian Imperial Force in the Middle East, New Guinea, Borneo, and with the British Commonwealth Occupation Force in Japan. After leaving the Army in August 1947, he enrolled at the University of Adelaide where he obtained a BSc and an MSc, under a special entry as a Returned Service Personnel to study geophysics. He joined the South Australian Geological Survey in January 1956 as Assistant Geophysicist, and worked with Geophysicist Ken Seedsman under Senior Geophysicist John Webb for four years, carrying out ground gravity and magnetic surveys. He then moved into seismic work, and under the guidance of Heli Wopfner was instrumental in the discovery of natural gas in the Cooper Basin. Seismic field trips under Bernie were renowned for methodical organisation and immaculate military precision.

In 1974, Bernie was appointed Supervising Geophysicist in charge of an expanded branch comprising 34 staff who were responsible for producing the first state Bouguer gravity, total magnetic intensity and depth to magnetic basement maps.

He put all his renowned military training and disciplinary tactics to marshal and inspire an initially apathetic group of geophysicists to become members of the SA Branch of the ASEG. He also understood that to attract people to meetings on a regular basis required a venue that could provide drinks (more army experiences?).

Dave Cockshell remembers the first planned meeting at the AMF (organised by Bernie & Ted Moorcroft). "When we all turned up for the first meeting and found the place all locked up. We duly adjourned to the nearby Feathers Hotel, which perhaps was more appropriate for a mob of geophysicists."

The SA Branch probably rivalled NSW in terms of its support and vigour, with Bernie as President, and certainly its strength was a factor in SA becoming the first choice when it was decided to rotate the Committee and Secretariat out of Sydney and through the other States in the early 1980s.



Bernie Milton in 1976 examining the set of anomalies (magnetic and gravity) that helped define the location of Olympic Dam. Those same maps also helped define the basis of Tim O'Driscoll's G3 and other lineaments. Watching intently are Reg Nelson (at left), now Managing Director Beach Petroleum, and Colin Branch.

I (Reg Nelson) personally feel a great debt to Bernie. He helped shape my career as a geophysicist and I recall the companionship he provided on the many field trips we did together. SA also has a great debt to him. He realised very early the value of good quality regional geophysical maps and applied full resources to complete the first statewide aeromagnetic, gravity and seismic shotpoint compilations. Bernie also pushed the use of new techniques with vigour. He supported the introduction of high resolution seismic instruments and methods (I was very heavily involved in this) and championed its use in hard rock investigations. I believe this stemmed from an abortive attempt to use conventional petroleum seismic equipment and methods to try to outline the Olympic Dam orebody after its discovery in the mid-1970s (SSL crew and Vibroseis).

He was made an Honorary Member of the Australian Society of Exploration Geophysicists in 1981 and retired from the Department in 1982. He will be remembered as an advocate for combining geophysical methods with geological studies to more effectively explore the state and define its mineral and petroleum wealth.

A great Australian and a great South Australian. A champion of the ASEG and geophysics. And a good bloke who liked wine, music and literature.

Nick Dunstan, Reg Nelson and Dave Cockshell

Bernie Milton happy in the field.

Geoscience Australia

High-Resolution seismic imaging of the Cadell Fault Scarp for earthquake hazard assessment

The historical record of seismicity in Australia is too short (<150 years) to confidently define seismic source zones and recurrence rates for large, potentially damaging earthquakes. This results in uncertainty in assessments of earthquake hazard and the risk posed to communities and infrastructure. The most promising way to extend the record of earthquake activity is to look for evidence of large pre-historic earth quakes in the landscape. This evidence includes Quaternary fault scarps, tilt blocks and disruptions to drainage patterns. A recent Geoscience Australia compilation for evidence of Quaternary tectonics identified over one hundred examples of recently active structures in Australia, testifying that a greater hazard may exist from large earthquakes than is evident from the recorded history alone. Most of these structures have not been studied in detail, and in particular, have not been dated, so the recurrence rate for damaging events is unknown.

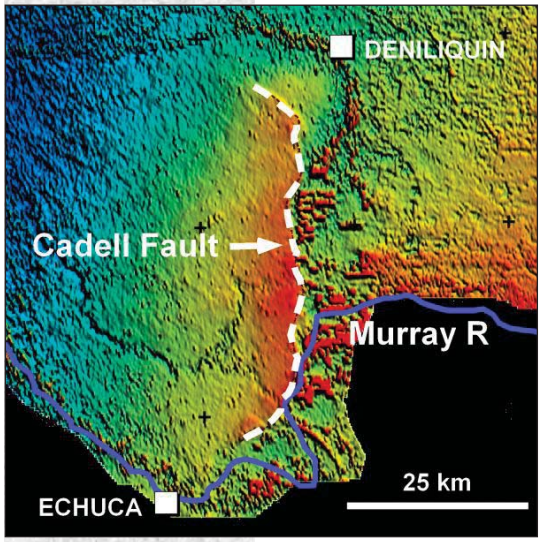


Fig. 1. The Cadell Fault, DEM courtesy of Geological Survey of NSW

One example of recent tectonic activity lies between Echuca and Deniliquin, near the Victoria-New South Wales border. Geologically recent uplift has resulted in the formation of the Cadell Fault Scarp which dammed the Murray River and diverted its course, first northwards, and later south along its present channel. The scarp extends along a north-south strike for at least 50 km and reaches a maximum height of about 13 m. It displaces the sands and clays of the Murray Basin sediments which overlie Palaeozoic bedrock at a depth of 100 to 250 m.

Fig. 2. The seismic sources a) The ANSIR MiniVibe climbing the Cadell Fault Scarp, b) the vibrator plate on the ground, c) using a hammer source on the scarp.

To map and date the faulting associated with this uplift it is necessary to excavate one or more trenches across the fault. However, erosion of the uplifted scarp may have displaced the topographic expression away from the fault, so it is an advantage if sub-surface imaging can be used to define the present-day location of the fault prior to trenching. To address this problem, Geoscience Australia has acquired multi-channel high-resolution seismic reflection and refraction data along traverses across the fault scarp. The source used was the Australian National Seismic Imaging Resource (ANSIR) IVI T1500 Mini Vibrator operating in P-wave mode. The data were recorded on a 24-channel Stratavisor seismic acquisition system. Each source vibration comprised four 10-second sweeps with a frequency of 10-240 Hz which were correlated and then stacked. The listening time was 2 s and the recording sample interval was 1 ms. The receivers comprised groups of four 10 Hz geophones deployed at 10 m intervals. The sources were located at every receiver location and additional sources were located at offsets of up to a kilometre to record refraction data.

A short spread was recorded across the scarp with a station interval of 5 m using a hammer source. This was done to provide higher spatial resolution and to compare the results with the vibrator source. In addition to the seismic data, ground penetrating radar data (GPR) and resistivity data were acquired at selected locations along the seismic traverses by Monash University GeoScope. As the resolution of the seismic data precludes imaging at very shallow depths, these methods were selected to sample the sub-surface down to approximately 3 metres depth. The GPR was acquired using a PulseEkko 100 system at 0.2 and 0.5 m station spacing. The resistivity was acquired using a Geometrics OhmMapper TR2 system at 1 m station intervals.

The seismic data are currently being processed and interpreted and will be combined with the GPR and resistivity results to define suitable locations for trenching the Cadell Fault. Samples from the trench walls will be dated by Optically Stimulated Luminescence (OSL) dating techniques to determine the latest movement along the fault and the recurrence rate of earlier events. The results will constrain earthquake hazard assessments for the region and for south east Australia in general.

Contact Clive Collins (clive.collins@ga.gov.au) for further information.

Earthquakes Online

Searching for Australian earthquakes is no longer a shaky experience. Geoscience Australia's Quakes earthquake database is now online through the Geoscience Australia web site, providing easy access to key information about Australia's earthquakes and seismicity.

The database contains Australian earthquakes from 1841 to the present, with magnitudes ranging from 0 to 7.2 (the estimated magnitude of Australia's largest earthquake, at Meeberrie, WA). The database also contains overseas earthquakes greater than magnitude six. The earliest overseas earthquake listed in the database occurred in Jordan in 2150 BC. The database is populated progressively as real-time seismograph data are analysed and the locations of earthquake are determined.

The database may be searched through either a map or text-based interface. The information returned can be tailored to the user's specific needs and can be downloaded to the user's computer. The earthquakes can be plotted on a map with a number of optional backgrounds, and details of earthquakes can be queried either individually or as groups within specified areas. The

maps can be zoomed-in to the area of interest and can be plotted by the user.

The ready availability of information about Australia's earthquakes will assist the Australian general public, researchers and other interested parties both in Australia and overseas.

Address:
http://www.ga.gov.au/oracle/quake/quake_online.jsp

Index of airborne geophysical surveys: 18.3 million km of airborne data

Index Record – hardcopy and digital versions

The Eighth Edition of the Index of Australian (GA/AGSO/BMR and State) Government Airborne Geophysical Surveys has been released in both hardcopy and digital formats. This edition of the Index contains a more comprehensive coverage of surveys than the previous edition released in May 2003. There is now a total of about 18.3 million km of airborne geophysical data in the GA database. Information on surveys prior to 2003 has been updated and additional surveys have been included from various State and Australian Government exploration initiatives and the ongoing airborne survey work of Government bodies. Specifications of several open file surveys are also included in this release.

The hardcopy version of the index (published as Geoscience Australia Record No. 2004/08) contains a summary of the major specifications of over 900 airborne surveys. The digital version of the index is available in PDF format from the Geoscience Australia website.

Interactive survey coverage information and digital files

An updated interactive database of metadata for Australian airborne geophysical surveys has also been released. Digital data files of the Index of Airborne Geophysical Surveys are provided in AEROMAP, ESRI Shape and MapInfo formats showing the coverage over Australia of Geoscience Australia and State Government airborne magnetic and radiometric surveys. The metadata files have been updated to 30 April 2004 and are available as three separate digital zip files for clients who require support for AEROMAP, ArcView and MapInfo applications.

The PC-based Windows software package AEROMAP is continuing to be supported with updated survey metadata files. The software is available as a single digital zip file which contains one copy of the program and associated digital information.

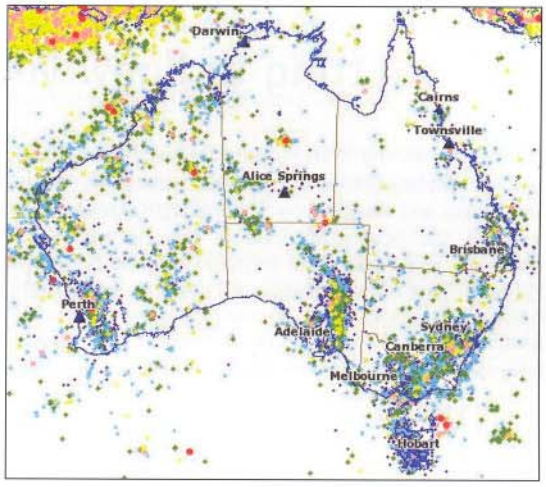


Fig. 4. Australian earthquakes in the Geoscience Australia database, 1841-2004. Colours represent magnitudes: red 6.5-9.9; pink 5.5-6.5; yellow 4.5-5.5; green 3.5-4.5; light blue 2.5-3.5; dark blue 0.0-2.5.

Note: The latest Australian airborne survey coverage information is also available free via the online Airborne Surveys Index Database on the Geoscience Australia website at http://www.ga.gov.au/oracle/argus/.

Index Maps

Updated colour index maps showing the coverage over Australia of Geoscience Australia and State Government airborne magnetic, radiometric and gravity surveys are also included in this release.

The airborne magnetic and radiometric survey coverage maps discriminate between surveys employing flight line spacings of 500 m and less, and wider line spacings. The maps also show State/Territory borders and the names of 1:250 000 Sheet areas. Scale is 1:10 000 000.

The 2004 Gravity Station Coverage Map indicates the extent of coverage over onshore Australia of gravity stations with an indication of relative reliability for each station. This map has a more complete coverage than the 2003 Map with the inclusion of approximately 100,000 more gravity stations. There are now details of approximately 1.1 million gravity stations in the onshore GA data base.

For further information on the Index Record, Index Maps, AEROMAP or the digital data files contact Murray Richardson at Geoscience Australia E-mail: murray.richardson@ga.gov.au

Getting to know your to know your noise

Margarita Norvill

margarita@geophy.curtin.edu.au

Noise is something every geophysicist has to constantly manage. Noise can be a nuisance, though it is also interesting and enlightening. This addition of Web Waves explores the beauty of noise in the electromagnetic spectrum, and shows some of the more exciting aspects. Every geophysicist will be familiar with the geomagnetic spectrum of noise.

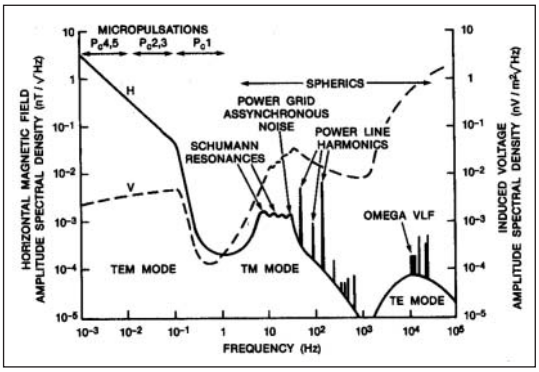


Fig. 1. Geomagnetic Spectrum.

The micropulsations are reactions between plasma from the sun and the earth's magnetic field, these micropulsations are related to magnetic storms and Aurora. The greatest source of geomagnetic noise over 1 Hz is atmospheric lighting discharges, know as "spherics". The earth's ionosphere acts as a spherical waveguide for electromagnetic guided waves, these waves resonate at a number of frequencies, known as the "Schumann Resonances". "Sprites" and "Elves" are triggered by the positive cloud-to-ground lightning flashes that occur in the stratiform regions of mesoscale convective systems. Sprites are big luminous glows hovering high above large thunderstorms. Spherics cause dielectric breakdown in the upper atmosphere, which lead to these brief luminous sprites. It's the same principal as a neon sign, where a very low density gas is excited with high voltage. Elves are described as the emission of light when a nitrogen molecule has been excited by a collision with an energized electron in the night time lower ionosphere. Cultural noise sources in the geomagnetic spectrum include noise from the mains power grid (50 Hz and harmonics of, in Australia), personal (or portable) electronic devices, Navy VLF communication, older data files my contain navigation signals such as "Omega" which have been phased out with the onset of global positioning systems.

GENERAL SITES

Radio Waves below 22 kHz ★★★★★
http://www.vlf.it

This site is a jewel of knowledge. With great posts, including simple earth-ionosphere waveguide calculations, magnetic field variations aiming to trace earthquake precursors, the signal component received with an earth dipole and why some signals present on aerial receivers can't be received with earth probes and noise suppression techniques for a personal computer.

Space Weather ★★★★½
http://www.spaceweather.com/

Fig. 2 Space weather from the active Sun.

Space weather, including: interplanetary magnetic field, solar activity, geomagnetic storms, and near earth asteroids. An interesting phenomenon that I had not known about until exploring this site was noctilucent clouds. There is a funda mental difference between noctilucent clouds and any other type of clouds. Most clouds exist within about 10 km of the Earth's surface; however, noctilucent clouds exist at a height of 82 km. They are thus not part of the normal weather system but appear to be more connected with astronomical phenomena. For more on noctilucent clouds check out http://science.nasa.gov/headlines/y2003/19feb_nlc.htm.

SEVEM: Survey of ELF and VLF Experiments in the Magnetosphere ★★★
http://www.magnet.oma.be/sevem/index.html

This site displays a documented catalogue of missions/ satellites that surveyed the electromagnetic VLF and ELF environment in the terrestrial magnetosphere since 1959. The orbital parameters are given for each satellite, as well as contact people, bibliographical references concerning the experiments and preliminary results. The location where data are stored is also given.

VERSIM: VLF-ELF Remote Sensing of Ionospheres and Magnetospheres ★★★
http://www.physics.otago.ac.nz/versim/index.html

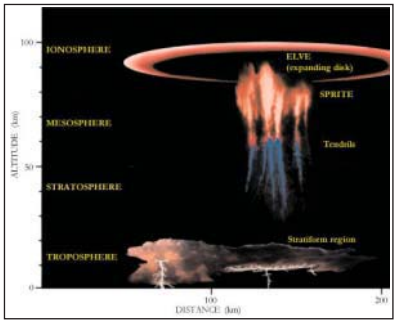


Fig. 3. Sprites and Elves.

VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere (VERSIM) is an international group of scientists interested in studying the behaviour of the magnetosphere and ionosphere by means of ELF and VLF radio waves, both naturally and artificially generated. At present the main subjects of interest include plasma structures and boundaries, wave-particle and wave-wave interactions, wave-induced particle precipitation, wave propagation in magnetosphere and ionosphere, sprites and the effects of lightning on the ionosphere.

Oulu Space Physics Textbook ★★★★½
http://www.oulu.fi/~spaceweb/textbook/

The text aims to cover the main knowledge from the fields of heliospheric, magnetospheric, and ionospheric physics. The basic design rule has been to take advantage of the internal cross-linking the html medium allows. This makes it easier to appreciate the rich phenomenology of the near-Earth space, and to see how different phenomena can be related.

Space Environment Center ★★★★★
http://www.sel.noaa.gov/index.html

The Space Environment Center (SEC) provides real-time monitoring and forecasting of solar and geophysical events, conducts research in solar-terrestrial physics, and develops techniques for forecasting solar and geophysical disturbances. SEC's Space Weather Operations Center is jointly operated by National Oceanic and Atmospheric Administration (NOAA) and the US Air Force, and is the US national and world warning center for disturbances that can affect people and equipment working in the space environment.

Check out the NOAA POESS Auroral Activity data. Instruments on board the NOAA Polar-orbiting Operational Environmental Satellite continually monitor the power flux carried by the protons and electrons that produce aurora in the atmosphere. The Space Environment Center has developed a technique that uses the power flux observations obtained during a single pass of the satellite over a polar region (which takes about 25 minutes) to estimate the total power deposited in an entire polar region by these auroral particles. The power input estimate is converted to an auroral activity index that ranges from 1 to 10. Current animation of recent polar pass plots can be viewed for the Northern and Southern Hemispheres.

LISTENING TO THE ELECTROMAGNETIC SPECTRUM

All geophysical data is prone to noise. Some data sources can be difficult to identify. Listening to your data either during acquisition or playing recorded files back can be an easy way to distinguish noise sources.

Altair's Natural Radio Projects ★★★★★
http://www.altair.org/index.html

You can get distracted for hours on this site. A must is the natural radio page where you can tune in to the music of the spheres – listen to the roar of Jupiter, the spin of a pulsar or the energy emitted by an electrogenic fish! The introduction to electro magnetic page has a great wave propagation simulation, amp litude frequency and attenuation may be altered and the resultant wave observed. There is guidance on how to build your own antenna, as well as Tesla coils, a cloud charge monitor and an electromagnetic can crusher (I really want one of these for Christmas!).

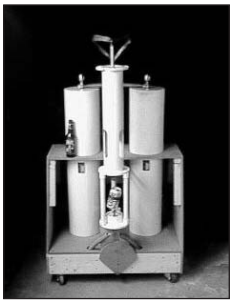


Fig. 4. Electromagnetic can crusher.

McGreevy's Ground Based ELF-VLF recordings ★★★
http://www-pw.physics.uiowa.edu/mcgreevy/

This site has a plethora of sound files.

Audio and sound files ★★★½
http://www.astrosurf.com/lombry/audiofiles-astronautic.htm

All audio recordings related to astronautic events, transmissions from satellite and other spacecrafts, as well as reports from astronauts and cosmonauts on orbit. There are numerous scientific recordings like the sound of meteor showers, auroral emissions, geomagnetic storms, solar flares, Jupiter hisses and bursts, pulsars, natural phenomena, and more.

Advanced VLF Signals ★★★½
http://image.gsfc.nasa.gov/poetry/inspire/advanced.html

This site is a must for its sound files, listen to spherics, tweeks, whistlers, choruses, power line harmonics and navigation signals (such as Omega). Next time you are out recording data why not take a headset and plug it into your acquisition system and have a listen to the noise sources in your field area. The site offers a casual scientific explanation EM phenomenon of the sound files you are listening too.

MICROPULSATIONS

Listening for Cosmic Rays ★★★★
http://www.bartol.udel.edu/~neutronm/listen/main.html

The Inuvik Research Centre is home to a cosmic ray (neutron) monitor. Data collected by the cosmic ray monitor provides information about the strength of solar and galactic cosmic rays, and disturbances in the solar-terrestrial environment. The site gives explanation of cosmic rays, tracks solar activity and magnetic storms.

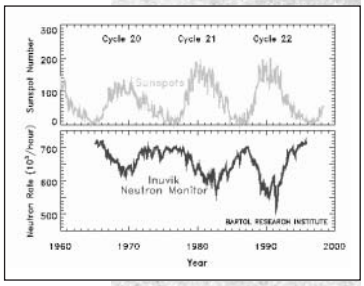


Fig. 5. Neutrons and Cosmic Rays. Solar activity peaks every 11 years when sunspot number reaches a maximum. Fewer cosmic rays reach Earth at these times, because the Sun emits plasma and magnetic fields which expel some cosmic rays from the solar system. The cosmic ray data were recorded by the Inuvik neutron monitor.

Aurora and cosmic rays are both affected by solar activity. Charged particles (electrons) from the solar wind are directed by the magnetic field towards the northern and southern polar regions of the ionosphere. Interactions between the charged particles and the atmospheric ions of nitrogen and oxygen produce a colourful light. The shifting patterns in the sky are due to changes in the magnetic and electric fields along the paths of the particles streaming toward Earth. The auroras occur in an oval band around both the south and north magnetic poles. This oval band spreads into lower latitudes during high solar activity and huge flows of incoming particles.

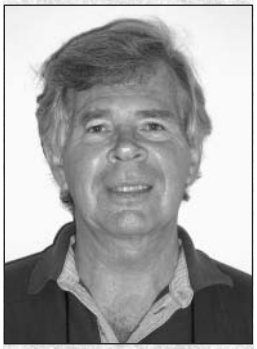
SPHERIC AND SCHUMANN RESONANCES

Monitoring global lightning with Schumann resonances ★★★½
http://web.mit.edu/civenv/html/people/alumni_newsletters/winter_02/art2.htm

This is a link to an article in Civil and Environmental Engineering at Massachusetts Institute of Technology. The article explores the relationship between lighting strikes and Schumann resonances as well as global storm activity, an interesting read.

Continued on page 18

140 Years ago – Neumayer and a meteorite



Doug Morrison

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When the pioneer German geophysicist and hydrographer Georg Balthasar von Neumayer (1826-1909) left the Colony of Victoria for the last time in 1864 he took all of his scientific records with him for later publication. Luckily for us he published.

Neumayer holds a significant place in the history of science in Australia – he firstly established and maintained the Flagstaff Hill Observatory in Melbourne and over a number of years performed a regional magnetic survey of Victoria, part of which included two short inspections and surveys of the Cranbourne meteorites in 1861 and 1862.

His first visit to the largest of the meteorites was on 12th February 1861.

"...The earth around the meteorite had been removed to the depth of two feet; the lower part, however, was not visible, the hole being partly filled up with water. A magnetic needle suspended by a silk thread and approached towards it, showed at once that the upper accessible part was of northern magnetic polarity, the South end of the needle being attracted. Moving the needle about 1 foot 10 in. below the upper surface of the mass its magnetism changed from North to South, from which I concluded that its total height would be about 4 ft. But the distance from the top at which this change in polarity took place, was by no means constant for all parts of the sides of the mass varying from 2 ft. 4 in. to 1 ft. 4 in., from which I concluded that the shape of its lower part was that of a wedge; basing thereupon, I calculated the total weight of the mass to be 4.3 tons. ** I had four specimens taken off from the nucleus and one from the crust. Their specific gravities I found to be respectively 7.60, 7.51, 7.51, 7.12 and 3.66. Drawings were made and measurements taken..."

Fig. 1. Richard Daintree's photograph of the meteorite. His caption reads: "Cranbourne meteorite with the screw-jack with which it was moved from its position for the first time since its arrival on this planet, 21 February 1862." Note Neumayer's chalk annotations S and E (N and W hidden) and the chalk line probably tracing the 'magnetic equator'. ***Photograph provided courtesy of the La Trobe Collection, State Library of Victoria.***

A following footnote reads: "Subsequent actual weighing determined its weight to be 8200 lbs. (4.1 tons)."

A year later, on the 20th and 21st February 1862, Neumayer joined R. L. J. Ellery, the government geologist of Victoria and his assistant Richard Daintree, following an invitation to witness the removal of this meteorite. Neumayer took more magnetic, orientation and physical measurements of the now exposed meteorite in situ and Daintree took photos (see Figure 1).

The above narrative is part of Neumayers "Results of the Magnetic Survey of the Colony of Victoria Executed during the Years 1858-1864" published in Mannheim, Germany 1869 and Neumayer's description, tables, sketches and maps could very well be the earliest published interpretation in exploration geophysics.

The meteorite, by the way, went to the British Museum despite considerable pleading and protests from locals.

Continued from page 17

The GP-1 Lightning Locator ★★★★
http://bub2.met.psu.edu/default.htm

The GP-1 Lightning Locator is a free-standing lightning receiving system that allows the approximate location of lightning activity within 400 km of the receiver site. It employs an antenna array to intercept broadband electromagnetic radiation from distant cloud-to-ground, or return, strokes to provide signals for hardware processing in the Interface. A personal computer analyzes these hardware signals and plots the results on the monitor screen map.

Fig. 6. Lightening locator.

Sprite chasing from the back porch ½
http://www.fma-research.com/Papers&presentations/spr-view-1.html

This site reviews the story of how sprites were discovered and how you might be able to spot some on your own. To view sprites, you need to find a location with a good view of the horizon far away from the city lights. It is best to choose a dark night with no moonlight. Let your eyes adapt to the dark for at least ten minutes. Look in the direction of the big storms. If you can see the illuminated tops of the distant storms, shield your eyes (a piece of cardboard can help) from the lightning flashing within the clouds. Concentrate your gaze at an altitude about four to five times the height of the cloud top, then be patient. In the more active storms, sprites can occur every one or two minutes, but every five to ten minutes is more common. Sprites only last from one one-hundredth to one-tenth of a second. Blink and you can miss one. Due to a quirk in human night vision, you are often more likely to perceive them out of the corner of your eye. What will you see? To many it looks like the aurora borealis turning on and off in an instant. The true sprite color is salmon red, but at such low light levels the eye can play tricks on you and you might perceive them as green, orange or white. If you are looking in the right place and think you saw something, you probably did.

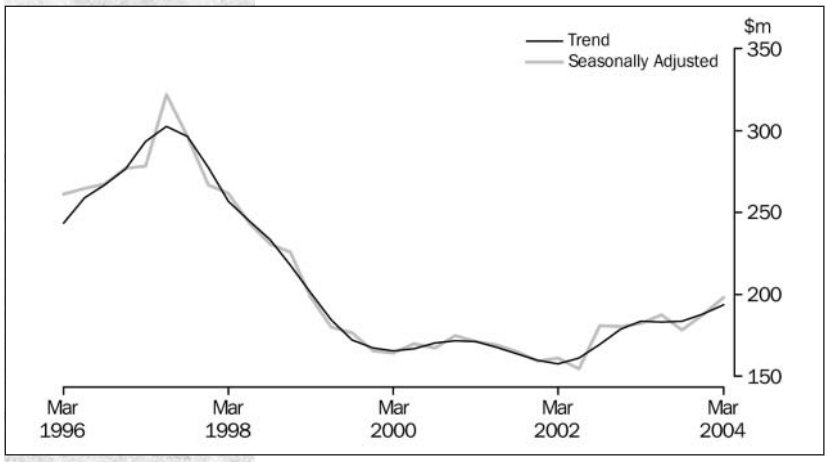
Star Rating

Content/information available on web pages	2
Navigation friendly	1
Aesthetically Pleasing	1
Currency	1
TOTAL	5

Mineral exploration steady while petroleum plummets

Minerals

Figures released by the Australian Bureau of Statistics showed that while the actual expenditure decreased in the March 2004 quarter by $32.2M the trend estimate increased by 3.1% to $193.9M. After being flat between March and September quarters 2003, the estimate has risen in the last two quarters and is now 5.6% higher than the March quarter 2003. Figure 1, which shows the data from March 1996 through to March 2004, clearly indicates the gradual recovery over the last year.



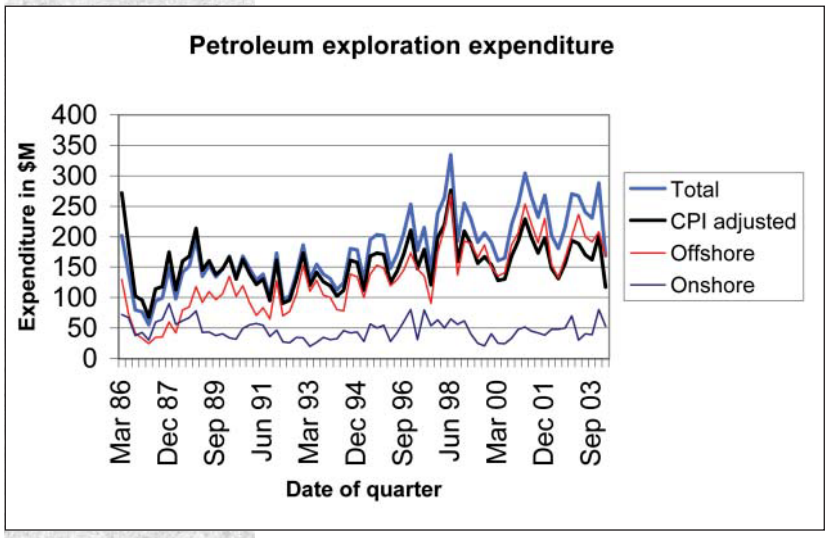


Fig. 1. (Top) Trend and seasonally adjusted quarterly mineral exploration expenditure from March 1996 to March 2004 (provided by the Australian Bureau of Statistics).

Fig. 2. (Above) Quarterly petroleum exploration expenditure from March 1986 through March 2004 for onshore and offshore areas.

Expenditure on production leases remained relatively unchanged, whereas expenditure on all other areas decreased by $31.9M (20.8%). The March quarter is invariably affected by the wet season in northern Australia and 2004 was no exception. Western Australia had the largest decrease of $25.5M (20.9%), which was spread across all mineral groups. In spite of this decrease, it still accounted for 57.7% of the total expenditure

Exploration for gold continued to dominate the scene and accounted for 54.5% of the total of $167.3M in the March quarter. The next largest was the Nickel/Cobalt grouping, which came in $15.5M at 9.3%. Coal exploration nearly halved having decreased from $24.1M to $13.7M.

The total metres drilled decreased by 16.7% to 1104 km in the March quarter 2004 (Down 0.6% in seasonally adjusted terms). Metres drilled on production leases increased slightly to 423 km while metres drilled on all other areas decreased by 25.6% to 681 km.

Petroleum

A number of petroleum exploration licences came to a close in 2003, resulting in a lower than usual March quarter. Expectations for the six months to June 2004 (as recorded in the December 2003 survey) were relatively high, suggesting the March quarter downturn may only be temporary.

Expenditure on petroleum exploration for the March quarter 2004 fell by $119.3M (41.4%) to $168.8M; in real terms (CPI adjusted) this is the lowest level since the March quarter 1995. Petroleum expenditure is now $97.7M (36.7%) lower than in the March quarter 2003.

Expenditure on exploration on both production leases and all other areas fell this quarter, with production leases falling by $14.4M (40.2%), and all other areas falling by $104.9M (41.6%). Offshore exploration had a strong decrease of $91.8M (44.2%), with non-drilling activity accounting for the majority of the fall. Onshore exploration expenditure also decreased this quarter, by $27.4M (34.0%).

Figure 2 shows quarterly petroleum exploration expenditure from March 1986 through March 2004 for onshore and offshore areas.

At first sight it appears very strange that at a time of rising oil prices and with global pressures on supply, that this huge decrease took place at all. Let's hope that the downward trend is reversed quickly.

Petratherm listed as a hot rock energy explorer[1]

Petratherm is the latest company in the geothermal energy field to be listed on the ASX. In July it completed a successful Initial Public Offering that raised $4 million to get started, and has a market capitalization of over $7 million. Petratherm was established on 24 October 2003 with the aim of obtaining tenements suitable for the production of economically viable hot rock energy.

To date, three Tenements have been obtained which are characterised by:

- Potential occurrence of rocks with naturally occurring radiogenic minerals;
- Proximity to major infrastructure;
- Depth to top of target rock in the three kilometre range;
- Potential heat exchange reservoir characteristics; and
- Location not affected by problems of restricted access.

Continued on page 21

[1] *Information taken from: http://www.petratherm.com.au/index.htm*

The International Handbook of Earthquake & Engineering Seismology, Part A (International Geophysics)

Editors:
William H. K. Lee, Hiroo Kanamori, Paul C. Jennings, Carl Kisslinger

Academic Press (an imprint of Elsevier Science), 2002, 933 pages, hardback, A$260.00

ISBN: 0124406521

Reviewed by:

David Robinson david.robinson@ga.gov.au

The International Handbook of Earthquake & Engineering Seismology, Part A, is the first in a two volume series. A project of the International Association of Seismology and Physics of the Earth's Interior (IASPEI), the handbooks cover a diverse range of topics related to seismology and earthquake engineering. The editors have brought together contributions from over twelve hundred people and fifty different countries to create this truly international body of literature, the release of which coincides with the one hundred year anniversary of IASPEI (originally the International Association of Seismology). Part A utilises six themes and fifty six individual manuscripts to educate the reader on both present and historical theories relating to seismology, earthquake mechanics and the Earth's interior.

Theme I is entitled "History and Prefatory Essays" and covers a range of topics including the history of seismology, earthquake engineering and the formation of international bodies to assist with research and communication. The discussion extends as far back as 330BCE when Aristotle attributed earthquakes to winds. Important contributions from the Jesuit community are introduced with particular attention given to the establishment and maintenance of seismic observatories from 1868 onwards. Prefatory discussions on continental drift, earthquake mechanisms and tectonics help to set the scene for the remainder of the volume.

"Theoretical Seismology", Theme II, covers a range of theory including seismology, ray theory, normal modes of the planet, inversion of surface waves, attenuation and the physics of earthquakes. The "Observational Seismology" chapter, Theme III, provides an introduction to instrumentation, digital recording and interpreting seismograms. The chapter describes the major sources of noise in observational seismology and concludes with a number of fascinating articles that cover the use of observational seismology for earthquake, nuclear test and volcano monitoring as well as discussions on marine seismology and tsunamis.

Theme IV, "Earthquake Geology and Mechanics" describes our understanding of the complex earthquake source, including a discussion of rock failure, stress fields, induced strain and active fault zones. The use of paleoseismology, geodetic measurements, geochemistry and electromagnetic fields are all discussed in the context of how they assist our understanding of the cause, recurrence and effect of earthquakes. "Seismicity of the Earth", Theme V describes seismicity in a global context, highlighting areas of relatively higher seismicity and identifying some of the words deadliest earthquakes. Magnitude and intensity scales are introduced, the statistical features of seismicity described and the USGS moment tensor catalogue discussed.

The final chapter in Part A, "Earth's Structure" introduces seismic tomography and describes the Earth's interior, velocity structure, anisotropy, and oceanic crust. A CD is provided which contains appendices for many of the manuscripts as well reports, papers and/or software that individual authors have included to supplement their articles.

The International Handbook of Earthquake & Engineering Seismology, Part A is an impressive collection of manuscripts that have been cleverly grouped to create an outstanding publication. Whilst there exists variation in the quality of individual manuscripts the book as a whole is an essential reference for researchers, consultants, and students of seismology and earthquake engineering. The editors are to be commended for their efforts.

Copies can be purchased directly from Elsevier Australia Customer Service on Tel. 1800 263 951, fax (02) 9517 2249 or email service@elsevier.com.au.

Continued from page 20

The three Hot Rock energy projects are spread over 1,500 km^2 of northern South Australia; at Ferguson Hill north of Olympic Dam, and Callabonna and Paralana near Mount Painter.

The tenements are thought to contain hot rocks at depths of 3-3.5 km - and at temperatures 8 to 25 times the heat of most granites - making it one of the most thermally active hot rock zones in the world.

"The immediate program involves a series of shallow depth wells to around 600-750 m. The technology, developed in partnership with the University of Adelaide, allows economic evaluation of Hot Rock deposits without the need for deeper, more expensive drilling, and with a focus on exploring areas closer to commercial markets.

Successful assessment of hot rock depth limits will be followed by a series of test wells, evaluation of thermal reservoirs, the completion of injection and production holes, the establishment of a heat exchange system and a final additional drilling program on a grid spacing to establish a commercial power plant.

ABSTRACTS

SECTION 4

MONDAY
SESSION 2 / STREAM 1
SEISMIC TECHNICAL FORUM I:
MAKING THE MOST OF ATTRIBUTES

KEYNOTE

USEFUL 3-D SEISMIC ATTRIBUTES

MIKE BAHORICH, APACHE CORPORATION

3D SEISMIC STRATIGRAPHY AND SEISMIC ATTRIBUTES ANALYSIS: A POWERFUL APPROACH TO MAXIMISE THE CHARACTERISATION OF PALAEOZOIC DEPOSITIONAL SYSTEMS (AUSTRALIAN NORTHWEST SHELF)

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This paper presents an example of geological exploration significantly increased by the integration of a large spectrum of seismic attributes.

A workflow combining a classic seismic stratigraphic approach integrated with analysis of seismic attribute maps enables a significant increase in the readability of the seismic data and the recognition of subtle structural and stratigraphic features. Therefore, despite the lack of stratigraphic control from well data, a coherent model can be proposed for the upper Palaeozoic depositional system of the proximal part of the Dampier Sub-basin (Australian Northwest Shelf).

This enables the definition of 6 repetitive "stacked units" interpreted as 6 phases of glacial advance/retreat. A thorough analysis of the last "stacked units" allows to refining the interpretation. It presents: a basal unit interpreted as basal moraine eroding and draping the underlying deposits and characterised by a highly reflective seismic facies; and a series of paraglacial sequences which are interpreted as the product of the deglaciation with proximal ice-marginal fans, submarine (glacio-influenced?) channels, intermediate to distal fans and a terminal marine sequence.

THE ADVANTAGE OF 3D VISUALIZATION FOR 2D SEISMIC INTERPRETATION

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When geoscientists think of visualization software and applications, the image of 3d seismic volumes usually comes to mind. Eastern Star Gas and Seismic Micro-Technology (SMT) have used SMT's visualization and interpretation software to assist in the process of interpreting faults and horizons on 2d seismic data. The interpretation workflow used on this project is also summarized.

A rigorous technical investigation has been applied to this seismic project using SMT's software, which contains all of the functionality described in this paper. The data used for this study is the Whalan Creek Seismic Survey acquired in Petroleum Exploration Licence No. 6 (PEL 6), located in the Surat / Bowen Basin in New South Wales.

Seismic lines that tied 3 wells within the survey area were initially interpreted and synthetics were generated to understand and correlate the relationship between the well and seismic data. A total of 10 wells in PEL 6 and additional wells within the Surat / Bowen Basin were used in the interpretation. Aeromagnetic and gravity data were also used to develop a better understanding of the regional setting.

The interpretation of the Whalan Creek Seismic Survey follows a workflow that initially examines the seismic lines in a three-dimensional perspective to determine the mistie analysis needed. Well synthetics were generated and the geological interpretation from the wells was integrated with the interpretation of the seismic lines. Various seismic attributes, seismic models, and geological attributes were investigated along each of the seismic lines to examine the relationships between the geophysical and geological interpretations and to validate the final interpretations.

SEISMICALLY CONSTRAINED HIGH RESOLUTION GEOLOGIC MODELLING

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Geological reservoir modelling encompasses the 3-dimensional quantitative determination of reservoir limits, structure, volume, heterogeneity, and reservoir properties through the detailed integration and continued iteration of petrophysics, geology, geophysics and reservoir engineering. This iterative and integrated approach combines geological information with seismic constraints on rock property determination. The resulting reservoir simulation model yields better forecasts of field performance than a wells only geological model, by capturing the inherent heterogeneities seen in the majority of hydrocarbon reservoirs. The advantage that the seismic modelling method has over conventional non-seismic methods is the ability to maintain the high vertical resolution provided by the well control, while increasing the spatial resolution. This is accomplished by utilizing seismic inversion data, combined with the geological model, and the existing reservoir properties determined from well control.

An example reservoir characterization project from the deepwater Gulf of Mexico utilizes seismically constrained reservoir modelling techniques for preserving reservoir heterogeneity and recognizing geological trends associated with porosity. The high-resolution model was developed by integrating stochastic seismic inversion data with well logs to provide an accurate representation of the reservoir. Insertion of the high-resolution model into a reservoir simulator resulted in a very close production history match on the first iteration. Only minor adjustments are required to refine the history match. As a result of the method providing results that closely matched the production history on the first iteration makes the seismically constrained model not only a tool to locate infill wells and plan new field developments but also for facilities planning where existing well control is limited.

SESSION 3 / STREAM 1
AVO AND RESERVOIR CHARACTERISATION

RESERVOIR PROPERTY ESTIMATION IN THE CARBONATE RESERVOIR WITH AVO INVERSION – A CASE STUDY

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One of the fundamental aims of the geophysics is to develop attributes which are understandable and acceptable to seismic interpreters, geologists and reservoir engineers. Elastic impedance inversion from far offset seismic reflection data can be considered as one of such desired attributes. It can used to derive elastic rock properties, which can be used for quick determination of lithology and fluid content. The role of the rock property inversion, as a tool for characterisation of carbonate reservoirs, has not been established. A carbonate reservoir in the South-West of Iran is selected to examine the feasibility of rock property inversion for reservoir property estimation and lithological characterization.

Of particular important was to apply this methodology in an area where reservoir rock is of a low reflectivity and acoustic impedance alone fails to separate high from low porosity zones. Lambda-Rho (??) and Mu-Rho (μ?) attributes were computed from both rock physics lab measurements and 2D surface seismic survey. We show that the variation of μ? across a carbonate reservoir can be used to distinguish high porosity-permeability areas from non-reserve zones. The field data results correlate well with core sample measurements. We also show that in this case ?? cannot be reliably used to discriminate between oil and brine saturation.

RESERVOIR CHARACTERIZATION OF THE FLAG SANDSTONE, BARROW SUB-BASIN, USING AN INTEGRATED MULTI-PARAMETER SEISMIC AVO INVERSION TECHNIQUE

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The Lower Cretaceous Flag Sandstone within the Barrow Sub-basin is a proven hydrocarbon reservoir. The main trapping mechanism is four-way dip closed anticlines, formed by drape compaction. An integrated, multi-parameter seismic AVO inversion technique was utilized that improved the mapping of the Flag Sandstone and identified the presence of trapped hydrocarbons.

The identification of the Flag Sandstone on seismic sections is complicated due to a low acoustic impedance contrast between the Flag Sandstone and the overlying shales. The same interface gives a good AVO response. Previous interpretation efforts have used the seismic AVO response to map the top of the Flag Sandstone on far-angle stacks. These efforts were very successful for mapping structure but were influenced by wavelet tuning effects and were limited for high grading the structures based on hydrocarbon potential. To aid in characterizing the fluid distribution in the reservoir rocks a simultaneous AVO inversion algorithm was used based on 3 partial angle stacks and conditioned well logs, inverting for acoustic and shear impedance.

The results of this multi-parameter impedance inversion produced a variety of attributes. The Vp/Vs attribute was aimed at improving the TWT structural pick whereas P-impedance became the basis for discriminating water and oil saturated sands.

AZIMUTHAL ANISOTROPHY FOR FRACTURED RESERVOIR CHARACTERIZATION IN THE PRESENCE OF STRUCTURAL DIPS

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In this work, the effect of natural fractures on the azimuthal response from structured reservoirs encased within carbonate rocks is investigated through forward modelling. Two fractured carbonate reservoirs are examined: the first one is composed by sediments nearly flat; the second one is in an area with reflectors having dip up to twenty degrees.

When modelling fracture behavior, even if fractures are sub-vertical, it is usual to suppose that they are vertical. For dipping reflectors, even if fractures are supposed to be vertical, they are not normal to vertical versus the dipping reflectors. Thus, the reflections from a dipping reflector above vertical fractures are quite similar to reflections from a flat reflector with inclined fractures below.

We compare synthetic seismic data from two different models having respectively vertical fractures and sub-vertical fractures (with an inclination of 70°). Fracture inclination perturbations give azimuthal variations especially on results of converted waves.

Indeed, reflections from dipping interfaces present azimuthal variations of amplitudes even for isotropic media. For a model composed by several dipping layers, we investigate the combined effects of fractures and dipping reflectors.

In particular, we discuss Amplitudes versus Offset and Azimuth (AVOA) of converted waves that, at present, have been used just for their splitting and we show how AVOA can help fracture characterization.

AZIMUTHAL VARIATION IN THE PP SEISMIC SIGNATURE: DISPLAY OF HIGH-DIMENSIONAL DATA, AVO AZ MODELLING AND INTERPRETATION

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3D PP full-azimuth, full-offset surveys are being processed to determine the azimuthal variation in AVO (AVOA) and in velocities, among other quantities. A map display of the 3-dimensional number that quantifies the AVOA – the large AVO gradient, azimuth of the large AVO gradient and azimuthal variation in the AVO gradient – tells the viewer about the ***contrasts*** in the shear wave birefringence across the boundary. The shear-wave birefringence is usually taken as proportional to the fracture density. Two types of additional information are needed to assess what the P-wave AVOA is telling us: 1) the azimuthal interval velocity information above and below the reflector; and 2) anisotropic AVOA modelling to depict various geologic scenarios likely present at given locations.

SESSION 4 / STREAM 1

THE EFFECTS OF FLUIDS ON SEISMIC RESPONSE

NUMERICAL ROCK PHYSICS: FLUID EFFECTS ON WAVE PROPAGATION

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This paper is concerned with numerical considerations of fluid effects on wave propagation. The focus is on effective elastic properties (i.e. velocities) in different kinds of dry and fluid-saturated fractured media. We apply the so-called rotated staggered finite-difference grid (RSG) technique. Using this modified grid it is possible to simulate the propagation of elastic waves in a 2D or 3D medium containing cracks, pores or free surfaces without explicit boundary conditions and without averaging elastic moduli. Therefore the RSG allows an efficient and precise numerical study of effective velocities in fractured structures. This is also true for structures where theoretically it is only possible to predict upper and lower bounds.

We simulate the propagation of plane P- and S-waves through three kinds of randomly cracked 3D media. Each model realization differs in the porosity of the medium and is performed for dry and fluid-saturated pores. The synthetic results are compared with the predictions of the well known Gassmann equation and the Biot velocity relations. Although we have a very low porosity in our models, the numerical calculations showed that the Gassmann equation cannot be applied for isolated pores (thin penny-shaped cracks). For Fontainebleau sandstone we observe with our dynamic finite-difference approach the exact same elastic properties as with a static finite-element approach. For this case the Gassmann equation can be checked successfully. Additionally, we show that so-called open-cell Gaussian random field models are a useful tool to study wave propagation in fluid-saturated fractured media. For all synthetic models considered in this study the high-frequency limit of the Biot velocity relations is very close to the predictions of the Gassmann equation. However, using synthetic rock models saturated with artificial "heavy" water we can roughly estimate the corresponding tortuosity parameter.

MODEL-BASED PREDICTION OF LITHOLOGY, PORE FLUID AND POROSITY

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We present a deterministic methodology for mapping the lithology, pore fluid, and porosity from seismic data. The input is the P- and S-wave data volumes that may come, e.g., from acoustic and elastic impedance inversion or cross-well measurements. The output is the pore fluid type (hydrocarbon versus water), total porosity, and clay content. The key element of this methodology is a site-specific rock physics model that provides the needed transforms from the elastic rock properties to the reservoir properties. The model is established by comparing model-based predictions, such as impedance versus porosity, to the relations present in well log data. Once selected, the model is used to identify the presence of hydrocarbons from a combination of the P-wave impedance and Poisson's ratio. Then the P-wave impedance is used to map porosity and clay content assuming that a deterministic relation exists between the latter two properties. All deterministic equations are calibrated at a well. These equations subsequently are applied to upscaled well log data to confirm their validity at the seismic scale.

A PVT CHAMBER FOR OBSERVING THE TIME-LAPSE SEISMIC RESPONSE TO PRESSURE

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As oil fields produce liquids (oil or gas/condensate), they undergo pressure change, with the pressure reducing as a function of production rates. Equally, the high production of water from a reservoir can cause major reduction in pressures of gas fields resulting in an increase in the gas cap size and a potential loss of gas through spillage to the surrounding formations.

The injection of water or CO2 into reservoirs or underground storage areas causes an increase in local pressure which in turn, has the potential to cause local increases in permeability in the reservoir or at the storage site. Time-lapse three dimensional (3-D) seismic methods are used to monitor the fluid movement during both fluid extraction in producing fields and injection of water or CO2 for EOR or storage purposes.

Little is understood about the seismic effects caused by variations in either pore pressure or rock matrix stress as a result of these operations. During 2003, a pressure/volume/temperature (PVT) chamber was built at Curtin University to simulate such effects, and to establish the seismic reflection response under these variations.

This paper discusses the development of this facility and the applications of this unique PVT chamber.

TIME-LAPSE ANALOG MODELLING OF TURBIDITE CHANNEL SANDS

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This paper describes a research program at the Australian Resources Research Centre to establish and use an analog model of a turbidite channel reservoir to investigate issues with reservoir simulations and time-lapse seismic monitoring of these complex fields. The project goal is to gain a better understanding of issues relating to uncertainty in reservoir simulations of channelized fields and their seismic expression. The results demonstrate the potential of using carefully scaled analog models to reproduce realistic reservoir phenomena in a controlled laboratory environment for integrated reservoir engineering and time-lapse seismic research.

QUANTITATIVE PREDICTION METHODOLOGY FOR DIFFERENTIAL STRESSES AND DISCRIMINATION BETWEEN PRESSURE AND FLUID SATURATION BASED ON SEISMIC ATTRIBUTES DERIVED FROM EXPERIMENTALLY RECORDED WAVEFORMS

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A quantitative methodology for remote prediction of differential stresses is proposed, based on rock physics responses to various overpressure mechanisms. The method utilises relationships between various seismic attributes and differential pressures which were established through a series of laboratory tests. A number of ultrasonic experiments simulating normal compaction, disequilibrium compaction, fluid expansion and tectonic mechanisms of overpressure were performed on reservoir sandstone and shale core samples. The velocity changes and the effects of different stress paths on transmitted ultrasonic pulses were investigated through changes of instantaneous waveform attributes. In all measurements the dependence between seismic velocities and differential stresses coincide well with Eberhart-Phillips empirical relationship. A positive relationship between differential pressure and several instantaneous seismic attributes has been established for the first time in these experiments. Results proved that well-known empirical relationships between differential pressure and seismic velocity are also applicable for a number of seismic attributes.

Similarly, based on the combined X-ray CT images and ultrasonic measurements conducted on core samples, the sensitivity of instantaneous seismic attributes to various degree of fluid saturation has been analysed. It was found that several seismic attributes exhibit, in form, similar relationships to the known theoretical models established between seismic velocities and fluid saturation. These results indicate that seismic attributes can be used as alternative approach for discrimination between changes caused by increased pore pressure and fluid saturation.

This enables the prediction of differential stresses by using seismic attribute changes. The proposed methodology has been tested on a 3D seismic dataset from the Northwest Shelf of Australia and shows good agreement with both the distribution of normally pressured and overpressured wells as well as the magnitude of the overpressures present.

SESSION 2 / STREAM 2
EM PROCESSING

AEM TARGET DETECTION IN GEOLOGICAL NOISE

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Target selection and ranking is a critical aspect of mineral exploration that is complicated when the host geology either masks or mimics the responses from targets of interest. The approach described here uses statistical signal processing techniques, specifically matched filtering, to help recognise targets in the presence of such confusing effects.

The essence of this approach is to assume that the data are composed of noise, generated by the background geology, and signals generated by targets of exploration interest. It is this recognition of the geology as a noise source, which allows traditional signal processing strategies to be applied to the problem. The critical step, absolutely necessary to success, involves pre-whitening the data so that those characteristics of the target that are as different as possible from this "geological noise" are emphasised.

Matched filtering is a well-established technique in fields other than mineral exploration. Work here has shown that, in many instances, it can also be applied successfully to AEM data. It provides a useful way of highlighting targets for further investigation by simplifying the interpretation process and filtering out many complex anomalies that are not feasible targets. This paper presents some of the necessary theory and the results of a number of case studies where the technique has been applied.

FOOTPRINTS OF AIRBORNE ELECTROMAGNETIC SYSTEMS OVER ONE-DIMENSIONAL EARTHS

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We have used an inductive-limit model to compare footprint sizes for a variety of common airborne electromagnetic survey geometries. The model incorporates the flight height and orientation of the transmitter, and accounts for electromagnetic coupling between the induced current system and the receiver. Horizontal magnetic dipole transmitters are shown to have a smaller footprint than vertical magnetic dipole sources. Given typical survey heights for helicopter and fixed wing airborne electromagnetic systems, the helicopter VCX geometry has the smallest inductive-limit footprint (40 m), and the fixed-wing, towed bird system the largest (550 m for a system measuring the vertical component of B-field).

We also present preliminary calculations of frequency-domain airborne electromagnetic footprint sizes for the case of finite frequency or half-space conductivity. The original definition of the footprint is extended to be the side length of the cubic volume, centred below the transmitter, which contains the induced currents responsible for 90% of the secondary field measured at the receiver. The in-phase footprint size for a horizontal coplanar helicopter frequency-domain system is shown to increase from around 3.7 times the flight height at the inductive limit to > 9 times the flight height for induction numbers < 0.7. The analysis also shows that the quadrature footprint is approximately two-thirds that of the in-phase footprint, suggesting a higher spatial resolution for this component.

AN ASSESSMENT OF CSAMT DATA FOR LOCATION OF MINERALISED TARGETS UNDER GLACIAL COVER (WESTERN TASMANIA) AND BASALT COVER (VICTORIAN GOLDFIELDS)

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New algorithms for all-frequency apparent resistivity, static corrections and Bostick transforms of CSAMT data allow real-time production of parasections of resistivity vs depth from profiles of CSAMT data. This allows rapid visualisation of 2D and 3D CSAMT model data and comparison with field data. Interactive fitting of parasections of model and field data provides an alternative to formal inversion.

The process is used to model the effect of glacial erosion features in CSAMT data from Western Tasmania and assess the sensitivity of the CSAMT method to the detection of targets such as steeply-dipping graphitic and mineralised alteration zones. The approach has advantages of flagging data affected by cultural (power transmission line) noise, provides clear discrimination between effects of surficial conductive variations such as filled glacial erosion features, and discriminates between genuine dipping conductors, vertical conductors, and artefacts from near-surface effects which may generate "apparent" vertical conductive anomalies.

A similar approach using CSAMT data from basalt-covered terrain in the Victorian goldfields, combined with 3D EM modelling, was successful in identifying a prospective sulfidic conductor in the Ordovician basement, beneath variably-conductive basalt cover.

MODELLING THE ELECTROMAGNETIC RESPONSE IN COMPLEX GEOLOGICAL STRUCTURES USING THE 3D FINITE-ELEMENT METHOD BASED ON THE HEXAHEDRAL AND THE TETRAHEDRAL EDGE-ELEMENT TECHNIQUE

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The demand for an accurate and efficient general electromagnetic (EM) program to model the EM field in complex geological structures led us to the development of the three-dimensional edge finite-element program. It has the capability to model the frequency- and time-domain electromagnetic (EM) fields in the inhomogeneous complex structures at any resistivities contrasts and at any survey types. The use of the edge finite-element method instead of the conventional nodal finite-element method is necessary to satisfy the inherent continuity constraint across the interface of the adjacent finite-element cells. The program is developed based on the edge hexahedral element with the linear basis function. Rather then solving for the electric field we reformulated the program to solve for the Schelkunoff's potentials resulting in the improvement of its performance significantly. On the 2 GHz desktop computer the program required less than 2 minutes computation time per frequency per station to compute the response of a complex large model in the domain of 2km X 2km X 1km. The run time is adequate for some application, but it is still considered significant for the time-domain EM field computation and for modelling the airborne survey. Subsequently we increase the number of the unknowns in each element by subdividing the hexahedral element into 5 tetrahedral elements to enable the program to use bigger cells and reducing its cell number requirement. The modelling of the EM response of 2 interacting targets and complex geological structures example are demonstrated to show the ability of the program in solving complex problems.

DISCOVERIES THROUGH INNOVATION IN APPLICATIONS OF AIRBORNE AND GROUND TDEM IN VERY CONDUCTIVE ENVIRONMENT

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In the Buffalo Head Hills diamond province Alberta, Canada, kimberlites have intruded a thick sequence of sedimentary units with thickness in excess of 300-500 m and resistivities of 5 -10 Om. In contrast to the conductive sediments the kimberlite intrusive is invariably characterised by much higher electrical resistivities.

These "resistive" kimberlites can be detected by both airborne and ground time domain EM methods. Because of the host sediments very low resistivity, the resistive kimberlite response in many cases appears counter intuitive to the expectations based on the simpler analysis of the problem which ignores the EM interactions between a 3D body and a conductive host. For similar reasons, successful detection of kimberlites in the Buffalo Head Hills province also required developments of algorithms, which facilitate correction of airborne TDEM data for variations in aircraft altitude and pitch. "Anomaly hunting" analysis, which decomposes the spatial and temporal characteristics of the EM response into a number of components and innovations in the inversion and transformations of ground TDEM data sets was also required. Application of standard Conductivity-Depth-Image (CDI) techniques was not appropriate to the solution to the problem. A new pseudo 1D-inversion algorithm was developed to partially assist in the assessment of the data.

A number of areas previously covered by detailed airborne magnetic surveys were re-surveyed with the Geotem airborne TDEM system. Using the developed concepts and insights has resulted in a number of new diamond-bearing non-magnetic kimberlite discoveries. New discoveries for example, include kimberlites K296 a with a surface area of some 500 by 500 m and K252 with a an estimated mini-bulk sample diamond content of 55.0 cpht, the highest estimated diamond content of all Alberta kimberlites to date.

SESSION 3 / STREAM 2

PETROLEUM CASE HISTORIES

SALT TECTONICS IN THE OFFICER BASIN: IMPLICATIONS FOR TRAP FORMATION AND PETROLEUM EXPLORATION

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The Neoproterozoic Officer Basin in Western Australia is an inland frontier area that covers about 300 000 km² in Western Australia and 225 000 km² in South Australia. The present-day structural-stratigraphic framework is dominated by salt deformation and associated features. In the central western Officer Basin, approximately 6500km of 2D seismic data were recently reinterpreted and integrated with potential field regional datasets. This has led to improved understanding of the halokinetic evolution and the petroleum potential of the region, summarized herein.

Compressional processes, associated with tectonism in the adjacent Paterson Orogen, are probably the key mechanism initiating multi-phase mobilization of a thick halite-dominated sequence, the Browne Formation, low in the succession. Significant salt redistribution resulted in thickness variations of the Browne Formation and the overlying section, and a variety of halokinetic structures.

Prospective structures caused by salt tectonics include drape folds with a potential for multiple pay, thrust-related anticlinal features, combined traps at diapirs' flanks and enhanced porosity traps. Most of these traps were in place before the main phases of hydrocarbon generation and could form attractive petroleum exploration targets.

IMPROVING THE RESOLUTION OF DEEP-CRUSTAL SEISMIC DATA TO STUDY SHALLOW GAS HYDRATES ON THE HIKURANGI MARGIN, NEW ZEALAND

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Methane gas hydrate, an ice-like form of water and methane, is abundant on continental margins worldwide and may constitute a future energy source. The Hikurangi margin offshore of New Zealand is predicted to contain vast quantities of gas hydrate. Much of our knowledge on Hikurangi margin gas hydrates stems from crustal seismic data which are of limited use for gas hydrate reconnaissance because of relatively low resolution. We here present results from reprocessing of a crustal seismic line with a focus on maximising resolution. We benchmarked our results to a higher-resolution survey that was recently acquired along this line. While the reprocessed crustal data are not ideal for gas hydrate investigations, we are able to identify most major features relevant to gas hydrate occurrence, in particular bottom simulating reflections, free gas close to the seafloor, and normal faults that intersect the seafloor. Our results demonstrate that reprocessing of crustal seismic data for maximum resolution may lead to significant improvements for studying gas hydrates.

COOPER BASIN WORKSTATION DATA PROVISION- PITFALLS AND PROGRESS

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Santos has provided Primary Industries and Resources South Australia (PIRSA) with a copy of its workstation files of seismic and well data covering the Cooper and Eromanga Basins of South Australia, The seismic dataset includes workstation-loaded data for over 5000 seismic lines while the well dataset covers 1300 wells in the former PELs5&6 licence areas. These data are now available to other explorers to facilitate successful exploration in the area.

The 2D seismic stacked section data were provided in GeoFrame archive format while a separate GeoFrame project file exists for well data. The seismic dataset provided by Santos contains a comprehensive set of seismic lines from 1975-2000 with several versions of many lines. Bulk shifts/timing issues have been resolved between data vintages and coordinates are included with the trace data.

Whilst the data are reasonably easy to load into other GeoFrame workstations, substantial effort has been undertaken to enable loading into other interpretative platforms. This paper describes a number of issues raised in the transcription and the outcomes of the process.

The result of these processes is the ability of PIRSA to now provide to all parties interested in the Cooper and Eromanga Basins, a consistent and comprehensive set of 2D seismic data and well data that is readily loadable to a range of workstation platforms.

AUSTRALIAN NORTHWEST MARGIN, METEORITE IMPACT AND SEISMIC VELOCITIES: IS THERE A CONNECTION?

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The Bedout High in the Roebuck (formerly offshore Canning) Basin at the NW Australian Margin (NWAM) has recently been re-interpreted as a massive impact structure that appears to be associated with the global Permian/Triassic extinction event. This impact may have significantly modified the crustal structure in the region. Depth conversion of reflection seismic data indicates that depth to basement at the top of the Bedout High is ~ 3.9 km, and that the High stands more than 4 km above the surrounding sedimentary basins. The basement and crust in the Roebuck Basin have a number of features that distinguish it from other basins at the NWAM. Rapid crustal thinning outboard of the Bedout High and the presence of a thick layer of magmatic underplating in the lower crust are among these features. The meteorite impact may have been one of the possible causes to have triggered upper mantle melting and generation of a voluminous layer of underplated material. On a finer scale, OBS-derived seismic velocity variation along the basement is speculatively interpreted to be consistent with impact-related effects. However, existing seismic and potential field data do not allow accurate estimates of the extent of the crust affected by the meteorite impact, and effects that it may have had on the subsequent rifting, thermal, sedimentation and hydrocarbon maturation regimes in the area. Further multidisciplinary research is necessary to answer these questions.

SESSION 4 / STREAM 2

Geothermal

Keynote

HOT DRY ROCK GEOTHERMAL ENERGY

Prame Chopra, Firector , Geodynamics Limited

HOT DRY ROCK GEOTHERMAL EXPLORATION IN AUSTRALIA

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Hot dry rock (HDR) geothermal energy is obtained by circulating water between injection and production wells through hot subsurface rocks. The recovered hot water should be around 250°C for efficient electricity generation. South Australia has become a focus for HDR developments due to its exceptionally hot subsurface rocks. Previous HDR projects have focused on areas of known high geothermal gradient, based, for example, on experience from petroleum wells, e.g. the European Soultz-sous-Forêts site and Geodynamics' Habanero-1 well in the Cooper Basin. An alternative strategy is to explore for the highest geothermal gradients closest to electricity markets. Petratherm Ltd. holds geothermal exploration licences within the uniquely hot South Australian Heat Flow Anomaly and will target buried thermally anomalous granites and radiogenic iron oxides therein. Thermal modelling indicates that temperatures of 250°C may be attained at depths <4 km within the licences. The thermal conductivity of the cover rocks is as important a factor as the heat-generating potential of the basement in generating exceptionally high geothermal gradients.

THERMAL MODELLING OF THE HOT DRY ROCK GEOTHERMAL RESOURCE BENEATH GEL99 IN THE COOPER BASIN, SOUTH AUSTRALIA

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The aim of this project was to estimate the distribution of temperature within the crystalline basement beneath Geothermal Exploration Lease GEL99, in the Cooper Basin, South Australia. The purpose was to constrain the energy potential (and economic value) of the underlying hot dry rock geothermal resource.

One-dimensional conductive heat flow models were constructed for 12 wells in the vicinity of the permit. The models utilised temperature and lithological information derived from petroleum industry boreholes. Results indicate that surface heat flow is close to 100 mW/m2 across much of GEL99, with some localised variation near the Big Lake gas field. The relationship between surface heat flow and basement depth suggests that heat is generated in the underlying granite at a rate of about 10 µW/m3. The high basement heat generation explains the relatively high surface heat flow.

Vertical conductive heat flow was extrapolated into the basement underlying each well in order to predict the temperature profile. Results suggest that the highest basement temperatures are in the vicinity of Moomba North 1, where the temperature may exceed 260°C at a depth of 5 km.

TESTING MODELS FOR BOTTOM-HOLE TEMPERATURE RECOVERY, COOPER BASIN, SOUTH AUSTRALIA

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True formation temperature (TFT) is a key parameter in geothermal resource evaluation. Measurements of TFT require deployment of a thermometer to depth within the crust, most commonly down a small diameter borehole. Unfortunately, the act of drilling removes heat from the region where temperature is to be recorded. This induced thermal anomaly may persist for months or even years depending upon both in situ conditions and the style and depth of the drilling. In the absence of sufficient time for full down hole thermal re-equilibration, measured bottom of hole temperature (BHT) may be significantly less than TFT. Numerous models have been proposed to correct disturbed BHT measurements. To date, very few of these models have been adequately tested.

A unique opportunity to examine models of BHT recovery exists in data from the Cooper Basin, South Australia. Extensively drilled for both petroleum exploration and production, a large database of post-drilling BHT measurements is available for wells in this region. Included within these data is a subset of 335 wells for which temperature data are available from post-suspension completion logs. These data, collected several weeks to months after the end of drilling, are a close approximation to TFT for the bottom of hole.

This combination of short and long-term temperature measurements has allowed an assessment of the performance of BHT recovery models for a subset of 61Cooper Basin wells. Four models were tested: the Horner plot (as derived from the line source model of Bullard, 1947), the zero-circulation model of Cooper & Jones (1959), the empirical exponential model of Perrier & Raiga-Clemenceau (1984) and the empirical semi-log plot of Pitt (1986). In all cases model predictions were found to be biased when compared with the TFT. The magnitude and direction of this bias is found to be dependent upon assumptions implicit in each model.

SESSION 2 / STREAM 3

Gravity Gradiometry

Keynote

FALCON AIRBORNE GRAVITY PROJECTS

Phil Harman, Gravity Capital

ESTIMATING THE PRE-MINING GRAVITY AND GRAVITY GRADIENT RESPONSE OF THE BROKEN HILL AG-PB-ZN DEPOSIT

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Mining of the Broken Hill Ag-Pb-Zn deposit has substantially modified what was originally a positive anomalous mass. When an airborne gravity gradiometer (AGG) survey was flown over the Broken Hill region in early 2003, the measured response reflected the modified mass distribution. To answer the questions "What was the original response of the orebody?" and "Would this response have been detected had the survey been flown prior to mining?", an estimate of the changes in response brought about by mining activities was made and added to the survey data to produce an image of the pre-mining gravity response.

To estimate the change in response, a 3D model of the mined portion of the deposit was built. An estimate of the change in mass due to mining activities was made and this mass was distributed with uniform density throughout the model. The gravity and vertical gravity gradient response

of the orebody model was then calculated, filtered to match the characteristics of the AGG data and added to the observed survey data.

The 'corrected' data show distinct gravity and gravity gradient highs over the northern and southern parts of the orebody which hosted the bulk of the reserves. Although the anomalous response is close to the noise levels of the survey data, we can conclude that the AGG survey would have detected an anomalous response from the Broken Hill orebody had the survey been flown prior to mining. However, there are other geological features in the survey area that produce similar anomalies, notably a number of amphibolite units.

CASE HISTORIES OF HIGH-ACCURACY LAND GRAVITY GRADIENT MEASUREMENTS

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The concept of using gravity gradient measurements for gaining knowledge of the subterranean zone is not new. Instruments have been built and field measurements have been conducted over the past 100 years. Improvements in both sensor performance and survey procedures have resulted in the present capability of making high accuracy (sub-Eötvös) measurements in real-world areas of interest. A summary of recent field activity using Lockheed Martin gradiometer systems will be presented in this paper. Recent improvements have resulted in a land-based gravity gradiometer system capable for use in a broad range of land applications, including void and tunnel detection, void characterization, and time-lapse reservoir monitoring.

TOO OLD FOR MODERN EXPLORATION? OLD TORSION BALANCE OBSERVATIONS REVISITED

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Although gravity gradiometry was among the first geophysical methods used successfully in applied geophysics (Eötvös torsion balance), the technology fell from favour after the 1930s. Here we present a new analysis of torsion balance measurements that were made at that time to detect salt domes in the Northwest German Basin.

The study was aimed at assessing methods for interpretation of torsion balance observations. The approach is to synthesize classical procedures with computer based numerical methods, taking horizontal gradients Wxz and Wyz as input parameters. First we give an overview of torsion balance operational details and then discuss the interpretation of torsion balance data.

A total of 39 maps at 1:25,000 scale covering the Northwest German Basin have been digitised. These maps provide some 40,000 torsion balance measurements, but no field books or field forms are available. The gradients were digitised from old paper maps, then reprocessed and recalculated. 3D modelling of Wxz, Wyz and other components of the Eötvös tensor provides detailed insight into the geometry of salt domes and provides additional constraints for modelling the Bouguer gravity field.

3D forward modelling is conducted using the IGMAS program package. This package allows the calculation of potential, gravity and its components, and the Eötvös tensor components. Results show that knowledge of the second derivatives of the potential could fundamentally change the role of gravity field measurements in underground investigations, not only for resource exploration, but also for investigations of large fault systems like the Dead Sea Transform.

3D FULL TENSOR GRADIOMETRY: A HIGH RESOLUTION GRAVITY MEASURING INSTRUMENT RESOLVING AMBIGUOUS GEOLOGICAL INTERPRETATIONS.

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The high resolution, high precision gravity gradient measuring technology, Bell Geospace's 3D FTG (Full Tensor Gradiometry), is presented as an exploration tool to enhance and solve ambiguous geological interpretations from conventional methods. Its high frequency character produces a Total Gravity Field that identifies subtle density contrasts within section allowing it to be used in detailed hydrocarbon and mineral exploration projects, both offshore and onshore.

This paper presents two case histories describing the results from an airborne and a marine survey. Both studies demonstrate the technology's ability not only in determining target shape but also in mapping target prospects across large sedimentary basins. The first example presented in this paper images a salt dome onshore Louisiana, USA, and infers about its emplacement through direct mapping of controlling structure. The second identifies and maps a series of low density sedimentary deposits on the flanks of the Judd Basin offshore NW Europe.

The implications for exploration initiatives are significant as FTG data reduces risk in geological interpretation, thus facilitating a rapid decision making process.

SESSION 3 / STREAM 3
EM SYSTEMS

THE GEOTECH VTEM TIME-DOMAIN HELICOPTER EM SYSTEM

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The Geotech Ltd. VTEM heli-time domain EM system entered into commercial service in late 2002 after a developed program that started in early 2001. Since then, the system has performed surveys in Canada, the USA, Brazil and southern Africa for a range of mineral deposit styles in a variety of geological settings.

The VTEM system bears similarity to many of the past and currently operating heli-time domain system designs but has focused more than other developments on operational simplicity and flexibility in how the system is configured. A very high dipole (coupled with very low system noise levels) is deemed a major differentiating factor of the system compared with others in current operation.

In terms of applications, VTEM is seen as an effective bridge between existing airborne electromagnetics technologies; combining the high spatial resolution associated with helicopter systems but with a depth of investigation similar to what fixed wing time-domain systems were traditionally required to achieve.

ENHANCING ELECTRICAL SIGNALS WITH SENSOR ARRAYS

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Increasingly, electrical surveys employ multiple sensors to make data collection more efficient. The use of multiple sensors can also be used to improve signal fidelity from each sensor, leading to more accurate geological models and greater depth of investigation. New procedures to remove noise in data collected using an array of sensors have been developed and tested. These algorithms attempt to remove two types of noise: harmonic noise associated with the mains power grid and atmospheric transients due to distant lightning strikes and electrical storms. Field tests demonstrate improvements in signal-to-noise by two orders of magnitude. The algorithms are applicable to any type of electrical or EM survey conducted with a sensor array.

THE EMERGING ROLE OF HELICOPTER TIME DOMAIN EM SYSTEMS

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Helicopter time domain electromagnetic (H-TEM) systems are an emerging technology. The ability to integrate the great depth penetration of fixed-wing systems with the spatial resolution and conductance discrimination of helicopter frequency domain systems is an important development for the detection of discrete conductors.

H-TEM systems can be configured with multiple receiver coils to make their responses more diagnostic, such as the discrimination of thick from thin conductors. The use of a rigid geometry allows these systems to measure during the transmitter on-time where high conductance targets produce a stronger response.

In areas of conductive overburden, it is possible to remove much of the high amplitude response due to surface conductivity from deeper bedrock conductors by subtracting the off-time response from the corresponding on-time response. The resultant profiles are more diagnostic of bedrock conductors than are the late off-time channels from the same system at a lower base frequency.

NOVEL WAYS TO PROCESS AND MODEL GEOTEM DATA

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Data processing methods originally developed for the TEMPEST system allow GEOTEM half-sine data to be deconvolved and transformed to GEOTEM square-wave data. The advantages of the transformed square-wave data are that they refer to a standardised waveform that does not vary through a survey. The high-frequency information contained in the data recorded during the transmitter pulse can be readily utilised and the data can be easily corrected for variations in the transmitter loop height, pitch, roll and receiver coil offset. Modelling results from transformed GEOTEM data acquired across the Bull Creek mineralisation indicate that the transformation works well for survey data. Traditional off-time, single component conductivity - depth modelling of GEOTEM data can be improved by utilizing the full waveform and by inverting multicomponent datasets. In highly conductive terrain, such as above seawater, where system parameters such as the bird position are hard to derive reliably from the time - domain in-phase component as a proxy for the primary field, the joint inversion of multicomponent data helps to correctly resolve layered-earth parameters. Jointly inverting the 3-component on- and offtime data of a GEOTEM bathymetry survey in the Torres Strait showed that the data fit can be greatly improved by allowing the inversion to determine the receiver offset and attitude. This results in greater confidence in the derived conductivity - depth values.

SESSION 4 / STREAM 3

MINERAL EXPLORATION GREENFIELDS

THE WATERLOO AND AMORAC NICKEL DEPOSITS, WESTERN AUSTRALIA: A GEOPHYSICAL CASE HISTORY

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The Waterloo and Amorac nickel sulphide deposits are significant discoveries located in the north eastern goldfields region of Western Australia. They were found as a result of the systematic application of geophysical techniques during a greenfields exploration program. The deposits are 300 m from each other, blind, and are overlain by 80 m of deeply weathered basement rocks. Despite their close proximity, the deposits are quite separate and different in style.

Interpretation of detailed aeromagnetic data was first used to delineate komatiite-basalt contacts of interest for nickel sulphide exploration. Then these contacts were surveyed with a moving loop TEM survey (Inloop and Slingram receivers) which delineated nine basement conductors. Finally, fixed loop TEM surveys were used to better define the targets for drill testing.

Drill hole TEM surveys have been used since the discovery to guide drilling and better define the mineralisation size, location, orientation, and character. Complicated geometry and multiple conductive sources make careful interpretation and modelling essential.

REGIONAL TARGET GENERATION FOR PORPHYRY CU-MO SYSTEMS IN THE ERDENET AREA, MONGOLIA

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A regional structural interpretation was undertaken from an integrated study of high-resolution airborne geophysics, JERS-1/SAR and geological data around the Erdenet porphyry Cu-Mo deposit in northern Mongolia. Geophysical signatures of the Erdenet deposit have been identified and extrapolated regionally.

The district-scale area was divided into 5 domains based on a combination of structural and geophysical character. The most prospective domain contains numerous concentric, high to low magnetically zoned bodies, which represent igneous plutons of the Selenge Complex and a series of discrete low or remanently magnetised bodies of the younger Erdenet Complex porphyries. The domains are delineated or enveloped by a series of major regional fault or shear zones, with approximate N-, W- or NW-trends. The porphyries of the Erdenet Complex appear to align along a NW-trending sub-domain boundary.

Major 'late' W-trending, left-lateral transpressional structures, such as the Vitim Suture Zone dominate the region and appear to control the distribution and orientation of the magnetic/structural domains. Application of a Riedel, simple shear ellipsoid model, suggests that NW-trending structures that appear to control the current position of the Erdenet Complex porphyries are equivalent to X or P shears.

Target areas were delineated based on structural and/or litho-magnetic features. Subsequent ground verification, IP surveys and drilling have tested some of these targets and identified significant hydrothermal alteration.

GEOPHYSICAL SURVEYING OVER VMS DEPOSITS IN OMAN

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Airborne and ground geophysical information was acquired to help locate prospective ground and to directly detect Cyprus-type Volcanogenic Massive Sulphides in the Northern Oman Ophiolite terrane.

Airborne magnetic low zones were identified as areas of interest for ground geophysical surveying since footwall alteration, including magnetite destruction, is associated with the generation of these copper-rich VMS deposits.

The Hatta and Shinas gossans and surrounding prospective volcanic rocks were surveyed with Time Domain Gradient Array Induced Polarisation, 100 m single moving loop SiroTEM and ground magnetic data.

The 2 Mt Shinas deposit hidden beneath 20 m of resistive gravel cover, exhibits a weak Ch5 TEM anomaly related to copper-rich pyritic massive sulphide and an associated discrete IP anomaly coincident with the underlying stringer mineralisation. These are down-faulted from the outcropping auriferous debris flow breccia gossan.

At a lower stratigraphic position in the nearby Hatta area, SiroTEM and Gradient Array IP anomalies have outlined four smaller massive sulphide breccia deposits that host economic copper grades. These deposits are associated with a major hydrothermal upflow zone in the footwall basalts that is characterised by magnetite depletion and weak chargeability.

A combined approach of airborne geophysics, Landsat, geochemistry and geological mapping identified prospective areas for the utilisation of ground geophysics, which provided valuable guidance to site discovery drillholes.

HOISTEM DATA PROCESSING FOR DISCOVERY OF HIGH GRADE MANGANESE ORE UNDER REGOLITH COVER

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A time domain airborne electromagnetic (AEM) survey was flown with the HoistEM system over the Woodie Woodie manganese mine corridor in the east Pilbara of Western Australia. Conductivity depth image (CDI) processing and decay analysis helped to discriminate shallow, regolith related responses from conductive ore. EM conductivity mapping using CDIs correlated with about half of the known manganese ore zones, and recent drilling of several new EM targets in areas of regolith and bedrock cover discovered over 6 large tonnage manganese ore bodies to date. EMFlow has made it practical to process data gathered by HoistEM to separate the ore body response from conductive paleochannels and other conductive features related to bedrock geology or the regolith, for data editing to remove noise, and for experimentation with EMFlow parameters to produce more reliable results. The CDI results were further refined by calibration to borehole conductivity results. The survey testes and processing results demonstrate that HEM is a cost-effective method for exploration of podiform, high grade manganese ore bodies, as along as the host rocks are comparatively resistive and flight line spacing of 80 m or less is used.

SESSION 2 / STREAM 4

Environmental and Near Surface 1

Keynote

AIRBORNE GEOPHYSICS IN ENVIRONMENTAL MANAGEMENT - A EUROPEAN PERSPECTIVE

Michael Lee, British Geological Survey

UXO LOCATION USING TOTAL FIELD MAGNETICS IN SE ASIA

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Unexploded Ordnance (UXO) is a major problem in a large number of areas throughout the world and SE Asia is no exception. As most of the older ordnance is of ferrous composition, total field magnetics is an eminently suitable tool for its location.

During the past few years work has been carried out on two major infrastructure development projects in SE Asia, one being in Hong Kong and the other in Taiwan. The projects have involved the use of tightly spaced total field magnetic traverses to locate buried UXO. The located items were then removed to allow for safe operations on the sites.

Both sites were intended for public access and thus required a high level of confidence that no UXO remained buried on site.

Both clients have adopted the results of the survey as an approved methodology for the location and removal of buried UXO.

CAVITY INVESTIGATIONS FOR THE AUSTRALIAN MARINE COMPLEX IN WESTERN AUSTRALIA

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The Western Australian and Federal Governments have funded the development of substantial new coastal infrastructure at Jervoise Bay, 23 km south of Perth. The site, which is to be known as The Australian Marine Complex, has been developed to facilitate and enhance the opportunities created by the clustering of the marine, defence and resource based industries in the area. It is envisaged the site will be used for the construction of oil rigs and other large mobile or semi-mobile structures.

The site is located on the Tamala limestone which is known to host karst features in other areas. Considering the large loads that will be moved across the site, it was crucial that any cavities which exist beneath the area were identified. The detection of cavities with dimensions as small as a few metres beneath 60 ha of land presented a significant challenge. The use of drilling or excavation over this area was clearly impractical and consequently a geophysical solution was sought.

The choice of a geophysical solution was further complicated by the presence of both areas reclaimed from the sea by the dumping of fill and native onshore areas. Consequently it was necessary to detect cavities that may be dry, fresh water filled or saline water filled. Two primary geophysical techniques were chosen. These were ground penetrating radar (GPR) over the fresh water saturated areas and time domain electromagnetic (TDEM) data over the saline water saturated areas. A new towed time domain system ("TinyTEM") was used to collect the TDEM data. To ensure rapid data acquisition with precise positioning, all GPR and TDEM data were collected using real time kinematic GPS for navigation and positioning. This presentation will show some the results of these surveys together with the results of follow-up resistivity surveys which were used to narrow down the number of targets which required further investigation by drilling.

AIRBORNE BATHYMETRIC LIDAR - SUPPORTING SHALLOW WATER EXPLORATION AND DEVELOPMENT

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Over the last five years the use of airborne lidar technology as a bathymetric survey tool has increased substantially. The systems are well suited to surveying in clear, coastal water and surveys have been performed for a variety of reasons, including: updating nautical charts, supporting coastal and reef management, and oil and gas exploration and development. Seamlessly and safely surveying shallow, complex and drying areas is possible with an airborne platform and because the swath width of the systems are independent of water depth shallow areas are surveyed with no loss of efficiency. Because airborne lidar systems are able to efficiently operate in areas where acoustic, vessel mounted, systems suffer significant inefficiencies a new segment of the bathymetric survey market has been defined; contract surveys for airborne lidar systems.

In Australia the two users of airborne bathymetric lidar technology have been the Royal Australian Navy and the offshore Oil and Gas Exploration community. Since 1998 several companies involved in offshore exploration including the explorers themselves as well as seismic exploration companies have commissioned airborne bathymetric lidar surveys. Bathymetric surveys have been completed for a variety of purposes; supporting seismic acquisition in poorly charted and dangerous waters, allowing efficient route planning for pipeline construction in complex and environmentally sensitive areas and provided bathymetric and topographic data to allow evaluation of alternative pipeline landfall locations. In each case the ability of airborne lidar systems to efficiently and safely survey large and remote areas when acoustic systems either could not operate or could not meet tight schedules was important to the end user of the data.The summary is a short, informative abstract of no more than 200 to 300 words. References should not be cited. The summary should not simply list the topics covered in the paper, but should (1) state the scope and principal objectives of the research, (2) describe the methods used, (3) summarise the results, and (4) state the principal conclusions.

EVALUATION OF 2D RESISTIVITY IMAGING TECHNIQUE FOR MAPPING AND MONITORING OF SUBSURFACE CAVITY COLLAPSED INTO SINKHOLE

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Geo-environmental hazard from near-surface cavities collapsed into sinkholes is increasing alarmingly in northeast Thailand. Detailed subsurface studies in the areas of concern are required for identification of sinkhole-prone areas, which may relieve fear of sinkhole hazard and help prevent possible and significant damage from the hazard. Thus, we examined the usefulness and capability of a 2D resistivity imaging technique for mapping and monitoring of surface cavities. We conducted 2D resistivity surveys at a man-made square tunnel, where the subsurface geology is known, and at the nearby sinkhole areas. Synthetic resistivity data of various electrode configurations including Wenner, Dipole-Dipole, Schlumberger, Pole-Pole, and Pole-Dipole were generated from the model similar to a known geology of the tunnel. We conducted a resistivity survey across the tunnel similar to the synthetic data. The results from the field data show that the Dipole-Dipole and Wenner configurations provide better tunnel imaging. The tunnel appears as a lateral anomaly in a homogenous medium. The anomalous zone of the tunnel is distinguishable by the zone with high resistivity, surrounding with the lower background resistivity. However, the locations of the tunnel anomaly appear misplace in 2 out of 3 on the field resistivity pseudosections. It is different from the synthetic resistivity pseudosection. This suggests a strong 3D effect from nearby structures. Results from the nearby sinkhole areas show that a Dipole-Dipole configuration provides a better result for cavity imaging than the Wenner configuration. An anomalous zone of the cavity is distinguished by very low resistivity zone surrounded by the higher background resistivity. These two results suggest that the 2D resistivity surveys provide a reasonable basis for mapping a subsurface cavity. In addition, the 2D resistivity survey was found to be useful for monitoring progressive cavity expansion, as a similar resistivity survey was acquired at the same location at different times.

SESSION 3 / STREAM 4

Environmental and Near Surface 2

SEAWATER DEPTH DETERMINATION USING THE HELICOPTER HOISTEM SYSTEM

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Interpretation of helicopter time domain data from a recent HoisTEM survey of Sydney Harbour has been undertaken to identify the boundary between seawater and seafloor on the basis of the expected conductivity contrast. The survey area overlies an area previously surveyed using a frequency domain DIGHEM (V) system. Both conductivity-depth imaging (CDI) and 1D inversion have been applied. Interpreted seawater depths are compared with accurate bathymetric soundings, in order to appraise the airborne EM bathymetry method for this HoisTEM dataset.

Various strategies have been employed in order to optimise the interpretation of HoisTEM data using accurate sea depth ground truths and knowledge of the sea floor in Sydney Harbour. CDI processing, forward modelling, and 1D inversion are under investigation.

The CDI processing involves determination of apparent conductivity at each delay time, followed by estimation of the apparent depth as the depth of maximum current in a half-space with conductivity equal to the apparent conductivity at the time in question. Variable transmitter current is taken into account during the CDI processing. For a given seawater conductivity, optimal transmitter moment and altitude can be determined prior to CDI processing via successive single parameter inversions of an early time channel.

An extensive comparison of modelled and observed HoisTEM responses over deep and shallow seawater showed that very good agreement could be achieved for models with the correct depth of water provided the seawater conductivity was lowered from its measured value of 5 S/m to about 3.5 S/m. This modelling investigation also provided useful insights into the quantitative effects of variations in transmitter altitude.

1D inversion of HoisTEM data supports these findings and initial results suggest that the correct seawater depth can be inferred provided a low seawater conductivity is adopted.

RADON EFFECTS IN GROUND GAMMA-RAY SPECTROMETRIC SURVEYS

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A significant problem for ground-based gamma-ray spectrometric surveys is the effect of emanation radon on estimated uranium concentration estimates. Radon gas (a daughter product in the U238 decay series) escapes from rocks and soils near the earth's surface into the lower atmosphere. Under early morning, still-air conditions, radon concentrates as a thin layer near the earth's surface. If ground radiometric surveying is undertaken before this radon layer is mixed into the lower atmosphere, large errors in U concentration estimates result.

This paper shows the effect of early-morning radon accumulation on a

quad-bike gamma-ray spectrometric survey near Boorowa, NSW. Paddocks surveyed early-morning show much higher apparent uranium concentrations than those surveyed later in the day. We demonstrate the radon diurnal effect by recording the apparent U concentration at a fixed site over several weeks. Typically, there is a build-up of radon near the earth's surface overnight. Radon concentration reaches a maximum at about 7 am before slowly dispersing over a period of 2-3 hours. The diurnal data also show the effect of rainfall on apparent U concentrations. Rain precipitates radioactive daughter products of atmospheric radon onto the ground resulting in a significant increase in apparent U concentration. These short-lived daughter products decay to insignificant concentrations within about 3 hours. Ground surveys should not be conducted within 3 hours of rain, or under early-morning, still-air conditions.

GRAVITY AND MAGNETIC TENSOR DATA: POSSIBLE USE IN REGOLITH EXPLORATION

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The regolith obscures much of Australia's bedrock geology, posing problems in mineral exploration under cover. Gravity and magnetic tensor data may provide significant improvements over conventional geophysical exploration, by producing maps showing subtle variations in the field data which relate to the subsurface geology, but hidden to standard total or vertical field measurements. This paper examines forward potential field responses of three dimensional regolith models containing targets like palaeochannels and land mines. A finite element approach is used, summing the field responses from many small elementary cubes, to build up complex structures to yield the full field response at a specified height above the ground. The gravity tensor data ranges over values from -0.12 to 0.2 Eötvös, and the magnetics range from -1.2 to 0.6 mT/m (when measured at the surface). When a flight height of 80 m is used, the responses diminish significantly, and only regional features are detectable. These values are compared to the ranges of measurable values from existing systems, and it is shown that the magnetic case is most suited to regolith studies. The resolution required for the gravity tensor appears to be less than is possible with current systems.

THE HYDRAULIC AND ELECTRICAL FRACTAL DIMENSION OF REGOLITH

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Electrical and electromagnetic (EM) geophysical data from a line or grid are usually converted into two- or three-dimensional resistivity models of the Earth. In regions of relatively uniform geology, variability of measurements is assumed to be random and Gaussian, such that the Earth models are found from a maximum likelihood approach. In this paper, we show that such variability is not Gaussian, and has a scale-length dependence, expressed as a fractal dimension. We argue that the fractal dimension of electrical and EM data is causally determined from Earth heterogeneity, which provides a link with hydraulic conductivity in porous and fractured media that also has a fractal dimension.

This paper presents initial analyses of data from two sites within South Australia. NanoTEM time domain electromagnetic (TEM) data were collected at Tunkillia in the Gawler Craton with a target of identifying palaeochannels for gold exploration. Analysis of survey data revealed a good correlation between regions of low resistivity and high fractal dimension. On the other hand, a river-borne NanoTEM survey of the River Murray sediments showed much lower correlation. We conclude that analysis of the variability of EM data may provide useful additional constraints on sub-surface properties.

SESSION 4 / STREAM 4

ENVIRONMENTAL AND NEAR SURFACE 3

NEW AIRBORNE COMPLIANCE MONITORING TECHNIQUES FOR SEISMIC OPERATIONSTITLE FIELD - HIGHLIGHT THIS TEXT AND REPLACE WITH YOUR TITLE

DRAGAN IVIC, ROB LANGLEY AND DAVE COCKSHELL
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Petroleum Group of Primary Industries and Resources of South Australia (PIRSA) has a regulatory responsibility to ensure seismic operations are carried out with minimal impact to the environment. As part of this role, continual improvements are made to techniques that are employed in monitoring compliance of seismic field operations with environmental requirements.

An innovative airborne video monitoring system has been developed to improve the effectiveness of assessing seismic field outcomes on the environment. This system increases the efficiency and effectiveness of monitoring extensive seismic lines in often environmentally sensitive or logistically challenging areas.

This system complements traditional ground-based methods of inspecting seismic operations. The aim of the system is to ensure that correct procedures are employed during seismic line preparation and that appropriate restorative work is carried out, to facilitate natural recovery of seismic lines.

The primary characteristics of the surveillance system are that it enables a stable and continuous video recording of large amounts of seismic lines in a short time, observations are environmentally non-invasive and observations can be made over terrain that may otherwise be difficult to access by ground based systems.

The airborne system has been developed using low cost, compact, readily available and proven technologies and equipment. It has proven to be economic and versatile for a variety of airborne monitoring operations.

USING GEOPHYSICS TO LOCATE BURIALS AND OTHER CULTURAL FEATURES, ISLE OF THE DEAD, PORT ARTHUR, TASMANIA

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Multi-technique geophysical investigations have been conducted on the convict-period cemetery on the Isle of the Dead, Port Arthur, Tasmania. With the exception of historic photographs and some limited historical research, very little is known about the layout of burials or physical characteristics of the subsurface. Approximately 1100 burials took place on the island and less than 10% of these were formally marked. Apparent conductivity and magnetic surveys were conducted across the accessible portion of the island to locate subsurface artefact that may be associated with individual burials. The results show gradual variations in soil conditions over the site, some surface cultural features such as pathways, and numerous near-surface unidentified ferrous objects. Although some of these features showed apparent linear patterning, this did not correlate with individual areas of disturbance visible in the ground penetrating radar (GPR) profiles. 500 MHz and 250 MHz GPR surveys provided detailed subsurface information and were used to define the lateral extent of individual anomalous responses and areas containing complex multiple reflectors. The former were classified into various types, according to amplitude, shape and continuity of the reflectors. They were interpreted as possible or probable graves and located on a cultural sensitivity plan as zones of high archaeological potential. Of the techniques used so far, GPR appears to be the most effective method for detecting disturbances associated with graves on the Isle of the Dead.

RADIOMETRIC STITCHING

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Large scale stitching of radiometric data has often been found to be intractable, its solutions elusive. The procedures used in the stitching of the successful Northern Territory Radiometric Map are described in this paper. Recommendations are made to facilitate radiometric stitching and some pitfalls are identified.

A convenient way of expressing the spatial detail of the total count has been found by substituting its high-passed form into the intensity layer of ternary images. An unexpected result of the merging and inclusion of the total count in the images has been the realisation of detail in the regolith between outcrops.

NET COMMUNITY BENEFITS AND SEISMIC LINE REMEDIATION - A CASE STUDY

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The Petroleum Group of Primary Industries and Resources South Australia (PIRSA) conducted an audit of seismic lines within Petroleum Exploration Licenses (PELs) 5 & 6 in 1999, to assess their condition upon expiry of these licenses.

A significant number of seismic lines located in gibber plains and residual tablelands to the north of Innamincka were identified as being in poor condition, particularly in regard to active erosion.

Maps were produced from low-level aerial videography of more than 1200 km of seismic lines that enabled detailed assessment of the amount of seismic lines in poor condition.

Physical rehabilitation of windrows or erosional gullies would be unlikely to make a significant improvement to the impacted lines. Rather than wasting money and effort by forcing Santos to undertake any physical remediation, PIRSA, Santos and NPWS agreed that funding of other environmental projects in the Innamincka Regional Reserve would provide a better net benefit to the local environment.

Santos has set up a fund for a range of environmental projects within the Innamincka Regional Reserve. In return the Government agrees that no further rehabilitation of the lines will be required. As part of the process, PIRSA undertook a risk assessment to ensure that the level of any such risk is acceptable.

ANOMALOUS HEAD WAVE AMPLITUDES OVER A LOW VELOCITY SHEAR ZONE.

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A three dimensional (3D) three component (3C) seismic refraction survey was carried out across an extension of the Lake George Fault at Bungendore. The seismic source was the IVI MiniVibe, and both compressional and shear wave shot records were generated.

The results show a narrow zone with a low seismic velocity which correlates with the extrapolated position of the fault. However, the amplitudes for the head waves associated with shear zone are also low. These results are contrary to the results over other shear zones at Mt Bulga and Spicers Creek, as well as deep refraction studies.

This paper compares the results of both compressional and shear wave models of the subsurface. The author hopes that he is able to think of a valid reason for this most unusual situation in time for his presentation at the Conference, if it is accepted! In the meantime, considerable efforts will be devoted to this problem.

TUESDAY
SESSION 1 / STREAM 1
Seismic Technical Forum II: AVO/Inversion Case Histories

Keynote

RECENT ADVANCES IN SEISMIC INVERSION AND THE ROAD AHEAD

Nader Dutta, WesternGeco

THE BORIS OIL FIELD IN THE GULF OF MEXICO - A GEOPHYSICAL CASE STUDY

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The Boris oil field was discovered in 2001 in Green Canyon block 282 in the deep water mini-basin area of the Gulf of Mexico. The Boris discovery was followed by the drilling of the Boris North appraisal well in 2002. First oil from the Boris field was produced in early 2003 with recoverable reserves estimated at 10 to 35 million barrels of oil equivalent. The Boris reservoir shows up as a bright seismic amplitude anomaly in Pliocene-age sand. Seismic reprocessing for robust amplitude fidelity and the use of Kirchhoff prestack time migration were the main geophysical tools that led to the discovery of the field.

The Boris reservoir is steeply dipping at a depth of approximately 4500 m. The original seismic data across the Boris field consisted of post-stack time migrated data that showed a broad, poorly defined amplitude with poor conformance to structure. After careful amplitude processing was input to prestack time migration, a bright well-defined amplitude 'appeared' on the seismic data with an excellent down-dip fit to structure. Concurrent with the reprocessing, a lithology and fluid prediction project was undertaken. Nearby well control was used to define rock property trends such as Vp versus depth, Vp versus Vs, and Vp versus density. The rock property trends were used to stochastically model the AVO response and the results were compared to the measured AVO response on the reprocessed seismic data. The results of the modelling showed that the fluid type at Boris was consistent with hydrocarbons. The Boris discovery well was drilled within three months of completing this reprocessing.

DEFINING THE SUBTLE TRAP - A BASS BASIN CASE HISTORY

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The Trefoil prospect is a low relief structural closure in the Bass Basin defined by a vintage 2D seismic grid. For such features, geological uncertainty can be reduced when a number of geophysical tools applied to a seismic data set all independently support a single model of the subsurface. This is particularly relevant for 2D data where the benefit of continuous structural and amplitude coverage of 3D data is not available. Geophysical techniques used to mature this prospect for drilling included pre-stack depth migration (PSDM), horizon-based stacking velocity analysis (HSVA), amplitude versus offset (AVO) analysis/modelling, and frequency attenuation mapping.

The application of these methods improved the understanding of the structure compared with previous work based on the same vintage 2D seismic dataset. These analyses consistently support the geological model that Trefoil is a low relief, four-way dip closed anticline, containing several gas columns that may be filled to spill.

It is shown that AVO anomalies at prospective levels closely match the final depth closure, as does a frequency attenuation anomaly. The convergence of this information from different methods has reduced the perceived risk to the point where the prospect is viewed as economically viable and is planned for drilling in 3Q 2004.

FLUID PROPERTY DISCRIMINATION FROM THE INVERSION OF AVO ATTRIBUTES

B RUSSELL, D HAMPSON AND L LINES

SESSION 2 / STREAM 1

SEISMIC ACQUISITION (MARINE)

A STRATEGY FOR OPTIMAL MARINE 4D ACQUISITION

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Repeating source-receiver azimuths can be an important aspect of 4D acquisition. Seismic repeatability will decrease with an increase of source-receiver azimuth differences between base and monitor surveys. This paper discusses a marine acquisition strategy with respect to the optimal preservation of source-receiver azimuths in the presence of feathering. We show that repeating shot positions is favourable for azimuth preservation in 4D acquisition in combination with overlap configurations (additional outer streamers). With a dense streamer separation, source-receiver azimuths can be repeated very accurately by using this strategy.

In a base survey, overlap configurations allow the vessel to follow the survey's pre-plot sail lines with significantly reduced crossline deviations. A well-conditioned base survey simplifies and optimizes the repetition of vessel/source positions in a future monitor survey.

THE REVOLUTION IN SEISMIC RESOLUTION: HIGH DENSITY 3D SPATIAL SAMPLING DEVELOPMENTS AND RESULTS

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Recent marine case studies have demonstrated that a significant component of the seismic "noise" contaminating 3D images actually arises during processing, as an unfortunate and inescapable artefact from poor 3D spatial sampling. When the cross-line acquisition dimension is sampled at an equally small interval as the inline dimension, a much larger frequency bandwidth than typical of standard 3D acquisition can preserved throughout all stages of processing, free of aliasing, and free of artefacts. Hence, it is observed that once the random noise component is suppressed below a certain threshold, other factors than mere fold are clearly contributing to the quality of a seismic image. It is quite poorly established how more complicated acquisition parameters, such as multi-streamer spread dimensions and shooting templates, influence the "S/N ratio" of seismic data - particularly after the application of multi-channel pre-stack processing algorithms, notably pre-stack migration.

Historically, efforts at towing the source and streamer at shallower depths rather fruitlessly delivered higher dominant signal frequencies, at the cost of degraded lower frequency amplitudes, increased survey noise, and with minimal perceivable improvements in target resolution. Even if means can be found to reduce the inherent noise incurred, resolution remains frustratingly restricted, and the emphasis upon higher frequencies during acquisition was largely wasted. The solution is to sample densely in both the shot and receiver domains, particularly in the cross-line direction.

Several case study examples demonstrate significant improvements in resolution and signal-to-noise content are routinely achieved by high-density seismic acquisition. Depending upon local geological conditions, high frequency amplitudes can be increased by up to 15 dB, frequency bandwidth can be doubled, 3D steep dip imaging can be significantly improved, and overall signal-to-noise ratio is improved, further contributing to better resolution. Hence, a powerful demonstration is made that tight 3D spatial sampling must be the foundation for all high resolution seismic acquisition.

SENSOR POSITIONING AND DATA ORIENTATION METHODS FOR FIXED GEOPHONE OCEAN BOTTOM CABLES IN SHALLOW WATER SURVEYS

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The positioning accuracy of receiver modules is very important when using ocean bottom systems to collect seismic data if one wishes to gain full advantage from the technique. Furthermore, in order to gain fully from the advantages of using lightweight fixed geophone cables, as opposed to gimbaled geophone systems, correct data orientation is also vital.

Both of these elements have been very successfully demonstrated in deep water surveys carried out over the last couple of years using a combination of Ultra Short Base Line acoustic systems and first-break picks. But, until very recently the challenges of obtaining both accurate positioning and the proper data orientation in shallow water had not been addressed and robust techniques implemented to overcome these challenges in the field.

This paper presents the results for both receiver positioning and geophone data orientation from a 3D 4-component OBC survey using fixed geophone cables acquired in water depths ranging from approximately 15 to 35m.

Highly accurate positioning of the receivers is demonstrated to have been obtained by combining "as-laid" positioning information with first-break analysis. Results are also presented from first-break hodogram analyses which were used to determine the cross line geophone data orientations onboard the recording vessel for QC purposes, coupling monitoring and to rotate the data of selected lines for initial evaluations of the converted-wave quality.

Near-vertical-incident source lines provided the necessary seismic traces to be used for both receiver positioning and hodogram analyses.

NUMERICAL MODELLING OF SEA WAVE MOVEMENT ON SEISMIC STREAMERS IN RELATION TO SWELL NOISE ON DATA

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Seismic surveys collected in rough sea conditions are subject to significant swell noise which reduces the data quality to a greater or lesser extent. This noise occurs in bursts throughout the data and is accentuated in the lower depths by amplitude gain functions during processing.

Mathematical or numerical modelling of ocean waves and swell was carried out in order to come to a much clearer understanding of the way in which the water movement due to waves acted on the seismic equipment deployed therein. The numerical modelling analyses were not only conducted on the modelled sea surface but also at the typical depth at which streamers are normally towed.

Algorithms were developed using the MATLAB programming package such that the user can input any values for chosen parameters such as swell wavelength, wave height limit, depth from zero (surface) downwards. The sea surface can be regarded as a composite of many wave harmonics which have varying wavelengths, wave-heights, and orientations. These were modelled for various swell wavelengths and wave-heights and also for water particle velocities in relation to wave-height which directly affect the amount of noise likely to occur on the data.

Results showed that longer wavelength swells have a much greater impact on data than swells of shorter wavelengths. This fact can make it possible to ascertain what effect a particular swell will have by closer analysis of its dominant wavelengths.

IMAGING BENEATH THE TARANAKI FAULT, NEW ZEALAND – A FEASIBILITY STUDY FOR WIDE-ANGLE SEISMIC SURVEYS

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The Taranaki overthrust fault at the the eastern boundary of New Zealand's most significant hydrocarbon province, the Taranaki Basin, presents a challenge to the exploration industry. Seismic imaging of potential hydrocarbon traps beneath the fault is difficult using conventional streamers with lengths of up to 6 km, mainly because the high velocities of overthrust greywacke deviate rays to large offsets. We present a modelling study of the feasibility of wide-angle experiments to undershoot the fault. We performed ray-tracing to predict ray coverage at horizons beneath the fault as a proxy for expected image quality. Our results suggest that by increasing the length of seismic streamers from 6 to 12 km, which is possible with modern streamers, ray coverage across potential hydrocarbon traps would increase significantly. Deeper targets, which would be of interest for studying the tectonic evolution of the Taranaki Basin and the source rock distribution, will require "true" wide-angle experiments with ocean bottom seismometers. We also predict significant coverage with P-to-S mode-converted waves. Elastic full-wavefield modelling using a simplified velocity model suggests strong mode conversion on the greywacke/sediment interfaces.

SESSION 3 / STREAM 1

Seismic Interpretation

AUTOMATED EVENT PICKING IN PRESTACK HYPERSPACE

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Seismic data mining is part of an interactive processing and interpretation workflow. The extraction of information will often have the prerequisite of picking reflection events. Methods that aid in automatically extracting information are required when handling large volumes of data. Migrated 3D seismic data in prestack form (which includes the offset dimension) creates a 4D hyperspace. An algorithm for tracking prestack reflection events in that hyperspace will be presented. The algorithm combines a range of techniques including supervised learning.

Results of automated picking will be presented for migrated, prestack, field 3D data. The algorithm was able to track a nominated reflection event in prestack hyperspace from a single seed pick. The results are superior to those produced using a 2D gather-based approach and a correlation autopicker.

A small number of manual picks are used to train a probabilistic neural network, which assigns each sample an event probability. These probabilities are updated using a set of flow features that propagate seed picks through the hyperspace. Flow features constrain possible picking locations based on inter-relationships with nearby picks and event probabilities in 4D. The combination of the global 4D event probability distribution and localised 4D flow feature updates, creates a highly constrained algorithm. Evolution of a picked event is controlled by quantitative assessment of previously made picks. The algorithm provides a quantitative measure of the reliability of each pick.

TUNING SEISMIC RESOLUTION BY FREQUENCY SHIFTING

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Resolution, in exploration seismology, is traditionally associated with the spectrum of the wavefield - its effective bandwidth and its effective central frequency. The larger the bandwidth, the higher the resolution is. If the bandwidth is kept the same, the seismic time resolution can be tuned up by increasing the dominant frequency of the signal or by the heterodyning technique in the terminology of radio communication. Heterodyning has been long exploited by communication engineers to translate signal spectra and make trade-offs between bandwidth and signal-to-noise levels in transforming signals from amplitude to phase modulated form. In the mapping of subsurface structures, phase information is as important as the shape of the envelope of the seismic signals. In this paper, we argue that heterodyning, if applied properly, enables a trade-off between detection precision and the signal-to-noise structure of the seismic data field. This will be illustrated by using synthetic and real data examples.

AUTOMATIC 3D FAULT EXTRACTION AND FAULT SURFACE SEPARATION

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Fault mapping is a very important part of the seismic interpretation. The process to manually map faults is very time consuming and it is subject to errors. We present an efficient method for local fault extraction, and fault surface separation. The method is based on a straightforward difference based 3D edge detection algorithm and does not use any cross-correlation, semblance or eigen-structure methods like the seismic continuity and seismic coherence methods. The robustness of the method is demonstrated in results from its application for small fault extraction in complex and seismically noisy environments.

INTERPRETATION ADVANCES IN NOISY DATA AREAS

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Interpretation challenges in noisy data regions are well known. In such locations, slow improvements in drilling success have historically been based upon incremental improvements in seismic processing technology, and gradual improvements in interpreter experience and competence.

Using several 3D data examples, I demonstrate a variety of means by which interpretation confidence and success in difficult areas has been significantly improved by viewing the entire acquisition-processing-interpretation process as one entity. The use of immersive visualization technology throughout the exploration process has been proven to be invaluable, providing powerful QC of all acquisition and processing stages, and enabling the interpreter to overcome historical difficulties establishing what data components are noise, and which are valid primary events. This approach therefore allows an objective review of the key acquisition and processing issues affecting data quality, and provides a platform for 3D survey planning, 4D reservoir monitoring, processing QC, interpretation, and reservoir exploitation.

SESSION 4 / STREAM 1

ANISOTROPIC: THE EFFECTS OF FRACTURES ON SEISMIC RESPONSE

KEYNOTE

THE WINDS OF CHANGE: ANISTROPIC ROCKS, THEIR PREFERRED DIRECTION OF FLUID FLOW AND THEIR ASSOCIATED SEISMIC SIGNATURES

HELOISE LYNN, LYNN INCORPORATED

THE IN SITU STRESS FIELD OF THE WEST TUNA AREA, GIPPSLAND BASIN: IMPLICATIONS FOR NATURAL FRACTURE-ENHANCED PERMEABILITY AND WELLBORE STABILITY

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The *in situ* stress field and natural fracture occurrence in the West Tuna area of the Gippsland Basin were evaluated in order to assess the potential for natural fracture-enhanced permeability in the deep intra-Latrobe group and Golden Beach Subgroup reservoirs, and to investigate wellbore stability issues in the area.

Borehole breakout and drilling-induced tensile fractures (DITFs) interpreted on six image logs from the West Tuna area constrain the maximum horizontal stress orientation to ~138°N. Leak-off test data suggest the upper bound to the minimum horizontal stress is ~20 MPa/km. The vertical stress was derived from density and sonic log data and ranges from 20 MPa/km at 1km to 22 MPa/km at 3km depth. The maximum horizontal stress magnitude was constrained to ~40 MPa/km using occurrence of DITFs. The *in situ* stress regime in the West Tuna area is therefore interpreted to lie on the boundary of strike-slip and reverse ($\sigma_{Hmax}>\sigma_v \approx \sigma_{hmin}$).

Natural fractures and wellbore failure (breakout and DITFs) were observed to form preferentially in the cemented sandstone units. Finite element methods were utilised to investigate the far-field and near-wellbore stress distribution between horizontal, interbedded sands and shales. Preliminary modelling indicates that a higher Poisson's ratio for the shale drives it towards a more isotropic far-field stress state. This decreases the propensity for wellbore failure in the shale layers.

Fracture susceptibility analysis of interpreted fracture sets in the sandstone units suggests that electrically conductive fractures are also optimally oriented to be hydraulically conductive in the far-field. Fractures in the shales are slightly less likely to be open and hydraulically conductive in the far-field due to the transition to a more isotropic *in situ* stress regime.

FLUID EFFECT ON SHEAR WAVE SPLITTING IN A POROUS FRACTURED RESERVOIR

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The presence of fractures in a reservoir is a main cause of azimuthal anisotropy of its elastic properties. A shear wave propagating in an azimuthally anisotropic medium splits into two components with different polarizations if the source polarization is not aligned with the principal symmetry axis. If the direction of shear wave propagation is not parallel to the plane of fracturing, shear-wave splitting will depend upon the normal fracture compliance, which in turn depends upon the properties of the filling fluid. If the system of pores and fractures in a fluid-saturated rock is interconnected, then fluid flow between pores and fractures must be taken into account. How shear-wave splitting varies with fluid properties depends upon the assumptions that are made regarding the pressure relationship existing between pores and fractures. In this paper we use the anisotropic Gassmann equations, and existing formulations for the excess compliance experienced due to fracturing, to estimate the splitting of vertically propagating shear waves as a function of the fluid modulus. This is done for a porous medium with a single set of dipping fractures and with two conjugate fracture sets dipping with opposite dips to the vertical. The estimation is achieved using two alternative approaches. The first approach assumes that the fractures and pore space are in full pressure equilibrium with respect to fluid flow. That is, the frequency of the elastic disturbance is low enough to allow enough time for fluid flow between the fractures and the pore space. In the second approach each of the fracture sets are in full pressure equilibrium with the surrounding pore space, but not with the other fracture set. That is, the frequency is low enough to allow fluid flow between a fracture set

and the surrounding pore space, but high enough so that there is not enough time during the period of the elastic disturbance for fluid flow between fracture sets to occur. It is found that the second approach yields a much stronger dependency of shear-wave splitting on the fluid modulus than the first one.

EVALUATING THE IMPACT OF FRACTURE-INDUCED ANISOTROPY ON RESERVOIR ROCK PROPERTY ESTIMATES MADE FROM SEISMIC DATA

B HANSEN, B GUREVICH, K LAWSON, K KOSTER

ATTENUATION OF COMPRESSIONAL WAVES IN POROUS ROCKS WITH ALIGNED FRACTURES – COMPARISON OF THE THEORY WITH THE NUMERICAL EXPERIMENTS

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Fractures in a porous rock are modelled as very thin and highly porous layers in a porous background. First, an effective elastic modulus for wave propagating in periodically layered poroelastic medium is obtained using Biot theory and propagator matrix approach. Then, layers representing fractures are taken to the limit of very high porosity, high permeability, and small thickness. In this limit effective elastic modulus of the fractured medium is obtained. When such porous fractured system is dry, it is equivalent to a transversely isotropic dry elastic porous material with linear-slip interfaces. When saturated with a liquid this system exhibits significant attenuation and velocity dispersion due to wave-induced fluid flow between background pores and fractures. At low frequencies the material properties are equal to those obtained by anisotropic Gassmann theory applied to a porous material with linear-slip interfaces. At high frequencies the results are equivalent to those for fractures in a solid (non-porous) background. The characteristic frequency of such attenuation and dispersion depends on the background permeability, fluid viscosity, as well as fracture density and spacing.

In order to validate our asymptotic theoretical model of attenuation and dispersion, we perform numerical experiments using a poroelastic extension of OASES reflectivity software, which can compute the plane-wave transmission coefficient for a stack of porous layers with given thicknesses. The theoretical results are in a very good agreement with numerical simulations for the periodic system of fractures when thickness of the fractures is constant. More importantly, good agreement holds even for a random distribution of fractures. This is explained by the fact that relaxation curve of attenuation depends only on the ratio between diffusion length (characteristic of background only) and thickness of fracture.

SESSION 1 / STREAM 2

COAL AND COAL BED METHANE 1

QUANTITATIVE GEOPHYSICAL LOG ANALYSIS IN COAL MEASURE SEQUENCES

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Geophysical logging is routinely undertaken as part of coal mine exploration programs. With minimal analysis, coal seam depth can be determined and estimates made of coal quality lithology and rock strength. Quantitative log interpretation will add to this information. We discuss log responses in terms of the mineralogy of the clastic sediments frequently found in the black coal mining areas of the Sydney and Bowen Basins. We find that the log responses can be tied to the mineralogy with reasonable confidence. If a full suite of logs is run, ambiguities in the interpretation may be resolved. A key driver in this work is geotechnical characterisation. With this additional geophysical input, it should be possible to develop improved rock mass classification schemes.

COAL BED METHANE PLAY AND PROSPECT EVALUATIONS USING GEOGRAPHIX SOFTWARE

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Evaluation of coalbed methane plays, prospects, and properties is challenging work. Complex and computationally intensive, it employs a considerable diversity and volume of data, and involves a lot of interpretive analysis and mapping. The sources of data can also be a bit typical and there will also be need to combine and display the data in unusual ways. Many geologic interpretation software packages on the market today were designed specifically to handle data and workflows in conventional reservoirs. Programs that are limited, inflexible, or lack versatility can therefore be severely challenged by the differences encountered in coalbed methane projects. GeoGraphix software is not limited or inflexible and is of considerable help to the geologist and engineer in handling and interpreting a large diversity and volume of data in CBM plays.

The primary objective in this CBM evaluation will be to lay-out a standard workflow for reservoir characterization, resources assessment, reserves estimation, and new well location selection on CBM properties using GeoGraphix software. Although the approach and techniques presented in this paper are very useful for many CBM plays, generalizing about what works or doesn't work in CBM plays is dangerous because the keys to making each a success are different. So, even though the workflow will cover many of the tasks that need to be done for any CBM play, it is very probable that this procedure will need to be adjusted and customized to the specific play.

A secondary objective of this paper will be to demonstrate practical application of fairly high-level CBM scientific theory in practical, real-world project settings. The main body of the paper will focus on the step-wise process of "How-To", with only some explanation. But there will be distinct need, at times, for some technical discussion of the "Why" in various sections.

COAL SEISMIC DEPTH CONVERSION FOR MINE DATA INTEGRATION: A CASE STUDY FROM THE SANDY CREEK 3D SEISMIC SURVEY

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In general, seismic data are presented in two-way reflection times but seismic times are not easily directly scalable to depths due to the variations of seismic velocity in space. Apparent structures in the time domain can be misleading. Conversion of seismic time sections to depth sections removes this ambiguity. In general, seismic depth conversion is a complex process requiring careful use of NMO and migration velocities, the study of well data and the generation of synthetic seismograms. The process is usually iterative, especially when the structures are complex. In this paper, we present a depth conversion algorithm designed for coal seismic data. Our method assumes that the coal seam structures are relatively simple and that there are numerous boreholes available to constrain the process. Once converted to depth, the seismic data can be exported into mine planning software and used to provide seam elevations for tasks such as in-seam drilling and other mine activities. Our method has been implemented into an MS Windows based program SeisWin and allows new boreholes to be incorporated without the need to go back to the original seismic processing contractor.

A 3D seismic data set from Xstrata's Sandy Creek mine is used to demonstrate our method. The results show that the depth conversion algorithm can accommodate different seismic processing. The depth-converted seismic data agrees with the geological model based on borehole data and from underground surveys. Given the confidence in the depth conversion, it is possible to look more closely into the data in order to make more detailed interpretations.

CAN 1D METHODS GENERATE USEFUL STARTING MODELS FOR TOMOGRAPHIC INVERSION OF NEAR SURFACE REFRACTION DATA?

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Tomographic inversion is seeing greater use in deriving velocity models of the near surface from seismic refraction data. However, case studies demonstrate that often, the models generated with tomography are significantly different from those generated with long standing widely accepted standard methods, such as the generalized reciprocal method (GRM). (See the Mt Bulga case history at http://www.bees.unsw.edu.au/staff/academic/palmer/starting_models.pdf). A major component of the tomographic methods is the generation of a starting model using a one dimensional (1D) algorithm, such as the tau-p algorithm. There are two major problems with this approach.

The first is that it is questionable whether the near surface can be realistically approximated with a 1D model. In this region, there can be large changes in both depth to, and seismic velocity within the target refractor. As a result, the traveltime graphs can show changes in slope which are caused by a 2D subsurface. However, 1D inversion algorithms do not recognize that these lateral variations are the result of a 2D subsurface and instead, generate a multiplicity of layers which are commensurate with a 1D interpretation.

In addition, tomographic inversion employs continuous velocity gradients, rather than distinct changes at interfaces. As a result, they are unable to accommodate velocity reversals, which are not unusual in the near surface. Furthermore, depths can be considerably larger than with GRM approaches.

This paper demonstrates the generation of a 1D model of the near surface from the inversion of surface waves. This model is computed independently of the first arrival refraction data, and is able to accommodate surface waves.

The comparison of tomography, GRM, RCS amplitudes, and surface wave inversion is very revealing!

SESSION 2 / STREAM 2

COAL AND COAL BED METHANE 2

UTILISATION OF FRACTURE PATTERNS FOR OPTIMISING CBM PRODUCTION IN THE SOUTHERN SYDNEY BASIN, AUSTRALIA

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This paper overviews Sydney Gas Ltd's ("SGL's") coal seam methane ("CSM") resource development program in the Sydney Basin in New South Wales, Australia. SGL's acreage provides an extensive contiguous coverage of the Sydney Basin, and is ideal as it straddles the main gas transmission line from Wollongong to Sydney to Newcastle.

An extensive study of the coal cleat system formed during coalification and the fractures that subsequently developed at both meso- and micro-scales, has recently been conducted in some fully cored boreholes located within SGL's Petroleum Exploration Licence No 2 ("PEL 2") in the Sydney Basin. Although the study is still ongoing, some interesting results have emerged for discussion.

Detailed fracture analysis has enabled SGL to construct the historical strain configuration for defining the indicative paleo and present stress orientations. The results are comparable with numerous sub-surface stress measurements performed in the Basin. These fracture data sets have enabled SGL to better design its production completion technique and thereby optimise the reservoir stimulation program for enhanced CSM production.

Production results have been further enhanced through the identification of a "High Production Fairway" within the study area. Fairway delineation was based on a range of reservoir characteristics which, in combination with initial production data, revealed a strong correlation between high production wells, gas content and gas composition distribution in the area.

GEOPHYSICAL STUDIES IN THE BOWEN BASIN: A COLLABORATIVE APPROACH

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Joint research on geophysical exploration for coal between the New Energy and Industrial Technology Development Organisation (NEDO) in Japan and the Queensland Department of Natural Resources, Mines and Energy covers three main components: (1) verification and evaluation of a previously developed coal exploration and assessment system, (2) a Coal Potentiality System, and (3) the regional geophysical and geological framework.

A test site at Coppabella Mine was used to create a geological model using the Kinematic Modelling System. Input into the model included drilling, geophysical logging, vertical seismic profiling, 2D and 3D seismic and gravity. The model is being assessed against the results of mining. Airborne magnetic and radiometric data are being progressively collected over the Bowen Basin. Data collected and interpreted to date have enhanced our understanding of the basin, in particular, the tectonic and structural history. The Coal Potentiality Evaluation System comprises three main parts: a series of databases, a GIS and the coal potentiality system which is an expert system. The GIS and Coal Potentiality System interact through a mediator. The databases provide geological, environmental, mining and economic data. The Coal Potentiality System was used to help define a project area in the northern Bowen Basin for further testing of the geophysical methods. Three fully cored boreholes support 10 km of 2D seismic.

Collaboration at an international and a local scale has been highly effective. It has provided ongoing development of geophysical exploration techniques, has provided an impetus for the re-evaluation of the geology of the Bowen Basin and has provided an avenue for the exchange of geophysical technology and ideas.

THE ARTIFICIAL INTELLIGENCE AND THE LITHOLOGICAL EVALUATION - CASE STUDY THE JIU COAL BASIN, ROMANIA

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The essential role of the geophysist is to evaluate the data according to the borehole measurements. These measurements represent data with a wide diversity of conditions. As interpreter, the geophysist has to posses and develop individual abilities, able to assimilate and compare various types of data, in order to produce reasonable explanations. The geophysical investigation in the Jiu valley, Romania, made since 1956, revealed, by "eye" observations, some specific criteria, able to characterize certain litological units. Still, these marker seams are disputed. By developing and using a neural computing approach, the authors succeeded to reveal by using a neural net these marker seams, along with the main litological types and to eliminate any further comment relative to this topic. A special neural computing program has been designed to evaluate directly the digital data of the logged geophysical curves.

SHALLOW, HIGH-RESOLUTION CONVERTED-WAVE SEISMOLOGY FOR COAL EXPLORATION

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Despite the considerable successes of multi-component seismology in the petroleum industry, there has been relatively little effort devoted to shallow, high-resolution converted-wave imaging in the coal sector. By analogy to petroleum-scale applications, converted-wave imaging in the coal environment offers interesting possibilities for independent validation of mapped structures, clearer imaging in the shallow sub-surface, and detection of gas, sandstone channels and/or fracture swarms.

Over the past two years Velseis Pty Ltd has conducted the first experiments in Australia to utilise shallow, high-resolution multi-component data and converted-wave technology to image coal seams. Three 2D multi-component coal-seismic datasets have been acquired in the Bowen Basin, Australia. Only minimal changes to conventional recording equipment and procedures have been required. A conventional dynamite source has been used, with a single, multi-component geophone replacing the conventional array of vertical geophones at each receiver.

Converted-wave processing algorithms developed within the petroleum sector have been successfully applied to the three trial datasets. This has involved specialised approaches to S-wave receiver statics, PS normal moveout and common conversion-point binning. Considerable experimentation to fine tune processing parameters and the converted-wave processing sequence has been necessary for optimum handling of the shallow, high-resolution data. Overall the processing of the PS data has been significantly more challenging, and has required more geological input, than conventional P-wave processing.

This research has demonstrated that converted-wave imagery is viable in the shallow environment. The derived PS images can extend the interpretation achieved with conventional P-wave images.

SESSION 3 / STREAM 2
TECHNOLOGY CASE STUDIES

3D SRME APPLICATION IN THE GULF OF MEXICO

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The effective removal of surface multiples is critical for imaging subsalt structures in the deepwater Gulf of Mexico. The widely used 2D surface-related multiple elimination (SRME) is inadequate for rugose reflectors. We extend the SRME methodology to three dimensions through the construction of high density and wide azimuth data. We demonstrate the success of our method with results from a case study.

LITHOLOGY AND FLUID PREDICTION IN LIGHTLY EXPLORED BASINS

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In this paper we present a methodology for performing lithology and fluid prediction in lightly explored basins. We use the deep water area of the Orange Basin, offshore South Africa to illustrate the methodology. In the Orange Basin, there are numerous wells drilled on the shelf, however, there have been no wells drilled in the deep water.

Firstly, petrophysical analysis of the shelf wells is performed to determine end member properties of the sands and shales. From the analysis, rock property trends such as Vp versus Vs and Vp versus density are determined. In addition, the uncertainties associated with the trends are also calculated. A critical step in extrapolating from the shelf to the deep water is to use seismic derived interval velocities to improve the estimate of Vp as a function of depth. Using seismic interval velocities and well data, we derive expressions for Vp of the sands and the shales that are functions both of depth and seismic interval velocity.

The rock property trends are used to perform stochastic AVO modelling for single interfaces. The AVO modelling gives an estimate of the average response of interfaces such as shale-to-brine sand and shale-to-gas sand interfaces, as well as a measure of the uncertainty of the estimate. Therefore, a range of AVO responses is provided. Lastly, the AVO modelling is compared with AVO anomalies observed on the seismic data.

INDUSTRIAL EVOLUTION OF DEPTH IMAGING MODEL BUILDING TECHNIQUES - A TIMOR SEA CASE STUDY

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The evolution of depth imaging technologies in the past ten years has seen significant changes in the way we built velocity-depth macro models used by pre-stack depth migration algorithms. Both the observation of the data used for tomography inversion of macro models and the performance of inversion themselves have undergone significant changes in the recent years. This has lead to new model building methodologies.

Depth imaging has been (and still is) regarded as a state of the art - yet long and expensive - solution to improve the quality of the interpretation material. How can new trends in model building methodologies provide solutions to faster, yet high quality depth imaging products? We attempt to answer this question.

A case study is presented where a comparison is made between two pre-stack depth migration results obtained with two different depth imaging model building techniques performed on the same dataset. At an industrial scale through this example we try to identify the key elements of the methodology that can make differences to the quality of the final product and the speed at which we obtain it.

For obvious economic reasons, rare are the opportunities to look at new technologies on the same field dataset where the work has been performed both before and after the evolution. However, the opportunity to examine such evolution has been made possible for depth imaging model building techniques with this Timor Sea case study.

IMPLEMENTATION OF VOLUME INTERPRETATION IN REVEALING UPSIDE POTENTIAL IN A MATURE FIELD, THE SANGATTA OILFIELD: A CASE STUDY

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The Sangatta Field is a shallow, medium sized oilfield, located in prolific Kutai Basin and was discovered in 1939. Field production began in 1972. Primary production derives from a Mid-Miocene fluviodeltaic reservoir. Three deep exploratory wells drilled on a crestal position in the mid-70's failed to encounter reservoir quality rock and paleontologically exhibited a deeper marine environment. Following conventional structural interpretation based on 3D shooting in 1993, a comprehensive 3D volume interpretation was conducted recently. This new method which combined conventional 3D interpretation with power of visualization, enabled interpretation of simultaneous multiple seismic attributes as single objects that improve the degree of confidence. This method eventually has revealed subtle seismic signatures that can be interpreted as a volumetrically significant geological body that possess reservoir quality and becomes an attractive exploration target. Further to this study, four deep exploratory wells are scheduled to be drilled during this year's drilling campaign.

SESSION 4 / STREAM 2

SEISMIC PROCESSING I

HYBRID VELOCITY MODEL PRESTACK IMAGING

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Deep-water marine seismic data often suffer from non-hyperbolic moveout distortions generated by highly variable seafloor topography.

The non-hyperbolic moveout is a result of lateral velocity variations across the rugose/dipping water bottom. Time migration assumes no lateral velocity variations and hence is unable to deal with these variations. The result of using a time migration algorithm is both a substandard image and perhaps more importantly, significant lateral movement of events. To overcome this limitation a hybrid depth migration coupled with a time velocity model building procedure is proposed.

With this procedure the non-hyperbolic moveout distortions caused by highly variable seafloors are accounted for. The only cost is in the added expense of running a Pre-Stack Depth algorithm rather than a Pre-Stack Time algorithm. The model building effort is comparable.

3D SEISMIC TRACE INTERPOLATION USING NONCAUSAL SPATIAL FILTERS

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Seismic datasets are often spatially undersampled in 3D exploration. Trace interpolation, a well-known solution to this sampling deficiency, is often used to generate unrecorded traces from a spatially undersampled dataset. One interpolation method used routinely for this task is the so-called f-x domain prediction filter interpolation method. This method operates on 2D seismic data to interpolate spatially aliased events. For 3D data, it is possible to extend the method to the f-x-y domain.

F-x-y prediction filters operate in the frequency space domain where for each frequency plane a two-dimensional prediction filter is computed. The 2-D filter can be computed by either 1) solving for a quadrant filter and then placing its conjugate flipped version opposite itself, this is called a pseudo-noncausal filter; or 2) solving for all the prediction coefficients in a single operation, this is called a non-causal filter.

While pseudo-noncausal filters are commonly used in trace interpolation methods, their non-causal counterparts can offer some significant advantages, namely, they are more centre-loaded, less sensitive to the size of window used in their derivation and better in handling amplitude variation.

In this paper we show how the technique of 2-D trace interpolation can be extended to 3-D trace interpolation. In addition, we demonstrate the benefits of using non-causal prediction filters over their pseudo non-causal counterparts through their applications on synthetic and field data.

AN EFFICIENT EXPLICIT 3D PRESTACK DEPTH MIGRATION

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An explicit, constrained operator is used for wavefield extrapolation in 3D wave equation depth migration. The migration cost and image quality benefit from its reduced number of independent coefficients, negligible numerical anisotropy, and flexibility that allows for different propagation angles and step sizes in the inline and crossline directions. In order to further reduce the computational workload we dynamically select operator lengths and extrapolation step sizes based on the wavenumber of the wave components being migrated. The phase-shifted linear interpolation that we propose for interpolating the extrapolated wavefield is suitable for the explicit migration, and significantly improves the accuracy of the result when compared with the linear interpolation typically used in implicit migrations.

PRACTICAL EVALUATION OF P AND S-WAVE SEPARATION VIA ELASTIC WAVEFIELD DECOMPOSITION

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Compressional (P) and shear (S) waves respond differently to the earth's geology. Hence an integrated interpretation of multi-component seismic data should provide more information about the sub-surface than is available from P-wave data alone. Conventional multi-component seismic analysis uses scalar component selection to provide P- and S-wave images. This approach has proven successful in many situations. However, where P energy contaminates the horizontal components, and S energy contaminates the vertical component, there is potential to achieve purer P- and S-wave records by more fully exploiting the true vector nature of multi-component seismic data.

One elegant vector-processing technique, here referred to as elastic wavefield decomposition (EWD), takes advantage of the P- and S-wave separation properties of the divergence and curl operators. Practical implementation of EWD requires information about the seismic wavefield at depth. This is achieved via downward continuation of the elastic data in the time domain via a finite-difference approach.

Synthetic and real on-shore multi-component seismic data are used to evaluate the practical viability of EWD for real-data applications. The robustness of the wavefield separation is dependent on the accuracy and smoothness of the velocity model used during the downward continuation stage of the algorithm. Velocity errors of up to 10% can be tolerated, after which significant artifacts appear in the separated records. A smooth velocity model will avoid contamination by spurious reflection events. P/S separation is still effective where a constant velocity model is used for data suffering from statics associated with lateral inhomogeneities in the near surface. Moderate noise contamination does

not seem to significantly impact on the wavefield separation results. In fact, the downward continuation process appears to suppress random noise. Application of EWD to a real two-component record appears to enhance the relative strength and coherency of the P- and S-wave reflection events in the extracted P and S records.

INVERSION FOR THOMSEN'S ANISTROPY PARAMETERS

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In order to extend seismic processing techniques to anisotropic media, it is required that we have a measure of the different anisotropy parameters.

The purpose of this study is to estimate the Thomsen's parameters, e and d, for transversely isotropic (TI) media using the shifted hyperbola NMO equation by Castle.

A non-linear inversion technique has been developed to invert the Castle's Shifted Hyperbola NMO Equation for obtaining the shift parameter. This method will be used for the estimation of these parameters over the Blackfoot field in western Canada.

SESSION 1 / STREAM 3

REGIONAL MAPPING

A VIRTUAL NATIONAL DATA GRID FOR AUSTRALIA - CURRENT SITUATION AND VISION FOR THE FUTURE

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Seamless access and efficient management of vast quantities of resource data is a significant and increasing challenge for both government and industry. CSIRO and Schlumberger embarked on a joint a study of geoscience data exchange between industry and government, based on their complementary domain of expertise and networks of national agencies and industry.

It is clear that rapidly increasing volumes of data, the need for faster more efficient business practices, low-price data storage and higher Internet bandwidth will change the way that companies and governments do business. To explore current perceptions and future directions for geoscience data management and data exchange, interviews were conducted with 19 petroleum companies, 9 minerals companies, 11 government groups, 4 software providers and 2 CRCs.

Perceptions in data exchange vary widely between industry and government. However some common themes emerge: few groups have the resources to properly manage, curate and add-value to data. Much time is spent (and wasted) in moving data around. Companies generally 'minimally comply' with regulations for data submission as they see little advantage in putting any more time into data submission than is required by legislation. Finally, data management is usually seen as a financial and administrative burden rather than an enabler to add value.

The vision promoted by most people visited can be summarised as the immediate need for a "Single interface that delivers all validated spatial geoscientific data independent of database structure and location". The need for multi-agency collaborative virtual databases is clear, and the way forward is as much controlled by policy issues as with technological enablers.

THE SHUTTLE RADAR TOPOGRAPHY MISSION-A NEW SOURCE OF NEAR-GLOBAL DIGITAL ELEVATION DATA

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The Shuttle Radar Topography Mission (SRTM) has generated a homogeneous near-global digital elevation model (DEM) of the Earth using single pass radar interferometry. The crew of Space Shuttle Endeavour (STS-99) operated the modified dual antenna synthetic aperture radar systems for 11 days in February 2000. SRTM acquired both C-band and X-Band synthetic aperture radar data, collecting 3-D data using a 60-metre mast extending from the shuttle payload bay, containing additional C-band and X-band receiver antennas.

SRTM DEM data have a horizontal resolution of 1 arc second (30 m at the equator) and vertical resolution of 10 m (C-band radar). SRTM-1 (1 arc second) data are only available for US territories with subsampled SRTM-3 (3 arc second) data provided for the rest of the world. The USGS are responsible for archiving the data with 3 arc second data being made available on a continent by continent basis. So far North and South America and Eurasia have been completed and the rest of the data processing is expected to be complete by July 2004. Comparison of SRTM DEM data with older GTOPO and altimetric DEMs shows a significant improvement in resolution, similar to that achieved by ASTER. The SRTM DEM data provide a useful new resource, especially in areas where limited topographic data are available. The data are free and in a simple format.

A CASE STUDY USING RADIOMETRICS AS A FIRST PASS TECHNIQUE TO GEOLOGICAL MAPPING IN THE MUSGRAVE PROVINCE IN SOUTH AUSTRALIA

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The use of radiometrics as a regional geological mapping tool is widespread. Ternary, single band, ratio images, profile sections and data fusion techniques were applied to airborne gamma-ray spectrometry data of the Musgrave Province in South Australia. Chemical variations, previously unrecognised were used as a basis for subdividing and mapping key lithologies of Birksgate Giles Complex, and the Kulgera Suite Granites.

Variations in emissivity were found to occur in conjunction with one or more of the following:

- key tectonic structures,
- in some cases differing magnetic susceptibility, and
- within distinct tectonic domains.

Due to limited geological mapping little is known about the Musgrave Province. However, the Giles Complex is considered as a unit of economic significance for nickel sulphides and PGE, so the need to map its extent becomes vital. Groundtruthing is required to determine the causes of emissivity variations, which may be due to alteration associated with hydrothermal fluids or mineralogical/lithological variations within geological units.

GAWLER CRATON UNCOVERED

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The 2003 Gawler Seismic Survey acquired 250 km of 60-fold, deep seismic reflection data along two intersecting lines in order to investigate the crustal structure of the eastern Gawler Craton, South Australia. Seismic reflection data processing has produced images of the crust down to the Moho, through the overlying Neoproterozoic successions, the Mesoproterozoic and Palaeoproterozoic Gawler Craton basement, and the

Palaeoproterozoic to Archaean middle crust. Of particular interest is the crustal structure imaged in basement in the vicinity of the Olympic Dam Cu-U-Au deposit.

The Gawler Craton seismic data show that the Olympic Dam deposit lies between two regions of different crustal structural character. The southern half of the north-south traverse is dominated by a series of northward dipping reflectors, some of which correlate spatially with interpreted faults. The northern half of the traverse contains little evidence of this style of faulting. The seismic data show the presence of a major unconformity that extends across this part of the Gawler Craton. A cover sequence with maximum thickness in excess of 5 km lies above this unconformity.

THE TANAMI 3D GEOLOGICAL MODEL - INTEGRATING GEOLOGY AND POTENTIAL FIELD DATA

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This study presents a 3D model of the regional geology of the Tanami region, Northern Territory. The Tanami region consists of large areas of shallow cover material obscuring multiply deformed Archaean and Palaeoproterozoic metasediments and granites.

The model consists of a skeleton of 19 serial geological cross-sections that have been tested by potential field modelling. The sections were located to cross geophysical anomalies at right angles to simulate a 2D modelling environment, while crossing regions of outcropping basement geology. The process of potential field modelling necessitated continuous reappraisal of the existing geological data and possible interpretations.

Modelled sections and basement interpretation maps were captured, spatially arranged and used to interpolate regional structures and features in 3D space. Modelled sections, interpolated surfaces, basement maps and other data sets were then combined in a simulated 3D space to produce the final web accessible model.

The final interpretive model provides unique simulated 3D views of the main geological structures and elements of this poorly exposed domain. In doing so, the model provides a framework to better constrain the gross crustal architecture of the region.

SESSION 2 / STREAM 3

MINERAL EXPLORATION – BROWNFIELDS

BOREHOLE LOGGING AND AUTOMATED INTERPRETATION OF DRILL HOLE LITHOLOGY FROM THE MUROWA KIMBERLITE, ZIMBABWE

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The first of the diamondiferous Murowa kimberlites was discovered in December 1997 through the follow-up of anomalous indicator stream sample results. From March 1997 until the year 2000 a program of drilling and shaft sinking was carried out to evaluate the resource. Borehole logging formed an integral part of the evaluation process used to define lithologies, measure densities and calculate sample volumes.

The five hypabyssal bodies at Murowa are a complex mix of various kimberlite lithologies which make accurate geological logging, especially of reverse circulation holes, difficult. Dual neutron, gamma-gamma density and magnetic susceptibility logs were used to estimate kimberlite and host lithology proportions in the reverse circulation holes as a routine part of the geological logging process.

Analysis of the physical properties of the various lithologies indicated that any brecciation and mixing of the hypabyssal macrocrystic kimberlite with country rock inclusions is reflected by a reduction in magnetic susceptibility. The lower apparent resistivities of the kimberlite lithologies within the resistive granite host explain why the pipes respond as conductors to surface geophysics.

LogTrans, a program developed by the Centre for Mining Technology and Equipment, Brisbane, was used to perform automated interpretation of the geophysical borehole logs. The software calculates the median values and ranges for each physical property for each lithology in a suite of training holes, and then applies these statistics to interpret data from other holes. Data from the diamond drill holes were used for training, and interpretation was carried out on the reverse circulation holes. LogTrans was also used to estimate kimberlite content based on a linear relationship at Murowa between percentage of kimberlite and apparent neutron porosity.

THE USE OF BOREHOLE RADAR FOR THE DELINEATION OF THIN TABULAR OREBODIES AHEAD OF MINING

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A significant portion of South Africa's current gold resources come from the Ventersdorp Contact Reef (VCR). The VCR is a tabular orebody, generally less than 1.2 m thick. Slopes, terraces and faults impact on VCR geometry. Gold is generally concentrated in palaeochannels, corresponding to terrace elevations. Conversely, slopes are generally associated with lower gold grades. To be able to site support pillars, such that they correspond with lower gold grade slope areas, has significant financial benefit. The geophysical challenge is, thus, to model the reef geometry prior to mining in order to facilitate optimal ore extraction.

Borehole radar has proven to be applicable for mapping topography on the VCR. In this paper a case study is presented where radargrams and 3D visualization from three boreholes show continuity of geometrical features on the VCR target horizon. The improved confidence in the geological model has an immediate impact on resource estimation and mine planning with immediate financial benefits.

BOREHOLE RADAR APPLICATION TO KIMBERLITE DELINEATION AT FINSCH DIAMOND MINE

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Finsch Mine is a world class diamond mine in the Northern Cape province of South Africa, producing roughly 2.4 million carats annually. The mine is currently busy with a project aimed at determining the feasibility of exploiting the resource below the current extraction level located 630 m below surface (Block 5).

In order to assist with delineating complex kimberlite pipe morphology at depth, the mine embarked on a project to evaluate borehole geophysical techniques that could be applied to detect and map the contact of the kimberlite pipe.

To this effect, GeoMole borehole radars (BHR) were deployed down two boreholes at 650 m level to perform single hole profiling as well as cross-hole scanning surveys. The objective of the BHR survey was to determine whether coherent reflection from the kimberlite-country rock interface could be obtained, and to establish the limits on the operational parameters such as range and resolution.

After data processing, using GeoMole's SeisWin software, a coherent reflection from the kimberlite pipe contact was clearly observed from distances up to 60 m through the dolomite country rock. The kimberlite interface appears to be quite sharp, cemented, smooth and curved. The BHR results indicated that the kimberlite pipe surface did not resemble a

smooth cone, but revealed three horizontal rounded ridges, penetrating 4 m to 8 m into the country rock, across the imaged flank of the pipe.

The range, resolution and accuracy obtained from the BHR surveys at Finsch Mine are of such high quality that it enhances the detail of and confidence in, pipe morphology significantly. This allows for more accurate geological modelling and resource estimations, resulting in meaningful project evaluation, tunnel design and ultimately sound investment decisions.

SUB-AUDIO MAGNETIC SURVEY EXPERIMENTS FOR HIGH-RESOLUTION, SUBSURFACE MAPPING OF REGOLITH AND MINERALISATION OVER A BLIND GOLD DISCOVERY NEAR AGNEW IN WESTERN AUSTRALIA

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Experimentation with sub-audio magnetic (SAM) survey parameters over a recently discovered Archaean mesothermal gold deposit demonstrates that this technology can be effective for identifying conductive, mineralised structures and regolith features at high resolution to a depth of 100 m, as long as the transmitter electrodes are placed sub-parallel to the strike direction of features to be detected. The horizontal TFMMR response produced by current channelling during SAM surveying is shown to have a very similar pattern to gradient array apparent conductivity results using 50 m dipole spacing or less. However, SAM TFMMR data are recorded using a magnetic sensor, thus avoiding electrical contact with the ground, and 2 m along line sample density provides much greater resolution. TFMMR anomaly trends were found to correspond to gold mineralised shears, and dips of these shears estimated using gravity modelling methods agree with drilling results. The main ore zone forms an elongated, shallow plunging pod of weakly chargeable ore that shows up in gradient array and dipole-dipole IP surveys. SAM TFMMIP was ineffective at imaging this ore zone using surface transmitter electrodes and 1Hz transmitter frequency. However, the SAM TFMMIP response of the main ore zone was later imaged in great detail by placing transmitter electrodes down boreholes into a shallow part of the ore body, and then down plunge 700 m to the south. SAM surveying using optimal survey parameters identified shallow conductive shears and deeper chargeability anomalies within the main ore zone that correlated to economic gold mineralisation, and the SAM results helped to target resource definition drilling.

REFLECTION SEISMIC SURVEYS AT ST IVES GOLD MINE, WA

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In September 2002 a medium resolution seismic reflection survey was undertaken at the St Ives Gold Field, Western Australia. The data were acquired by the Australian National Seismic Imaging Resource (ANSIR) using two Hemi60 vibrators and an ARAM24 acquisition system. The data were processed, and correlated with drillhole geology and drillhole geophysics to facilitate interpretation.

The seismic sections demonstrate that seismic reflection is effective at imaging stratigraphy and structure in Archaean terrains, even at relatively shallow depths (less than 500 m). A package of strong reflections is associated with the mafic stratigraphy at St Ives. A complex pattern of reflectors at the Victory Mine is correlated with a fault network interpreted from drilling. Results indicate that seismic reflection could be used for the discovery of new gold orebodies in this mature exploration province.

SESSION 3 / STREAM 3

Euler Depth Determinations

TOWARDS AUTOMATED MAPPING OF DEPTH TO MAGNETIC/GRAVITY BASEMENT - EXAMPLES USING NEW EXTENSIONS TO AN OLD METHODTITLE FIELD

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The Euler method of automating depth to source from potential field data has undergone resurgence in popularity, with several new extensions to the method developed. Perhaps the most revolutionary of these provides a solution of the structural index as part of the inversion process. Previously, structural index was a required input parameter. Many solutions are generated with the Euler method, and care is used to select the most appropriate. In some cases, accuracies of depth estimates within ±15% of depth of actual source below acquisition height are achieved.

Examples of Euler depth results from across three representative areas of Australia are used to demonstrate the utility of the method. Data are presented by several methods, including full 3D visualisation, which allows the solutions to be integrated with other data and inversion results. A depth to basement map of the Springvale 1:250 000 map sheet area in Queensland has previously been generated using the Naudy technique, and those results provide a useful comparison with depths derived using the Euler method. A small area in the eastern Yilgarn, Western Australia, contains an elongated sedimentary basin overlying shallow basement cross-cut by numerous dykes and faults. The magnetic expression of basement can be traced from near surface to a few hundred metres depth under basin cover. This is a good test of the method for providing estimates along the incline from outcrop to increasing thickness of cover. Basement to the eastern Gawler Craton (Olympic sub-domain) lies under several hundred metres of cover, and Euler depth estimates for this area are also examined.

YUMBARRA - A CASE STUDY IN GEOPHYSICAL 3D MAGNETIC MODELLING

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Yumbarra Conservation Park, in the State's west, is one of South Australia's most unspoilt parks and, is considered to have high conservation value. In November 1999 the South Australian government re-proclaimed Yumbarra Conservation Park to allow mineral exploration and mining. Yumbarra has become a test case of how exploration can be conducted within a conservation park. After considering environmental sensitivities, the acquisition of passive remotely sensed data became the preferred methodology in order to minimise disturbance. High resolution airborne geophysics was acquired over the region to better define the Yumbarra anomaly.

These data were extensively interrogated to provide solutions and models. The intent of undertaking this work was to reduce risk for the explorer and minimise any impacts of exploration on the region through the development of a more focused program based on the magnetic modelling results.

Extensive depth modelling was completed where Euler depth solutions, and mrG-strings were used to augment existing data and assist in exploration program design. Utilising 3D block modelling applications PIRSA geophysicists were able to achieve an improved understanding of the target anomaly to be tested. The results provided better defined regions for drill testing, which will further minimise any surface impacts.

A MULTILEVEL GENERALIZATION OF EULER DECONVOLUTION AND ITS COMPARISON WITH THE CONTINUOUS WAVELET TRANSFORM

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Recent implementations of Euler deconvolution allow simultaneous solutions for the source position and the structural index. This opens the way to a comparison between this technique and the Continuous Wavelet Transform (CWT) method that allows the estimation of essentially the same parameters. Direct comparison of Euler deconvolution and CWT methods is possible only by applying the first method to a potential field upward continued to many altitudes. While the two methods give very similar results when the gravity or magnetic field of a one-point source is concerned, they behave different for those sources characterized by fractional structural index, as many real geologic structures are (for example a limited throw fault).

In this paper, the variation of the Euler estimated parameters at many altitudes above a magnetized prism is described. Such a variation gives additional information on source geometric parameters and position, which may be recovered from plots of estimated depth and structural index vs. altitude: a) the extended or one-point nature of the source results clearly; b) it is possible to understand to which part of the source the depth estimate is related to; c) it is possible to get indications about the source thickness and lateral dimensions. On the other hand, for sources of finite extent, the CWT analysis may be made only for sets of levels and not at any level, differently from the above outlined Euler deconvolution approach. Nevertheless the results from these two methods are substantially consistent at high or low altitudes.

SESSION 4 / STREAM 3

PROCESSING MAGNETIC DATA

MINIMISING NOISE PROBLEMS WHEN DOWNWARD CONTINUING POTENTIAL FIELD DATA

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Due to the nature of the Fourier transform geophysical data must be prepared before the transform is calculated. This preparation usually takes the form of the removal of any trend from the data combined with the padding of the data to 2N points at the data edges. However, no data preparation procedure is perfect, and the result is that problems (in the form of edge effects) appear in the filtered data. When high-pass filters (such as derivatives or downward continuation) are used then these edge effects become particularly apparent.

This paper suggests three methods for the stable downward continuation of geophysical data (two of which may be combined). The first method is applied to an integrated horizontal or vertical derivative of the data rather than to the data itself. Since the derivatives can be calculated in the space domain where FFT edge effects are not present, this reduces the enhancement of the data at frequencies near the Nyquist, resulting in smaller edge effect problems. The second method measures the FFT-induced noise by comparing data that has been downward continued using both the space and frequency domain methods. The data are then compensated accordingly, and the compensated data may be downward continued to arbitrary distances that are not possible using space domain operators. The final method treats downward continuation as an inverse problem, which allows the control of both FFT-induced noise and other noise that is intrinsic to the dataset.

A NEW SET OF MAGNETIC FIELD DERIVATIVES FOR MAPPING MINERAL PROSPECTS

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A powerful new set of magnetic derivatives is reported, based on the Tilt derivative and its Total Horizontal derivative. They can be used to map geological structures, magnetic fabric, lineaments and depths more effectively than other commonly used derivatives. The methods described are similar to the local phase and local wavenumber but are formulated differently to make them easier to use in profile- and grid-based methods.

This contribution reveals new insights into why the Tilt derivative is better suited to mapping structure, due to its ability to (a) act as an effective AGC (Automatic Gain Control) filter, (b) out-perform the vertical derivative in mapping the spatial extent of bodies; and (c) map edges of bodies when applied to Reduced to the Pole (RTP) or Equator (RTE) magnetic fields by using the anomaly zero crossings.

The Total Horizontal derivative of the Tilt derivative is independent of inclination of the geomagnetic field and generates maximum values over the edges of bodies. Its negative reciprocal provides depth estimates which can be used to estimate depth to sources over large areas, thus allowing a rapid estimation of whether or not mineralised structures are recoverable.

These derivative methods have been applied to re-evaluating the Erindi gold prospect in Namibia using the recently acquired national high-resolution aeromagnetic data. All map images used in this paper have been generated using GETgrid™.

CONTACT MAPPING FROM GRIDDED MAGNETIC DATA - A COMPARISON OF TECHNIQUES

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Delineating the edges of magnetised bodies is a fundamental application of magnetic data to geological mapping in areas of limited exposure. Especially in Precambrian shield-like regions, locating lateral changes in magnetisation of the outcropping crystalline rocks provides spatial information that is crucial in extending mapped geology into sparsely exposed or completely covered areas. Although not all magnetic contacts correspond to lithological contacts, the former provide key information on structural regimes, deformation styles and trends, and magnetic texture.

Many techniques for contact mapping have been developed, some originally based on profile (2D) data and others designed specifically for grid-based (3D) data sets. Here, we evaluate five methods applied to gridded data. The first three are based on finding maxima of the horizontal gradient magnitude of the total field (TF-hgm), tilt (TI-hgm) and pseudogravity (PSG-hgm). The fourth and fifth methods rely on locating maxima of the analytic signal (AS) and the 3D local wavenumber (LW).

Method TF-hgm produces theoretically correct contact locations only when the data are reduced to the pole, and even then may produce false or secondary solutions mimicking contact trends. Method TI-hgm is less sensitive to field direction but also suffers from secondary maxima. Method PSG-hgm is perhaps the most established approach of those mentioned, and in the case of vertical contacts produces reliable maxima. However, knowledge of remanent magnetisation direction is required. Methods AS and LW theoretically produce maxima directly over contacts and are insensitive to magnetisation direction but are more sensitive to noise than the former, which limits their application to higher quality datasets.

SEPARATION FILTERING USING FRACTIONAL ORDER GRADIENTS

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Separation or layer filtering of regional and residual magnetic fields is an important component of magnetic interpretation. Separation filtering depends fundamentally on the concept of random distributions of sources within discrete layers and assumes that there is no statistical difference in response along each ideal layer and no correlation between the distributions in each layer. Separation filtering becomes very difficult when there is considerable overlap in the spectra of individual depth ensembles. The degree of separation achieved depends on the spectral b/B ratio, the ratio of the amplitudes of the shallow and deep ensembles. A high b/B ratio is needed to deconvolve the effects of shallow sources with minimum contamination by deeper sources.

It is well known that derivatives of potential fields enhance the field component associated with shallow features and de-emphasise the field from deeper sources. Fractional vertical derivatives provide an objective, flexible approach to shallow layer separation filtering as the order of the fractional derivative can be selected to match the data and optimise enhancement of the shallow field component. The method avoids the uncertainties in selecting spectral matched filter parameters. Different order fractional derivatives can be combined to produce RGB images and this can be a significant aid to the interpretation of the data.

The application of fractional derivative separation filtering is illustrated using high-resolution aeromagnetic data covering the Ghanzi-Chobe Fold Belt in Botswana. Total magnetic intensity data are dominated by crystalline basement anomalies. Progressively increasing the order of fractional vertical derivatives provides rejection of deeper basement anomalies and provides improved resolution of subtle supracrustal anomalies than the conventional vertical gradient.

SESSION 1 / STREAM 4

GROUNDWATER

COMPARISON OF SHALLOW SEISMIC AND SEISMOELECTRIC TECHNIQUES FOR GROUNDWATER SURVEYS: A CASE STUDY AT NARROMINE, NSW

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The Australian National Seismic Imaging Resource (ANSIR) acquired medium to high resolution seismic reflection data along three lines of approximately 4 km length near Narromine, NSW. The survey was a joint project with the Australian Nuclear Science and Technology Organisation (ANSTO), aimed at defining potential preferential groundwater flow paths and also to compare well understood seismic data with the less well known seismoelectric (or EKS) technique along the same lines. The site at Narromine was chosen because our collaborators in the NSW Dept. Land Water Conservation had defined a regional boundary to groundwater domains in the vicinity of Line 2. Line 3 is perpendicular to Line 2 and crosses the inferred groundwater domain.

The seismic data were acquired with an IVI MiniVib as the source, split spread geometry with 120 channels and a receiver group interval of 5 m, resulting in nominal 30 fold coverage. Processing involved both refraction analysis of first arrivals to create a velocity model of the subsurface as well as seismic reflection imaging. Critical steps in the reflection processing included high fidelity NMO correction and removal of automatic mutes to preserve data at shallow two way times. The seismoelectric data were acquired using GroundFlow equipment in standard configuration with both a hammer and shotgun seismic sources.

The statigraphy in the region consists of a bedrock mapped as the Devonian Hervey Group coarse grained quartzose sandstone with reddish siltstone, overlain by unconsolidated regolith and alluvium. A palaeochannel of the inferred path of the Macquarie River is intersected on Line 1. Bedrock features are observed in both the refractor models and the seismic sections, in particular, prominent highs on two intersecting lines. These highs are also interpreted on the seismoelectric sections.

Seismic surveys thus complement seismoelectric surveys by providing an independent image/model of the subsurface and a velocity model for depth conversion.

GRAVITY MONITORING WITH A CG5 SCINTREX AUTOGRAVIMETER

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A new Scintrex gravimeter, CG5, was released onto the market in 2002. The CG5/352, which was upgraded from the CG3M/352, was tested at various fields. CG5 meter has a new raw data acquisition mode. If the mode is enabled, unprocessed 6 Hz data (gravity, tilt-x, tilt-y, and temperature) are stored in memory. I examined the potential of the raw data recordings to improve the efficiency of gravity monitoring.

Long-term changes which evolve over months and years can be monitored by gravity measurements with profile or areal coverage at respective repetition intervals. If short-term changes are expected, high repletion rates and/or continuous gravity recordings will be required. Postprocessing the raw data is effective to detect signals both in the cases. A combination of the continuous measurements and reiteration surveys with CG5 meter can cover a considerable part of the ranges both in time and space domains.

INFLUENCE OF CAPILLARY FRINGE ON THE GROUNDWATER SURVEY USING GROUND-PENETRATING RADAR

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Ground-penetrating radar (GPR) is well known as one of the best tools to detect the groundwater surface. However, very few people take into account the effect of a capillary fringe over the water table with a groundwater survey. Water contents vary from 100 percent to several percent in this capillary fringe. The behaviour of contaminants is highly influenced by this transition zone. This also has an impact on the design of detailed exploration such as a time-lapse survey. In this study, we took a stepwise approach to examine the influence of the capillary fringe. First, the response of electromagnetic waves reflected from water table was examined in a small scale model in our laboratory. The result indicates that multiple reflections are sometimes detected around the water table and the capillary fringe. It also proved that the wave event which is considered to be reflected on the water table was actually emerged from the transition zone of water content inside the capillary fringe. The waveform of this reflection is not sharp compared with other reflections. This is because the dielectric constant gradually increases in the capillary fringe. In the second step, a field survey was applied to the edge of the Kurobe alluvial fan along the seashore. Our instrument having real-time kinematic GPS system enabled us the simple and rapid survey in the wild field with complicated surface roughness. Observed reflections are unshapely detected as the similar shape shown in the scale model experiment. Finally it is concluded that the influence of the capillary fringe should be taken into account the analysis of the detailed groundwater survey.

HYDROGEOLOGICAL MAPPING USING THE SEISMOELECTRIC METHOD

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Seismoelectric methods are based upon physical properties of the earth that produce electrical signals from seismic waves. The electrokinetic sounding (EKS) is one such method that has great potential for hydrogeological studies as it arises from the movement of pore fluids under seismic excitation. In theory, the method should be able to directly map changes in hydraulic permeability, rock porosity, or fluid-chemistry. A number of researchers have recently tried to exploit the phenomenon in groundwater problems where the conventional methods worked poorly. However, publications of successful case histories to support the theory are rare. This may be blamed upon the very weak amplitudes of the electrical signals generated from the seismic wave which are milivolts to nanovolts in magnitude, and the presence of cultural noise which is usually much greater in magnitude.

We demonstrate electrokinetic responses from formations more than 50 m deep in two test areas in Western Australia. One is over a saline paleochannel and the other over a freshwater aquifer. The data were generated from a sledgehammer source and recorded by a seismic acquisition system. Seismic refraction and reflection data provide seismic velocity information for depth conversion and support the seismoelectric data. The signals were then compared to borehole logs to find what physical contrasts were detected. Significant hydrogeological boundaries were detected up to 50 m deep in saline groundwater conditions, and at least 80 m deep in freshwater aquifers. In addition, we examine some pitfalls in the method and our approach to overcoming these problems.

GROUNDWATER RECHARGE MAPPING USING AIRBORNE RADIOMETRIC DATA

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In areas of dryland salinity identification of potential recharge areas is important in guiding remedial land use changes. In this study areas of high, moderate and low potential recharge were mapped using geophysical data in a study of the extent, causes and remediation of land salinity in the Bengworden area in eastern Victoria. Radiometric and digital elevation data from airborne geophysical surveys were used for to separate the data into classes using unsupervised classification. Further information was derived from topographic maps, magnetic data, and geomorphological studies to assign soil types. Relative potential recharge for each soil type was estimated and the resultant recharge map compared with bore hydrographs.

SESSION 2 / STREAM 4

GEOTECHNICAL 1

KEYNOTE

CONTRIBUTION OF GEOPHYSICS TO MAJOR ENGINEERING PROJECTS

B WHITELEY AND Coffey Geoscience

TOMO-STATICS APPROACH TO REFLECTION PROSPECTING OF URBAN ACTIVE FAULTS

Y ZHUOXIN, L BAOJIN, Z XIANKANG

THE EFFECT OF DIFFERENT ATTENUATION MODELS ON EARTHQUAKE HAZARD IN THE NEWCASTLE AND LAKE MACQUARIE REGION, AUSTRALIA

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Modelling earthquake hazard and risk involves the incorporation of source, attenuation, site response, building damage and financial loss models. Each of these input models has its own uncertainties. Moreover, in most cases there is more than one possible choice for each of the input models. For example, many regions of the world have several attenuation models that can be used in studies of earthquake hazard and risk.

This paper demonstrates the need to incorporate multiple attenuation models when modelling earthquake hazard and risk by illustrating the effect of using three different attenuation models. Results indicate that varying the attenuation model can almost double the earthquake hazard and triple the earthquake risk estimates in the Newcastle and Lake Macquarie region.

UTILIZATION OF SEISMIC SURFACE WAVES (GROUND ROLL) FOR NEAR-SURFACE INVESTIGATION

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Seismic surface waves, commonly known as ground roll in seismic exploration, have been treated as one of most troublesome source-generated noise to be attenuated by any means of acquisition and processing. Because of the dispersion property, however, ground roll can be utilized to solve various kinds of near-surface problems. One of the most common and valuable application is to infer shear-wave velocity (Vs) variation of the near-surface (usually shallower than 30 m) materials that is one of the most critical parameters for most of geotechnical projects. Other applications may include detection of near-surface anomalies such as voids, generation of static correction table to be used for the reflection processing, generation of Poisson's ratio map from a joint analysis with body wave (refraction), etc. The basics of data acquisition and processing adopted in the multichannel analysis of surface waves (MASW) method are briefly explained and some of the typical case studies are presented.

SESSION 3 / STREAM 4

GEOTECHNICAL 2

PASSIVE SEISMIC METHODS USING THE MICROTREMOR WAVE FIELD

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The microtremor wave-field consists predominantly of fundamental-mode surface waves that can provide seismic sounding information. The most common sources of microtremor seismic energy are road traffic, industrial machinery, and meteorological sources such as wave action. Velocity studies with the microtremor wave-field enable passive seismic investigations which are interpreted to yield a shear-wave velocity-depth profile; the technique is an analog of the better-known electrically passive magneto-telluric exploration technique.

The microtremor array method works well in areas where conventional seismic methods are difficult to justify for reasons of cultural noise, environmental restraints and safety.

Recent studies demonstrate the usefulness of the microtremor array method over a range of tasks including: estimation of thickness and shear-velocity of sands overlying lower-velocity clays in 50 to 100 m of Quaternary cover in the Perth Basin, the study of a 15 m thickness of high-velocity basalt overlying river sediments in the Melbourne area, and the assessment of thickness and shear-velocity of sediments to 1000 m depth in the Santa Clara valley, California.

Future possible exploration applications include seismic soundings for reconnaissance mapping of the thickness of regolith over prospective basement rocks, and independent estimation of sediment thickness for complementing EM sounding data in salinity studies.

RESOLVING A VELOCITY INVERSION AT THE GEOTECHNICAL SCALE USING THE MICROTREMOR (PASSIVE SEISMIC) SURVEY METHOD

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High levels of ambient noise and safety factors often limit the use of "active-source" seismic methods for geotechnical investigations in urban environments. A recent field test in Melbourne demonstrates the ability of the microtremor method using only Rayleigh waves, to resolve a velocity inversion resulting from the presence of a hard, 12 m thick basalt flow overlying 25 m of softer alluvial sediments and weathered mudstone. Normally the presence of the weaker underlying sediments would lead to an ambiguous or incorrect interpretation with conventional seismic refraction methods. However, this layer of sediments is resolved by the microtremor method and its inclusion is required in one-dimensional layered-earth modelling in order to reproduce the Rayleigh-wave coherency spectra computed from observed seismic noise records.

Nearby borehole data provided both a guide for interpretation and a confirmation of the usefulness of the passive Rayleigh-wave microtremor method. Sensitivity analyses of resolvable modelling parameters demonstrate that estimates of shear velocities and layer thicknesses are accurate to within approximately 10% to 20% using the spatial autocorrelation (SPAC) technique. Improved accuracy can be obtained by constraining shear velocities and/or layer thicknesses using independent site knowledge. Although there exists potential for ambiguity due to velocity-thickness equivalence, the microtremor method has significant potential as a site investigation tool in situations where the use of traditional seismic methods is limited.

ANTI-DISTURBANCE HIGH-RESOLUTION SHALLOW SEISMIC EXPLORATION FOR SURVEYING OF URBAN ACTIVE FAULTS

Y Zhouxin, L Baojin, Z Xiankang

GENERATING SHEAR WAVE MODELS OF THE NEAR SURFACE

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Shear wave models of the near surface are important for shear wave static corrections for seismic reflection surveys and for geotechnical applications. Shear wave arrivals are commonly present within the standard compressional wave vertical component seismic data.

Compressional and shear wave data seismic refraction data were recorded with two three dimensional (3D) three component (3C) surveys over shear zones at Spicers Creek catchment near Dubbo. The seismic source was an IVI Minivibe which generated both compressional and shear wave signals.

This paper demonstrates the generation of compressional and shear wave refraction convolution sections (RCS) (http://www.bees.unsw.edu.au/staff/academic/palmer/convolution.html), from both compressional and shear wave source signals. In particular, this paper shows how special processing can generate shear wave models using both vertical component signals and a compressional wave vibrator source.

WEDNESDAY
SESSION 1 / STREAM 1
PNG Case Studies

Keynote

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SEISMIC DELINEATION OF NEAR-FIELD EXPLORATION OPPORTUNITIES IN THE PAPUAN THRUST BELT: EXAMPLES FROM THE SE GOBE AREA

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Hydrocarbon exploration within the Papuan Thrust Belt has traditionally relied on non-seismic techniques to resolve the complex subsurface structure. Subsequent appraisal drilling for most PNG discoveries has defined a complex pattern of fault-bounded compartments which show differing fluid contacts and pressure isolation.

The Gobe Anticline forms a frontal hangingwall fold at the leading edge of the Papuan Thrust Belt, with the SE Gobe field forming the easternmost compartment. Experimental seismic data were first acquired over the Gobe area in 1996 with the recording of dip line PN96-204 and in 1998 by acquisition of the SE Gobe experimental dip line PN98-206. This resulted in the successful appraisal of the SE Gobe 7 well, which targeted the southern extent and cutoff of the Iagifu reservoir at depth. Following this success, further seismic acquisition and reprocessing were undertaken during 1999 and 2001 over selected areas of the Papuan thrust belt resulting in over 130 km of 2D seismic data along strike of the SE Gobe trend to define near- field exploration opportunities.

This high-quality seismic dataset significantly enhanced the ability to accurately determine the subsurface structure and identified additional low-risk hangingwall plays at Saunders and Bilip and defined an additional high-risk sub -thrust structure within a footwall play underlying Bilip. These prospects were drilled in 2001 by Chevron (operator for PDL4) and Santos (operator for PPL190) in 2002. Both hangingwall targets proved successful in encountering hydrocarbons. Saunders-1 resulted in a discovery sharing a common OWC at 1260 mss with SE Gobe and extended the known southeast limit of the field. Bilip-1 encountered a deeper down-plunge structural compartment with a GOC

established at 1722 mss and an OWC at 1735 mss. The footwall Iagifu subthrust target at Bilip was encountered at 2527 mss and was water wet. Geophysical modelling indicates remaining updip attic potential. These results highlight the increasing value of seismic definition in accurately imaging the subsurface and defining additional exploration opportunities within the Papuan Thrust Belt.

INTEGRATED USE OF SEISMIC, GROUND AND AIRBORNE GRAVITY/GRAVITY GRADIOMETER, AND GROUND GEOLOGICAL MAPPING METHODS IN THE EASTERN PAPUAN BASIN, PNG

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InterOil has complemented the use of seismic data in its PNG petroleum exploration licences with both ground and airborne gravity/gravity-gradient and aeromagnetic data. Potential field methods may be used to significantly reduce exploration costs in jungle-covered areas due to the relatively high effort and helicopter support required to deploy seismic equipment.

Airborne gravity gradient and aeromagnetic data are used to interpolate and extrapolate reprocessed seismic data in InterOil's PPL 236. They confirm and extend fault correlations on widely spaced seismic lines.

Seismic data acquired in PPLs 237 and 238 show that faults do not, as suspected by some, sole out at shallow depth (eg 1 to 2 km). Instead, steeply dipping faults continue to several kilometres Surface geological mapping, together with Landsat TM and digital terrain model data, greatly assist in planning, acquisition and interpretation of seismic data. Ground gravity data acquired along seismic lines shows good character which can be correlated with the seismic data interpretation.

Relatively low effort (shallow holes, small charges), optimally located seismic data acquisition is shown to be effective in substantially resolving ambiguous structure and extending interpretation from surface dip and lithology data. Potential field data, once calibrated with seismic data, is demonstrated as a method capable of substantially extending the seismic interpretation.

CASE STUDY: NW MORAN 1 - EXTENSION OF MORAN FIELD, PAPUAN FOLD BELT, PAPUA NEW GUINEA

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The main hydrocarbon risk when exploring in the Papuan Fold belt PPL219 license is the definition of the trap. Accurately determining whether the reservoir is involved in the hanging wall over thrust and optimally placing exploratory and appraisal wells in the subsurface has been the main challenge.

The PPL219 NW Moran 1 well was drilled in late 2003 to test the north-western extent of the 130 MM barrel Moran Field. The critical risk in this prospect was reservoir involvement and the definition of the main frontal thrust. This paper highlights the approach in which the PPL219 joint venture reduced structural risk, primarily, by way of acquiring and using 2D seismic data. A fully integrated interpretative workflow was adopted using surface geology, Strontium Age Dating and offset well data and 2D seismic.

The NW Moran 1 exploratory well successfully encountered oil columns within both Toro and Digimu sands in the hanging wall of the Moran over thrust. A VSP acquired in the NW Moran 1 ST3 well bore confirmed the location of the frontal thrust to the south and the possibility of forelimb potential in this part of the field.

SESSION 2 / STREAM 1

INNOVATIVE SEISMIC METHODS

KEYNOTE 1

PASSIVE SEISMIC: WHEN, WHERE AND WHY

P DUNCAN
Microseismic, USA
SEG

KEYNOTE 2

TIME-DEPTH PROCESSING OF GLOBAL OFFSET DATA: A NEW PERSPECTIVE FOR SEISMIC IMAGING IN THRUST BELT

PAOLO DELL'AVERSANA
Eni S.p.A. (EAGE Distinguished Lecturer)

A NODAL APPROACH TO WIDE APERTURE SEISMIC - USING MORE INFORMATION FROM THE SEISMIC WAVEFIELD

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Acquisition and interpretation of wide aperture seismic data using a nodal approach is providing a cost effective technique for both land and marine operations.

In the marine environment, developments in ocean bottom seismometer (OBS) technology are providing new and innovative ways of exploring for petroleum and maximizing reserves. There are distinct advantages of recording the seismic wave field at the seafloor using an OBS, rather than near the sea surface using streamer technology. These include:

1. OBS can acquire both the compressional (P) and shear (S) wave fields;
2. The seafloor is quieter ambient environment in which to record the seismic signals;
3. There is no tow noise, and lower source generated noise; and
4. Seismic acquisition is less affected by weather conditions.

Modern OBS are autonomous digital recorders, capable of continuously recording hydrophone and three component geophone channels at 2 ms sampling for periods of up to a month. Standard "reflection style" seismic records of common receiver gathers can be obtained directly from these continuous records by accurately recording the airgun array source time. The OBS units can used to either record the long offset (wide aperture) seismic wave field in conjunction with a conventional near-vertical reflection survey (piggy-back operation acquiring common receiver gathers), or in a stand-alone mode to record the wide aperture data.

Marine wide aperture seismic acquisition provided by OBS technology can image the sub-surface in regions where the near-vertical reflection method has very poor resolution - e.g. hard seafloor conditions, and sub-salt or sub-basalt targets. Wide aperture OBS acquisition of 3-component data give subsurface compressional and shear wavespeeds, which in turn provide useful information on the lithology and fluid content of subsurface targets. 3C data can also be processed to produce PS converted wave sections. Converted PS wave sections provide an advantage in resolution and penetration over conventional P-wave refection sections in situations such as imaging through gas saturated targets.

On the production side, OBS acquisition provides Vp/Vs information, which is critical for determining lithology and reservoir structure. This ability of OBS technology to provide both P and S wavespeed information, to operate in close proximity to wells without streamers, and acquire wide

aperture (long offset - AVO) data makes their use particularly attractive in both 2D and 3D seismic acquisition program for field development

Importantly, OBS units can be employed in a survey to acquire seismic data for near-vertical reflection processing, without the need to mobilize a specialized vessel for deploying a seismic streamer.

For land operations in areas of poor seismic acquisition, recording the seismic wavefield using autonomous seismometers over an extended range of offsets (wide aperture seismic) provides information from both the reflected and the refracted raypaths. In areas where the near-vertical reflections are poor, interpretation of the refracted diving waves provides a well-constrained velocity model, which can then be used to guide the near vertical processing.

KIRCHHOFF AND WAVE-EQUATION ANISOTROPIC MIGRATION IN THRUSTBELT AREAS

F AUBIN

SESSION 3 / STREAM 1

NON-SEISMIC FOR PETROLEUM

FALCON™ AIRBORNE GRAVITY GRADIOMETER RESULTS FROM THREE AREAS IN THE EAST GIPPSLAND BASIN, VICTORIA AND THE IMPLICATIONS FOR FURTHER EXPLORATION

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A brief outline of the Falcon airborne gravity gradiometer system is given including a description of the data processing and the final parameters that are available for geophysical interpretation.

Detailed gravity gradiometer surveys were flown over three areas. The first, centred over Lakes Entrance, provides a direct comparison with traditional land based gravity data acquisition. The results from the 103 land based stations are compared to the gravity information derived from the equivalent of approximately 1600 airborne 'stations'. Considerably more structural and lithological information can be derived from the data. The structural setting of the two known hydrocarbon fields is defined, which leads to the interpretation of further prospective areas, previously untested by drilling.

The other two areas are offshore; one covers the Snapper, Marlin and adjacent fields; the other includes the Baleen/Patricia fields extending northwards towards the coastline. The parameter GD provides the basis of the interpretation from which faulting and uplifted basement is proposed. Additional information taken from GDD and GUV derivatives provides support for the interpretation which also incorporates the airborne magnetic response acquired at the same time. The structural setting of the hydrocarbon fields is interpreted from the data and potential fluid migration paths defined. Untested prospective areas are identified and recommendations for further exploration are given.

GLOBAL MAPPING DEEP-WATER HYDROCARBON PLAYS OF THE CONTINENTAL MARGINS

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Since 1993 GETECH has been involved in developing new methods and techniques to recover gravity from satellite altimeter data with the specific aim of improving oil exploration methods in deep-water areas of the continental margins, worldwide. By a combination of new processing methods, we can recover anomalies that are accurately and reliably representing geological structures down to 10 km in wavelength. These improvements have been possible by applying:

- advanced seismic repicking methods to recover the onset of ERS-1 radar waveforms;
- a range of more accurate and globally consistent wet and dry Troposphere propagation and tidal corrections;
- careful data editing and validation based on data visualisation techniques;
- micro-levelling to resolve discrepancies between satellite tracks in order to derive a reliable geoid surface; and
- the 'Geoid to Gravity' conversion method which has significant advantages over existing methods.

The methodology has allowed us to map to within 2 and 5 km of the coast and significantly suppress noise that is prevalent and dominates existing solutions at 30 to 40 km wavelength. At these and shorter wavelengths the geological signal is effectively masked by the noise.

Examples of the resolution for Gulf of Mexico and Sulawesi, Indonesia are shown.

STRUCTURAL IMAGING OF THE ESH EL-MALLAHA AREA, GULF OF SUEZ, EGYPT USING THE EULER METHOD

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The Esh El-Mallaha area has a great importance due to its location on the western flank of the Gulf of Suez, Egypt. Areas around the Gulf of Suez represent potential prospects for hydrocarbon resources. However, seismic exploration in the area has had little success in locating hydrocarbon resources. The main exploration problem is the basement complex structure that characterises the area of interest.

In this study, we attempt to image the subsurface structure of the area using interpretation of magnetic data based on the Euler method. We have applied the Euler method to the total aeromagnetic data as well as its separated regional and residual components.

The results indicated that the area is dissected by a system of faults striking in a NW direction, which is the main direction of the Red Sea. Faults trending in a NE direction were also discontinuously traced. The results also provided information about a ring complex located at the south-western part of the area near the shore line of the Red Sea with an average depth of 3.5 km. Generally, application the Euler method to the separated components of the field provided excellent results, where these results were difficult to be obtained from the total-field data.

USING THE HYMAP AIRBORNE HYPERSPECTRAL SENSOR FOR OFFSHORE SEEPAGE MAPPING

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The HyMap airborne spectrometer is an airborne remote sensing instrument collecting data in 126 spectral channels from the visible (VIS) to the shortwave infrared (SWIR) wavelength regions. Applications are wide spanned ranging from mineral exploration to environmental monitoring. Offshore seepage mapping has always been a potential application, but not many open file reports can be found in freely accessible literature though oil & gas exploration companies are known to use the technology.

As part of a 2003 airborne survey campaign in the USA, HyVista Corporation collected airborne HyMap data over one of the most active natural oil seeps in the world, offshore Santa Barbara, California. These seeps are just off Coal Oil Point and spread over an area of 10's of sqkm. UCSB has been studying this seepage for many years and slick distribution

and flow rates are monitored regularly. A production platform called 'Holly' is also located in the seep area and can be clearly identified on the imagery.

Airborne hyperspectral seep mapping offers a new possibility of characterising seeps in an exploration area of interest. It offers the advantage of allowing spectral discrimination of seep components which may not be separable with conventional techniques like radar. HyMap's capability to sense in the SWIR offers the additional possibility of properly separating an effect called 'sunglint' from any data over open water, since water will absorb radiation almost 100 % at these wavelengths. Due to the same effect it is also possible to discriminate seepage with a strong surface expression from others, which is not possible with sensors having no SWIR spectral region.

The Santa Barbara oils seeps were surveyed with 4 parallel HyMap lines covering the major seepage and migration path of the slicks at the time. Different spectral components in the open water as well as the seep area are identified and mapped. Seamless data products are produced using advanced mapping techniques and utilising the hyperspectral nature of the data. Results of these different processing steps will be presented.

SESSION 4 / STREAM 1

SEISMIC PROCESSING II

PRACTICAL, 3D SURFACE-RELATED MULTIPLE PREDICTION (SMP)

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Prediction of surface multiples via 2D algorithms (e.g. SRME) is now routine in data processing, and is often effective in removing those multiples when combined with an adaptive subtraction. There are, however, many situations in which the 2D assumptions made on the geology and the acquisition geometry are invalid to the extent that the resultant errors in the predicted multiples are too large to allow those multiples to be effectively subtracted.

3D algorithms have the potential to overcome these problems, and are therefore very attractive. However there are many issues to be overcome when implementing a 3D algorithm for use on conventional data. These include inadequacies in the crossline sampling, the limited maximum crossline offset (aperture) of the recorded data, and irregularities in the acquisition geometry. This paper attempts to address these issues through the development of a methodology that predicts the required crossline aperture and the timing errors associated with a given acquisition geometry for a given mode of multiple. Knowledge of the aperture and timing errors is very useful in determining where a 3D prediction is appropriate, and in determining optimum parameters for that prediction.

The results demonstrate the accuracy and value of the predicted errors, and the benefits of a 3D prediction over a 2D prediction for conventional marine data. 3D surface-related multiple prediction is practical for such datasets. The error analysis can also be used to optimise the acquisition geometry and hence the level of success of both 2D and 3D algorithms.

Q-GUIDED WAVELET-DOMAIN AMPLITUDE CORRECTION

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This paper presents a novel way of treating seismic reflection amplitudes for transmission effects due to the overburden. The process has benefits for structural interpretation due to the improved visibility of events. Further processing of the data also benefits from a reduction in overburden-induced amplitude changes that can otherwise cause processing artefacts such as migration smiles.

A wavelet transform decomposition of the data is used to derive local frequency, space and time varying gain factors from windows of seismic data. These are then constrained using a frequency-constant residual Q model in order to stabilise them against noise or other sources of estimation error. The resulting gain factors are applied to each wavelet voice and the data is reconstructed by an inverse wavelet transform. This is referred to as a Q-guided amplitude correction, as shorthand for the process of constraining the data-derived scalars by frequency-constant residual Q.

A by-product of the process is that local estimates of relative Q are generated at the density of the original data volume, and can help with the overall interpretation of the data. Furthermore, once local amplitude variations have been removed, a coarsely sampled estimate of the background Q model can be used to compensate for any slowly varying amplitude and phase changes that exist throughout the survey area.

SEISMIC SPECTRUM BROADENING

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Stratigraphic interpretation is complicated in many cases due to the combination of seismic noise and narrow seismic bandwidth. Interpreters need to have the high frequency amplitudes estimated robustly so that the resulting wider seismic bandwidth can aid in the interpretation. The standard methods of high frequency enhancement typically amplify the noise at the high frequencies. Other methods make use of well log information, which in turn biases the frequency enhancing process.

A new method of spectrum broadening is presented that uses the information from the low and medium frequencies in order to estimate the high frequency amplitudes. The method does not generate time shifts, does not need any well log information and it generates a stable wavelet. Furthermore after low pass filtering to the original seismic bandwidth, the filtered spectrum broadened data do not contain any events which did not exist in the original data set. Examples of the application of this method demonstrate high correlation with well-log synthetics.

HIGH RESOLUTION TIME-FREQUENCY SPECTRAL ANALYSIS

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A new method for high resolution time-frequency spectral analysis is presented. The method generates seismic amplitudes in narrow frequency sub-bands from which the original migrated stacked data can be reconstructed with a 40-60 db accuracy. It is based on the wavelet packet best basis method developed by Coifman in the early 1990s. The method differs from all other existing methods in three aspects:

a) It generates amplitude spectral analysis results, not power spectra;

b) It provides significantly higher resolution than any other method and

c) It is a true amplitude method in terms of being able to reconstruct the original signal.

Therefore, it can be used for seismic inversion, fluid detection and waveform classification work.

APPLICATIONS OF MULTIGRID PROCESSING FEATURING DECONVOLUTION

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The efficient solution of linear systems is an important part of many routines in geophysical data processing and inversion. One option for the solution of very large systems is the multigrid method. The algorithms are fast, robust, and able to solve linear and nonlinear systems at a fraction

of the computer cost of other methods. Applications of multigrid processing are common in fluid dynamics but there has been little effort to apply the technique to seismic processing and inversion. Multigrid processing uses different grid sizes when forming iterative solutions to inverse problems. The process commences with an estimate on a coarse grid that is improved with one or more iterations of inversion. The data are then interpolated to a higher resolution grid and used as the input for another iterative solution. This sequence is repeated until the desired resolution and accuracy is obtained. Two examples are used to illustrate the properties and benefits of the method. A simple 2D solution to Laplace's equation illustrates the poor low frequency convergence of a conventional Gauss-Seidel method and the superior low frequency convergence of the multigrid method. A 1D deconvolution example also illustrates the simplicity and rapid convergence of the method.

SESSION 1 / STREAM 2

EXPLORATION IN NSW 1

GEOLOGICAL SURVEY ACTIVITIES AIDING EXPLORATION

T TYNE
Geological Survey of NSW

HYMAP OF BROKEN HILL - IMAGING SPECTROMETRY FOR ROCK AND MINERAL ABUNDANCE MAPPING

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HyMap imaging spectrometry data of the Broken Hill Block was acquired by the New South Wales Geological Survey in late 2002. The capacity of this data to map surface lithologies and mineralogies has been assessed by processing and interpreting the data for several, small, representative study sites. This work has shown that it is possible to map with some confidence the relative abundance of spectrally distinctive lithologies across several image swaths. The combination of several distinctive spectrally-derived lithologies allows for stratigraphic units, defined by conventional geological mapping, to also be mapped from the imagery. Subtle shifts in the position of critical absorption features allow for the recognition and mapping of mica and garnet compositions. These mineral factors are important in understanding both the geology and the mineral potential of the region. Examples drawn from local areas and from mineral prospects are given. Hyperspectrallly-derived maps of illite-, halloysite- and smectite-dominated endmembers have also been used to map surficial sediments and provide guidance for the identification of suitable media for geochemical sampling. When combined with geophysical data such as gravity, magnetics, radiometrics and digital elevation models, the hyperspectral data provides the surface component for the three dimensional visualization of a complex part of the upper Earth's crust.

AN IMPROVED PSEUDO-GRAVITY MAGNETIC TRANSFORM TECHNIQUE FOR INVESTIGATION OF DEEP MAGNETIC SOURCE ROCKS

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The pseudo-gravity transform is one of many possible FFT techniques that can be applied to aeromagnetic data. It enhances the anomalies associated with deep magnetic sources at the expense of the dominating shallow magnetic sources. This transform is an excellent interpretation tool for the detection of deep, magnetic igneous plutons and volcanic piles and the transformed data can be modelled using conventional gravity modelling tools. It is a suitable tool for interpreting deep-seated mineral plumbing systems associated with known, shallow mineral occurrences. The pseudo-gravity transform is derived by an integration of the total magnetic intensity grid data using conventional FFT tools. Padding of the grid around the region covered by the survey introduces long wavelength artefacts into the transformed grids. These long wavelength artefacts can obscure the targets that are the object of investigation. A variety of regional residual separation procedures is applied to the transformed grid to minimise the impact of the long wavelength artifacts. The improved pseudo-gravity transform is applied to the Goulburn 1:250 000 survey in the Lachlan Fold Belt of New South Wales to demonstrate the clear separation of deep sources that are difficult to detect or understand in the context of conventional magnetic image analysis. The results are contrasted with other filter techniques. Interpretive modelling of both the magnetic and the gravity transform data show how to derive more relevant geological information from magnetic surveys. By comparing the pseudo-gravity transform results with lower resolution ground gravity data, it is possible to obtain additional geological information by analysing the correlations.

USE OF POTENTIAL FIELD DATA AND MODELLING TO COMPLEMENT DETAILED GEOLOGICAL MAPPING IN THE BRAIDWOOD-GOULBURN AREA, NEW SOUTH WALES

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The Goulburn and Braidwood airborne geophysical surveys that cover part of the Southern Highlands of New South Wales have been flown as part of the National Geoscience Mapping Accord and the NSW Government's $30 million Exploration NSW initiative. The new airborne magnetic and radiometric survey data show that many of the geological boundaries on Department maps can now be improved in areas of sparse outcrop. Interpretation of the new data will greatly assist the definition of rock types and geological structures that may be associated with gold, silver, lead, zinc and copper mineralisation and for construction materials such as sand and gravel.

The airborne magnetic dataset has assisted in delineation of a number of major structural domains characterised by marked variations in strain and structural style. The survey areas are critically sited at the convergence of geological terranes already studied further to the north. These terranes are bounded by major fault structures - some of which appear to converge and then diverge.

Recent geological mapping, assisted by the interpretation of all the geophysical data, allows recognition of the complex volcanic and clastic stratigraphy of the mid-Late Silurian sequences. This has led to the recognition that the Hill End Trough and Ngunawal Basin (Captains Flat area) are most likely to both be part of a continuous marine basin, and expands the area prospective for VHMS Cu-Pb-Zn-Ag-Ba-Au deposits along the Frogmore Fault Zone in the west, and along the Yarralaw Fault Zone in the east.

Potential field modelling has contributed to a more-confident interpretation of the third dimension, and has provided control in the preparation of cross-sections.

NEW ENHANCEMENT FILTERS FOR GEOLOGICAL MAPPING: A CASE STUDY NEAR GOULBURN, NSW

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Two types of filters have been developed for the purpose of enhancing weak magnetic anomalies from near surface sources while simultaneously enhancing low amplitude, long wavelength magnetic anomalies from deep-seated or regional sources. The Edge filter group highlights edges surrounding both shallow and deeper magnetic sources. The results are used to infer the location of the boundaries of magnetised lithologies. The

Block filter group has the effect of transforming the data into "zones" which, similar to image classification systems, segregate anomalous zones into apparent lithological categories. Both filter groups change the textural character of a data set and thereby facilitate interpretation of geological structures.

The effect of each filter is demonstrated using theoretical model studies. The models include both shallow and deep sources with a range of magnetisations. Comparative studies are made with traditional filters using the same theoretical models. In order to simulate real conditions, Gaussian noise has been added to the model response. Techniques for noise reduction and geological signature enhancement are discussed in the paper.

The new approaches are applied to actual magnetic survey data covering part of the Goulburn 1:100 000 scale map sheet area, NSW. Some new geological inferences revealed by this process are discussed.

SESSION 2 / STREAM 2

EXPLORATION IN NSW 2

INTERPRETATION OF THE PETROLEUM POTENTIAL OF THE DARLING BASIN, A PROCESS OF INTEGRATION AND ITERATION

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With an area of over 100.000 km2 and sedimentary thicknesses of over 8000 m. the Darling Basin is the largest onshore basin in New South Wales and one of the largest in Australia. In the entire basin only 20 petroleum exploration wells have been drilled and approximately 1800 km of multifold seismic data recorded. This quantity of seismic data is grossly inadequate for a basin of this size and in addition acquisition has been concentrated over regional structural highs. These highs are usually poor data areas due to structural complexity and coupling problems in acquisition related to the high proportion of outcrop. However the available seismic data have confirmed the presence of large structures and the New South Wales Department of Mineral Resources is now undertaking a major study of the basin's petroleum potential.

The Darling Basin does have fair to good gravity and magnetic coverage and this has provided a solid basis for the current studies of the basin. Interpretations of the potential field data have been made with a view to interpreting the depth and structure of "basement" and also to interpreting intra-sedimentary structures.

The current evaluation of the basin is an iterative process. Recent potential field interpretations have utilised all the available information including seismic, well and surface geology. The Department of Mineral Resources is carrying out seismic programs based on these interpretations of the potential field and other available data. These seismic results are being used to update and modify, if necessary, the earlier interpretations. The seismic surveys as a by-product, have also indicated the existence of more extensive and better outcrop data than had previously been expected and the interpretation, or in some cases reinterpretation, of this outcrop data, is also being incorporated in the current study.

OVERVIEW INTERPRETATION OF THE MURRAY-RIVERINA EXPLORATION NSW AIRBORNE MAGNETIC/RADIOMETRIC SURVEY AND REGIONAL BOUGUER GRAVITY

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Overview scale interpretation of the Murray-Riverina airborne magnetic and radiometric survey has revealed many bedrock features in a region covered by significant overburden. Regional Bouguer gravity data suggest basins and granitic bodies at depth.

Pattern contrasts in the magnetic data contribute to a greater understanding of event timing and define numerous covered features, including granitic bodies, two areas of intrusive pipe-like clusters, possible extension basins of the Oaklands Basin and numerous mineral sand strand lines and their re-deposition as "lunettes".

Radiometric data in this area mainly reflect the lack of outcrop and define soil types and drainage patterns.

Opportunities exist for a number of deposit types of economic potential:

- petroleum near a Bouguer gravity low at Booligal;
- biogenic Gas and Coal in two grabens extending north from Hay;
- orogenic Gold associated with an extension of the Bendigo Terrane from Victoria into the Murray Basin;
- porphyry gold associated with previously unmapped granites; and
- diamonds associated with the clusters of intrusive pipes in the central west of the survey area.

GEOPHYSICAL AND GEOLOGICAL INTERPRETATION OF THE JUNEE - NARROMINE VOLCANIC BELT

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The Junee-Narromine Volcanic Belt is the westernmost and most poorly outcropping belt of Ordovician rocks that represent the dispersed remnants of the Ordovician Macquarie Arc. The northern part is under deep cover of Surat Basin.

In areas of poor or nonexistent outcrop such as these, most of the knowledge of the geometry and components of the geology comes from the interpretation and modelling of gravity and aeromagnetic data - interpolation between outcrops and extrapolation into areas of deep cover.

Most of the shape of the Junee-Narromine Volcanic Belt is a reflection of meridional bounding faults of the Tullamore Trend. Individual complexes are elongated N-S or NNW and deformation is generally low, except in the high strain zones. From north to south, Ordovician complexes with approximately meridional Tullamore trends become rotated into the Gilmore Trend and then become aligned along splay faults as thrust sheets (Gidginbung Volcanics) before being truncated by the Gilmore Fault.

ISOSTATIC CORRECTION OF NEW SOUTH WALES BOUGUER GRAVITY DATA

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The effect of the gravitational attraction of isostatic roots on the Bouguer gravity data for New South Wales is significant. The anomalies caused by isostatic compensation are most pronounced in the eastern third of the state. This is due to the load of the coastal mountain range being compensated, combined with the effect of the crustal thinning at the continental margin. To use the gravity data to interpret regional geological structure it is advisable to remove these large-amplitude long-wavelength anomalies as they tend to obscure the anomalies caused by the geological structures of interest. A variety of methods is available to perform this. The method used here is a relatively simple method that assumes isostatic equilibrium and zero crustal rigidity.

SESSION 3 / STREAM 2

SEISMIC TECHNICAL FORUM III (LAND ACQUISITION: CHOOSING THE BEST SOURCE)

VIBROSEIS OR DYNAMITE: INVESTIGATING SOURCE CHARACTERISTICS

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A comparison of recently acquired seismic data in the Bowen Basin has highlighted inherent differences in signal content between dynamite and Vibroseis sources. This work was undertaken to assist selection of the source for proposed 2D and 3D seismic surveys in the Bowen Basin where recent drilling successes have revived interest in the hydrocarbon potential of the Permian sequence. Although comparisons between dynamite and Vibroseis sources have been made previously, the topic remains relevant because of developments in acquisition technology, the use of seismic source modelling and the area-dependency of seismic data quality.

The motivation for acquisition of further 2D and 3D seismic data in the Surat-Bowen Basin are the petroleum discoveries in the Permian Tinowon Sandstone along the western flank of the Taroom Trough at Myall Creek, Churchie, Overston and Waggamba. Variable reservoir quality and extent make identification of Tinowon sands difficult and good quality, high resolution data are essential for exploration and development mapping of the prospective reservoir units. For this study, a pair of overlapping 2D seismic lines was selected, one recorded with a Vibroseis source in 1996 and the other with dynamite in 2000. Care was taken to select two modern lines with acquisition parameters that would minimise the attenuation of frequencies in the higher end of the signal spectrum, thus providing input data sets that would result in a valid Vibroseis-dynamite comparison.

Data processing was closely monitored to determine the effects of specific algorithms on signal content. Dynamite proved to have the greatest resolution in the Tinowon zone of interest, that is, around 1400 ms. Indeed, inspection of the signal spectra and particularly the bandpass filter panels on raw field records clearly showed that dynamite data contained higher frequencies and exhibited increased resolution relative to the Vibroseis data in the study area. Bandpass filtering is an effective means of evaluating seismic source characteristics.

Predictably, results showed that resolution of the dynamite and Vibroseis data converged with depth due to the natural frequency filter effect of the earth. Synthetic data produced from wavelets matching the Vibroseis and dynamite data demonstrated that the improved resolution expected from the dynamite source would improve imaging of the Permian section. Based on the results of this trial and other modelling, Origin Energy selected a dynamite source for their Myall Creek 3D survey. Mosaic Oil selected dynamite for both their 2003 2D and their 2004 3D seismic survey.

SEISMIC SOURCE MODELLING AND 3D SURVEY PARAMETER DESIGN, SURAT BASIN, AUSTRALIA

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Elastic synthetic seismograms for a dynamite and Vibroseis source are used to assist the selection of source type for a 3D seismic survey in the Surat Basin. The models are based on well logs and provide key information on seismic source characteristics, which are supported by seismic field data from the study area. The main targets are Permian sands interbedded with laterally extensive coal measures. Survey parameters such as source type, maximum and minimum source-receiver (S/R) offset, and seismic bandwidth are critical in detecting these sands especially if techniques such as AVO are to be used in subsequent data interpretation.

The methodology for determining the detectability of the modelled gas sand for each type of source is to subtract the seismogram for a shale model from the seismogram produced when the modelled target sand is present. These difference seismograms computed in t-p space show that with ground roll suppressed the sands can produce more than a 20% change in the modelled seismograms. This figure improves with increasing p value (or equivalent target offset) but is limited by interference from shear waves especially for a Vibroseis source. RMS amplitude attributes (within a window) are used to quantify this change.

In the study area it is shown that when compared to a buried (25 m) dynamite source, Vibroseis sources produce significantly larger amounts of ground roll on the near traces (offsets < 600 m at target) and of shear waves on the mid to far traces (offsets > 1.4 km). Furthermore, because the very strong near-normal incidence reflections from coal measures decay rapidly with offset, target sand detectability tends to increase significantly for larger offsets for both source types. For dynamite sources, detectability is relatively high for source-receiver offsets greater than about 1 km, out to at least 2 km.

Some deficiencies of the Vibroseis source may be reduced by careful noise filtering, however the lower sample density for most 3D surveys (compared to 2D) means that such filtering techniques may be less effective. The study highlights the benefits of seismic source modelling to assist survey design.

NUMERICAL MODELLING OF PSEUDO-RANDOM LAND SEISMIC SOURCES

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Environmental, logistical and security considerations mean that non-explosive, surface seismic sources must assume increasing future importance. The challenge is to make such sources more competitive with dynamite in terms of resolving power and signal-to-noise ratio. We use numerical modelling to explore possible improvements in Vibroseis reference-signal design, and algorithmic approaches to Mini-SOSIE stacking.

We revisit an alternative Vibroseis sweep comprising a constant frequency carrier which suffers polarity reversals according to a pseudo-random coding sequence. Numerical models allow various comparisons with the conventional swept-frequency approach. Visually, the correlation wavelet from the pseudo-random reference appears less affected by side lobes than the conventional Klauder wavelet. On the other hand the correlated pseudo-random trace is noisier away from the wavelet itself. A pseudo-random sweep built from half-cycle components has interesting theoretical possibilities, but practical implementation may be difficult.

Pseudo-random design concepts extend naturally to the Mini-SOSIE source, which stacks, in real time, numerous low-amplitude impacts, occurring at approximately random time intervals. We demonstrate the undesirable effect of non-randomness, and examine the feasibility of using predictive deconvolution to improve the randomness of the impact sequence prior to stacking.

Sign-bit stacking provides better attenuation of noise bursts than standard Mini-SOSIE stacking, although it may be prone to some amplitude distortions. A stacking procedure which incorporates a median-filtering stage appears to provide good noise-burst attenuation whilst maintaining reflection amplitudes.

SESSION 4 / STREAM 2

RESERVOIR MODELLING

LITHOLOGY SUBSTITUTION IN A SAND/SHALE SEQUENCE

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Geophysics as well as inversion of seismic data has improved considerably over the last decade. So much so that elastic inversion is rapidly becoming a commodity data product that oil companies understand and use for risk reduction. Many examples have been shown where the elastic impedance is used to estimate porosity, for example using a statistical regression on well data.

In this paper we review the use of Rock Physics Diagnostics applied to log data to illustrate a relational model between porosity, clay and saturation. We use these relations to estimate porosity from elastic impedance attributes. Using statistical fits may work locally around the property values experienced by a well for example, but away from the well a systematic approach is required to improve the confidence and thereby reduce the risk associated with such predictions.

Rock Physics Diagnostics is such a systematic approach and we present this methodology as essential for predicting rock properties from seismic data.

The main task of this case study was to identify productive sands from seismic away from well control. It was assumed that the sedimentary environment away from the well was the same as at the well. The well data (onshore North America) indicated the presence of blocky oil sand and down-fining cycle below.

Using this well log data as input we identified robust empirical models to describe the Vp and Vs behavior of the pay sands and surrounding shale. These models were then used to transform acoustic impedance and elastic impedance volumes into a pay sand porosity volume.

PERMEABILITY IN THE THIN SECTION

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Numerical simulations of fluid flow through 3D pore space can provide accurate estimations for permeability. A digital volume required for these numerical experiments may be obtained directly by microtomography or statistically reconstructed from 2D thin sections. Such a digital pore volume has to be statistically representative of the original rock. However, only small rock fragments, such as drill cuttings, and only 2D images of those may be available in the field. To address this practical constraint, we investigate how permeability can be estimated from small 2D images. We select a number of natural and artificial medium-to-high porosity well-sorted sandstones. 3D microtomography volumes are obtained from each of these physical samples. Then, analogous to making thin sections of drill cuttings, we select a large number of small 2D slices from a 3D scan. As a result, a single physical sample is used to produce hundreds of virtual-drill-cutting 2D images. Corresponding 3D pore space realizations are statistically generated from these 2D images, fluid flow is simulated in 3D, and the absolute permeability is computed. As expected, this permeability does not match the measured permeability of a physical sample, which is due to inherent variations of pore-space geometry among the small images. However, for all the physical samples, a single and clear trend is formed by cross-plotting the simulated permeability versus porosity. This trend is typical for clean sandstone. The simulated permeability of under-representative sandstone fragments does not match the physically measured data. Instead it provides a valid permeability-porosity transform which can be used to estimate permeability if porosity is independently known from well log or seismic measurement.

EFFECTIVE STRESS AND THE ELASTIC RESPONSE OF RESERVOIR SANDSTONES AND SHALES

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Effective stress is a key concept in determining reservoir pore pressures from seismic velocity data. It is usually defined as the difference, ΔP between confining (overburden) pressure, P_c and pore pressure, P_p. However, a more general definition is $\sigma' = P_c - nP_p$ where n is an effective stress coefficient. Seismic velocity is observed both in the field and in laboratory experiments to vary non-linearly with effective stress. Furthermore, a form of hysteresis in velocity is observed when reservoir rocks are subjected to differing pore pressure histories. The resulting hysteresis can be quantified with the effective stress coefficient. This coefficient is frequently derived from laboratory velocity-effective stress data at ultrasonic frequencies. This paper describes some recent laboratory based, rock physics experiments involving pore pressure history induced velocity hysteresis and the implications for reservoir 4D monitoring.

AN IMPROVED HIGH-ORDER ROTATED STAGGERED FINITE-DIFFERENCE ALGORITHM FOR SIMULATING SEISMIC WAVES IN HETEROGENEOUS VISCOELASTIC MEDIA

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By comparing the standard and staggered grid methods, a high-order rotated staggered grid algorithm has been developed for simulating seismic wave propagation in heterogeneous viscoelastic or transverse isotropic media. Numerical simulation results show that, staggered highorder staggered FD method is better than staggered pseudo-spectral method in modelling heterogeneous anisotropic or viscolastic media. Based on the algorithm, a uniform random function is used to establish random models with two kinds of components, i. e., clays and pure sandstones. These two media consist of various synthetic shale sand formations and are simulated for various clay contents. Elastic wave velocities and attenuations for various clay contents are simulated properly at the frequency around 10 kHz to 100 kHz. The numerical results show that our developed algorithms can be used for modelling composite media for studying elastic wave attenuation and velocity variation. The modelling analyses demonstrate that, the more the clay particles in the models, the more reflected backscattering produced when the wave length is around equal to the 10 times of the minimum size of the clays.

IN SITU FORMATION STRESS DETERMINATION USING SONIC LOGS AND IN-BOREHOLE-TOMOGRAPHIC-RECONSTRUCTION OF THE NEAR BOREHOLE SHEAR-WAVE DISTRIBUTION.

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For advanced borehole logging interpretation of cross-dipole shear-wave sondes with 'In-Borehole-Tomographic-Reconstruction' (IBTR)-techniques an effective method for the determination of the mechanical stress distribution in the formation was developed.

The method includes the reconstruction of the 3D-shear-wave velocity distribution in the immediate surrounding area of the borehole formation with tomographic algorithms.

The composition of the stress induced shear-wave velocity and comparison to the modelling results allow a quantitative interpretation. This log of the local formation stress anisotropy is excluded from both caliper-effects and the influences of shear-wave velocity anisotropies caused by sedimentary effects.

As examples logs of ratios of the local minimal/maximal formation-stress amplitudes $D_{SH}/_{SH}(z)$ were generated in a range of 0.90 ... 1.00 for two gas production boreholes.

SESSION 1 / STREAM 3

GENERAL STUDIES TED LILLEY STREAM

REGIONAL-RESIDUAL GRAVITY FIELD SEPARATION IN THE CENTRAL ANDES USING GLOBAL GEOPOTENTIAL MODELS

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Traditional methods of regional-residual gravity field separation typically involve high-pass filtering, low-order polynomial fitting or computations using isostatic models. All of these methods are susceptible to ambiguity and subjectivity in the selection of filter parameters, polynomial degree and isostatic model. Global Geopotential Models (GGMs), on the other hand, provide long-wavelength gravity data that are based on observations. Therefore, they have the potential to be used to more objectively define the regional gravity field and to give residual anomalies with reduced ambiguity.

We have examined residual gravity anomalies in the Central Andes computed using a regional field defined by the recent EIGEN-GRACE01S satellite-only GGM. The resulting residual anomalies show significant correlations with the active volcanic arc and the geometry of the subducting Nazca Plate. These results suggest that GGMs have a place in regional gravity interpretation, but the advantages over existing techniques remain to be thoroughly tested.

ENHANCEMENT OF MAGNETIC SIGNATURES OF IMPACT STRUCTURES

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Aeromagnetic surveys play an important role in the detection and analysis of terrestrial impact structures as large semi-regional aeromagnetic surveys are widely available.

Impact craters can be divided into two groups based on morphostructure, namely simple and complex. Simple craters are relatively small bowl-shaped depressions with an upraised and fractured rim whereas complex craters are larger with a central uplift zone.

Magnetic signatures of terrestrial impact craters vary greatly, reflecting the target rocks, the impact-related magnetisation and effects of crater fill and post-impact sediments. In basement rocks, the common signature is a magnetic low, ranging in amplitude from a few nT up to a few hundred nT. The central peak or ring uplift of crushed basement may produce strong magnetic highs. The magnetic signature may be due to shock demagnetisation, shock remagnetisation, and thermal and chemical remanent magnetisation effects. Impact craters in sedimentary targets are usually subdued and amplitudes of a few nT up to 10 nT are common.

Enhancement of magnetic signatures of impact structures using filtering techniques is an important part of detection and analysis. Derivatives and shaded relief techniques, along with separation filtering, are probably the most used methods. Algorithms for fractional order derivatives and circular shaded relief have dramatically improved filter results. The fractional derivative order can be varied to optimise separation of the impact magnetic signature. Circular shaded relief treats all directions equally unlike the fade-out for features sub-parallel to the shading direction evident in conventional shading.

The fractional order derivative and circular shaded relief algorithms are illustrated from impact structures in Australia and Canada in both basement and sedimentary cover rocks.

RIGIDITY OF THE ANDES FROM FLEXURAL MODELLING AND ADMITTANCE AND COHERANCE TECHNIQUES

R HACKNEY, A TASSARA, J KIRBY AND H GOETZE

AVO AND AI IN PNG: HYDROCARBON PROSPECT EVALUATION IN A FORELAND BASIN

D BENNETT

SESSION 2 / STREAM 3

LITHOSPHERE TED LILLEY STREAM

LITHOSPHERIC STRUCTURE IN THE AUSTRALIAN REGION - A SYNTHESIS OF SURFACE WAVE AND BODY WAVE STUDIES

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The configuration of earthquake belts around Australia provides a wealth of events at suitable distances to be used as probes into the seismic structure of the upper mantle. The few permanent seismic stations have been supplemented with extensive deployments of portable broadband stations for periods of a few months at each site. The broad band records have been used in a variety of studies of 3D structure.

Surface wave tomography is based on matching seismic waveforms on individual paths and then mapping the path-specific constraints on shear structure into a 3D model. Higher frequency body wave arrivals are refracted back from the variations in structure in the mantle and are particularly sensitive to discontinuities in structure. Observations out to 3000 km provide coverage of the structures down through the transition zone. For northern Australia, the combination of short-period and broadband observations provides detailed information on both P and S wavespeeds and attenuation structure.

There is a complex pattern of 3D structure beneath the Australian region. The cratonic region in the centre and west is underlain by a thick mantle lithosphere extending to around 200 km depth with fast wavespeeds (especially for S waves). However, the mobile belt in Central Australia has comparatively low wavespeeds to at least 75 km depth with fast lithospheric material beneath. In the asthenosphere the S wavespeeds diminish and there is significant attenuation. Beneath the eastern zone with Phanerozoic outcrop the lithosphere is generally thinner (less than 140 km) and the asthenosphere has a pronounced low velocity zone for S again with high attenuation.

CONSTRAINTS ON AUSTRALIAN LITHOSPHERE STRUCTURE USING MAGNETOTELLURICS

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Primary geophysical techniques used to image lithospheric structures are seismic reflection and magnetotellurics (MT). Seismic methods provide excellent constraints on geometry, but are expensive to acquire, and involve significant logistics and equipment. By comparison, MT methods use naturally occurring EM source-fields, and are a fraction of the cost to acquire with lower environmental impact. Observations of horizontal and vertical components of magnetic field and corresponding changes in horizontal and orthogonal electric fields provide information on both lateral and vertical changes in electrical resistivity. By measuring MT signals over a bandwidth of frequencies of 100 to 10-4 Hz (periods of 1 to 104 s), delineation of crust and mantle resistivities on scale lengths of 1-500 km are obtained.

Results from four recent MT transects across Australian Proterozoic cratonic boundaries are presented. These are:

(a) a 150-km long transect across the boundary between the Olary and Broken Hill Domains;

(b) a 50-km long transect in southern Gawler Craton across Kalinjala Shear Zone between the Donnington Suite intrusives and the Hutchison metasediments;

(c) a 200-km long profile through Olympic Dam in the eastern Gawler Craton; and

(d) a 150-km profile across the Redbank Shear Zone in the Arunta Block.

All transects have inter-site spacing of <10 km and between 15-35 sites. Integration with other geophysics, notably deep seismic data in the Gawler Craton, Broken Hill Domain and Arunta Blocks, and long-wavelength gravity responses are providing new constraints on the physical state of the deep crust and mantle, including fluid content, temperature and mineral content.

THE INTEGRATION OF GEOPHYSICS AND GEOCHEMISTRY REVEALS THE NATURE OF THE LITHOSPHERE BENEATH THE SLAVE CRATON (CANADA)

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The Slave Province in Canada is a small Archean fragment, bounded on the east by the Thelon magmatic arc (2.0-1.9 Ga) on the western edge of the Archean Rae Province and on the west by the Great Bear magmatic arc of the Wopmay Orogen (1.88-1.84 Ga). The northern and north-eastern part is overlapped by Upper Proterozoic and Phanerozoic supracrustal rocks. On the south, the Slave craton is separated by the Great Slave Lake Shear Zone from the Lower Proterozoic Chinchaga and Buffalo Head terranes.

We use robust geochemical methods based on mantle-derived xenoliths, heavy mineral concentrates from over 25 kimberlites, and representative diamond populations and their inclusions to construct sections that delineate the composition, structure and thermal state of the lithospheric mantle across the Slave Craton. This analysis reveals a distinct two-layered lithosphere beneath the craton: a shallow ultradepleted, olivine-rich layer and a deeper less depleted layer, interpreted as an Archean plume head.

We have mapped variations in the gravity/topography relationships across the Slave Province in terms of the effective elastic thickness (Te). The results show that the northern part of the craton is characterised by a relatively weak lithosphere (Te < 25 km), probably related to the intrusion of the Mackenzie Plume (ca 1270 Ma). The strongest lithosphere is found in the eastern part of the craton (Te > 56 km). A N-S zone of low Te along in the middle of the craton may map the deep extension of the suture between the ancient continental block making up the western part of the craton, and the younger accreted terranes that make up the eastern part. The zone of low Te gradient coincides with an area of strongly conductive upper mantle, and with the Nd/Pb isotope lines which define a major crustal boundary at depth, and is a major locus of kimberlite intrusion.

LITHOSPHERIC MAGNETOTELLURIC IMAGING IN CANADA: SIGNIFICANCE TO DIAMOND EXPLORATION

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Deep magnetotelluric (MT) surveys provide information on thickness, electrical resistivity, and tectonic history of Precambrian lithosphere that is relevant to diamond exploration. In regions where lithosphere is electrically resistive, its thickness can be inferred from the observed depth of a conductor at 100 km to 300 km taken as defining the top of the electrical asthenosphere. In some locations high conductivity is observed within the lithosphere, and at depths above the diamond stability field, may be attributed to the presence of graphite. The form of crustal and upper mantle conductors, interpreted with deep seismic information, provides information that can be used to constrain the tectonic history of a region e.g. defining the geometry of past subduction.

Surveys in the Slave Craton in northern Canada have identified an MT phase anomaly that is coincident with both a diamond-bearing Eocene kimberlite field and an upper mantle geochemical anomaly. The phase anomaly is explained by a conductor, with its upper surface at 80 to 120 km depth and the enhanced conductivity is interpreted as being due to graphite or an interconnected carbon grain-boundary film. In the western Superior Province in central Canada, MT surveys have delineated a mantle conductor at a depth of 130 km. The MT responses define the geoelectric fabric of both the crust and subcrustal lithosphere and indicate that the subcrustal lithosphere is of Archean age.

THE ANDEAN GRAVITY FIELD, FORWARD MODELLING AND DETERMINATION OF LITHOSPHERIC RIGIDITY

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The gravity field of the geologically contrasting Central and Southern Andes has been investigated with regard to isostatic state, crustal density structure and rigidity of the lithosphere. The gravity database, together with other geophysical data, is a product of several years of field data acquisition in the Central and Southern Andes as part of the German Collaborative Research Centre SFB267 ("Deformation Processes in the Andes").

All gravity data are tied to the IGSN71 gravity datum and are terrain-corrected. The gravity effect of the subducting Nazca Plate was removed from both Bouguer and isostatic residual anomalies and then correlated with mean topographic heights to identify areas of disturbed isostatic equilibrium.

The abundance of geophysical information obtained by the SFB267 and its partners (e.g. geological, structural, seismic and magnetotelluric data) allows the development of well-constrained 3D forward gravity models. These models allow estimation of subsurface loading and, therefore, permit more rigorous estimation of lithospheric rigidity than if topographic loading alone were considered. To date we have used estimates of surface and subsurface loading from such 3D models with a 2D coherency method to estimate lithospheric rigidity in the central Andes.

SESSION 3 / STREAM 3
MT AND EM TED LILLEY STREAM

THE USE OF MOHR CIRCLES IN THE INTERPRETATION OF MAGNETOTELLURIC DATA

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One of Ted Lilley's many original contributions to electromagnetic geophysics was his introduction of the Mohr circle as an aid in the analysis of the magnetotelluric (MT) impedance tensor. Although well known as a representation of the stress tensor in elasticity theory, the usefulness of Mohr circles was virtually unrecognised by the MT community until the pioneer paper of Lilley (1976). An important difference between the stress tensor and the MT tensor is that the former is real while the latter is complex, which means that the MT tensor must be represented by two Mohr circles rather than one. In his early treatments of MT data, Lilley by-passed this complication by concentrating solely on the real part of the MT tensor, and was able to identify various invariants of the real tensor geometrically on the Mohr circle diagram. In later discussions of the

physical interpretation of the seven independent invariants of the complex MT tensor, however, it became necessary to consider both real and imaginary Mohr circles together when seeking a geometrical representation of all the invariants. A significant advance was made with the introduction of the (real) phase tensor by Caldwell, Bibby and Brown (2002). Although the phase tensor has only three independent invariants, they retain the important physical properties of the seven invariants of the MT tensor, and can be displayed graphically in a single Mohr circle diagram. In particular, identification of the dimensionality of the regional conductivity structure becomes a straightforward matter whether or not the data are distorted by near-surface conductivity anomalies. An analysis of MT field data with error bars will be presented using the phase tensor and its Mohr circle representation in order to show when a two- or one-dimensional interpretation of the regional conductivity structure is appropriate and strike angles are calculated for two-dimensional structures.

MARINE ELECTROMAGNETICS IN AUSTRALIA; TED LILLEY'S CONTRIBUTIONS TO THE UNDERSTANDING OF THE ROLE OF THE MAGNETIC FIELD IN THE MARINE ENVIRONMENT

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The conductive ocean waters have a significant influence on electromagnetic induction within the Earth. Dr F.E.M. (Ted) Lilley was keenly aware of this through his many geomagnetic deep sounding studies within Australia, and the opportunity to venture into the marine environment came when Ted invited Jean Filluox's group from Scripps Institution of Oceanography in California to collaborate with him in the Tasman Project of Seafloor Magnetotelluric Exploration in 1983/4. Marine data obtained in this experiment was also examined for the signature of an ocean eddy (warm core ring) in the East Australian Current. The magnetic effects of ocean currents, eddies, oceanic swell and waves became a research theme Ted subsequently pursued over many years on a number of research cruises around Australia and in the Southern Ocean. This involved the use of magnetic total field recordings in free floating buoys and in depth profiles through the water column, as well as seafloor triaxial recording magnetometers.

THE MARINE MAGNETOTELLURIC METHOD FOR FUN AND PROFIT

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Electromagnetic methods provide direct estimates of seafloor porosity and pore fluid conductivity; physical properties that are difficult or impossible to obtain using seismic methods alone. One can use marine EM methods to carry out structural mapping of formations with different porosities, especially useful in terranes with high acoustic impedance contrasts, such as salt, basalt, and carbonate formations, or for magmatic systems at mid-ocean ridges. The magnetotelluric (MT) method is particularly suited to this type of work, being relatively inexpensive, capable of great depths of penetration, and relatively easy to interpret. We have developed a marine MT instrument deployed as a seafloor free vehicle capable of operating at ocean depths of 10 to 6000 m, sinking to the seafloor on 200 kg concrete anchors (necessary to maintain stability of the magnetic sensors) and returning on acoustic release by intrinsic buoyancy. The instrument is capable of recording up to 8 channels, with a bandwidth of a few hundred hertz to several thousand seconds. Induction coil magnetometers and silver-silver chloride electrodes are used for sensing the magnetic and electric fields respectively. With a power consumption of less than 500 mW, the instrument will record for over one month on one set of DD lithium batteries, allowing repeated redeployment without opening by retrieving data through an interface port in the pressure case. The size of the instrument is kept to less than one cubic meter by maintaining strict control of the power and weight budget; the magnetic sensors use aluminium wire coils which doubles the resistance noise, but reduces instrument weight by 10 kg. With 1000 deployment and recovery cycles logged, the instrument has a loss rate of less than 1% and a data recovery rate of better than 95%. We present results obtained from two studies: (a) At the Gemini sub-salt hydrocarbon discovery prospect in the Gulf of Mexico, we have obtained three-dimensional images of the salt from MT data, showing excellent agreement with the 3D seismic volume, yet also illuminating features difficult to interpret in the seismic sections alone. (b) At the mid-ocean ridge of the East Pacific Rise, we are able to image the magma chamber and the extent of hydrothermal circulation in the crust. Hopefully, by the time this talk is presented, the 5 sites of the pilot study will be augmented by 60 MT sites collected in February 2004.

MAPPING GROUNDWATER IN REGOLITH AND FRACTURED BEDROCK USING GROUND AND AIRBORNE GEOPHYSICS: CASE STUDIES FROM MALAWI AND BRAZIL

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Water supply exploration in rural regions of eastern Malawi (Africa) and northeastern Brazil (South America) is complicated by the highly irregular nature of aquifers in weathered regolith and crystalline bedrock. Drilling success can be as low as 30%.

Improvements in the success rate can be achieved by using simple geophysical investigations to target the thickest zones of weathering. Sophisticated geophysical surveys that image the full range in aquifer types can further improve the success rate to 70%. In Malawi, a total of 250 hand pumps were sited using a combination of borehole geophysics (natural gamma, conductivity and magnetic susceptibility), ground-based frequency-domain electromagnetics (Geonics EM34 and Apex Max-Min), and 2D electrical resistivity imaging. In a similar terrain in northeastern Brazil, resistivity profiling and Very Low Frequency electromagnetic surveys are the mainstay of water exploration. A recent project introduced ground-based and airborne frequency-domain electromagnetics (Geonics EM34 and Aerodat helicopter electromagnetics) to improve the imaging of complex fracture zones and the detection of saline aquifers. Helicopter-borne surveys are a valuable tool in groundwater exploration because they cover large areas at high resolution. In both case studies, inversion of geophysical data integrated with remote sensing images and hydrogeology has increased the chances of drilling successful wells and finding potable water for rural communities.

SESSION 4 / STREAM 3

MAGNETIC STUDIES TED LILLEY STREAM

A NEW GENERATION MAGNETIC ANOMALY GRID DATABASE OF AUSTRALIA (MAGDA) – USE OF INDEPENDENT DATA INCREASES THE ACCURACY OF LONG WAVELENGTH COMPONENTS OF CONTINENTAL-SCALE MERGES

P MILLIGAN, D RAVAT, R FRANKLIN

SATELLITE MAGNETIC DATA AND GEOMAGNETIC DAILY VARIATIONS

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Satellite magnetic data includes the slowly varying main field, the static lithospheric or crustal anomaly field, and fields associated with the regular daily variations of solar and lunar origin as well as magnetic disturbances. Satellite magnetic data are now available across a range of local times, and research is now being directed to studies of the daily variations from an 'above the ionosphere' point of view. The equatorial electrojet is easily seen in satellite orbits crossing the magnetic (dip) equator at local noon, and results are presented here for the satellite view of daily varying fields of ionospheric and magnetospheric origin.

GETMAG - A NEW MAGNETIC TENSOR GRADIOMETER FOR EXPLORATION

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CSIRO and Australian exploration companies have developed a new instrument for mineral exploration.

The GETMAG (Glass Earth Tensor Magnetic Airborne Gradiometer) instrument measures the magnetic gradient tensor and the components of the magnetic field. The sensors are high temperature superconducting (HTS) quantum interference devices (SQUIDs) operating at liquid nitrogen temperature. A superconducting transformer coupled to a SQUID magnetometer is rotated to detect all gradients perpendicular to the rotation axis. Three SQUID-loop assemblies are required to measure the full tensor.

Field trials demonstrate that the inversion of a few tensor measurements yields as much information as a high-resolution total magnetic intensity (TMI) survey. Direction to individual sources and their magnetic moments (reduced according to distance) can be determined directly from the tensor. GETMAG has applications in mineral exploration, environmental studies, ordnance detection, ship degaussing, submarine tracking and monitoring of marine currents.

The project was funded by CSIRO, BHP, De Beers, MIM, Newmont and WMC.

AN AUSTRALIAN GEOMAGNETIC FIELD DATABASE

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The Australian geomagnetic observatory network operated by Geoscience Australia currently comprises six permanent observatories on the Australian continent, two in Antarctica and one (at Macquarie Island) in between. The Geomagnetic program also carries out ongoing repeat station surveys comprising 15 "super repeat stations" that cover Australia, some south-west Pacific islands and Papua New Guinea. It has been estimated that these operations monitor variations of the Earth's magnetic field over approximately an eighth of the Earth's surface.

Geoscience Australia maintains a corporate database that has been gradually populated with data and information from all projects undertaken by the organisation. There is a long history of geomagnetic operations at the organisation as well as holdings of data acquired before the organisation existed. Software has been developed that enables geomagnetic data to be loaded into the corporate database as soon as it is transmitted to headquarters. This, together with the steady population with historical data, has allowed access to Australian geomagnetic data via the Internet.

SOME SNAPSHOTS FROM FIFTY YEARS OF GEOPHYSICS

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A person lucky enough to have worked in different aspects of geophysics in Australia over the last fifty years is sure to have a treasure trove of rich memories. Australia has the great good fortune to be a whole continent within one national boundary, and to be a marvellous laboratory for geophysical methods. The developments in geophysics which have taken place in Australia have been based, and have indeed been possible, because of strong rigorous traditions existing in mathematics, physics and geology.

A perspective to the present state of geophysics is obtained be re-visiting various geophysical experiences over fifty years. The path followed commences with trigonometrical surveying (which allows the fifty years time span!) and progresses through various aspects of magnetic and electromagnetic measurements. Part of the journey takes place on land, some is airborne, and some is by sea. Developments in electronics, and computers, have made geophysics a rapidly-developing and exciting subject.

The last fifty years of exploration work in Australia have taken place against the proving and acceptance of continental drift, plate tectonics and mantle convection. It has therefore been a time of remarkable intellectual stimulation and activity, of the widest possible importance to humankind.

SESSION 1 / STREAM 4

GRAVITY AND MAGNETIC STUDIES

THE TEXTURAL ANALYSIS OF POTENTIAL FIELD DATA

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Textural analysis is a powerful tool, but it is rarely applied to geophysical potential field data because the results are often noisy and ambiguous. New texture filters (based on grey-level co-occurrence matrices (GLCMs)) have been specifically designed for gravity and magnetic data, and are useful for the detection of subtle monopolar and dipolar geophysical anomalies. The method uses two GLCM kernels simultaneously: in the first kernel the GLCM vectors are oriented along the contour lines of the feature to be located, and in the second the vectors are oriented in the 'uphill' direction i.e. orthogonal to those of the first kernel. The ratio of the GLCM texture amplitudes from the two kernels then yields a maximum when the kernel is centred over an example of the feature within the data. The method has general application and is not limited to potential fields. It works with any type of target, as long as an example is available. Applications to both synthetic data and real data are demonstrated.

UNDERGROUND GRAVITY EXPLORATION AT CANNINGTON MINE

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We carried out an underground gravity survey at the Cannington silver-led-zinc mine, Queensland in November 2001. The main objective of the survey was to discover if there were any possible extensions of the known orebody. The survey stations were located in underground tunnels at different mine levels from 100 m to 600 m below the ground surface. A total of 253 stations of data were acquired.

A number of correction steps including free-air, double-Bouguer, regional trend, mine block model, and void corrections were successfully applied to the underground gravity data. This reduced the large amplitude range of 40 mGal in the original data to 0.68 mGal in the residual gravity data. The

effects of the known orebody, underground tunnels, and stopes were accurately compensated using a mine block model and a void block model provided by the mine staff. The residual data shows no coherent strong positive anomalies. A hypothesis testing of various models shows that it is unlikely that there is any unknown orebody of 15 million tons or larger located in the immediate vicinity (within 20 m) of the mine. Furthermore, it is unlikely that there is any orebody of 7 million tons or larger buried within 150 m below the bottom of the mine. However, the possibility of an orebody of 7 million tons located at 20 m away from the south and west sides of the mine can not be eliminated. Because of limited distribution of stations in the mine and the less sensitive nature of gravity to objects on the side, underground gravity data cannot see very far into the four sides of the mine.

To our knowledge, this is the first time such an extensive underground gravity survey has been performed anywhere in the world for the purpose of discovering new ore reserves where accurate compensation of the known mine density distribution is carried out.

MINIMISATION OF THE GRAVITY RESPONSE FROM MINE INFRASTRUCTURE: AN EXAMPLE FROM SONS OF GWALIA MINE, WA

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In near mine exploration, gravity surveys are generally detailed and mine infrastructure, such as waste dumps, tailings dams and open pits, if not taken into account, can often mask the gravity response from the bedrock geological sources.

This was the case at the Sons of Gwalia Mine near Leonora, Western Australia, where a gravity survey on a nominal 100x100m spacing was undertaken to assist in improving the geological framework. Large scale open pit and underground mining activities over the previous 20 years had resulted in significant mine infrastructure. Standard reductions of the gravity data showed a number of anomalous responses that correlated with the waste dumps and tailings dams. Hence there was a requirement to remove the gravity response of the mine infrastructure in order to maximise the response from bedrock sources and thus improve the interpretation.

The methodology used to minimise the effect of mine infrastructure on the gravity data involved three-dimensional forward modelling and removal of the gravity response of the waste dumps and tailing dams prior to conventional terrain correction. For the estimated densities adopted, the maximum infrastructure response was 3.6 mGal.

The results indicate that the bulk of the effects from mine infrastructure have been removed, allowing a clearer picture of the gravity response from bedrock geological sources. Some residual gravity response from the infrastructure, particularly the south-western tailings dam, is apparent. Its removal would require a refinement of the forward modelling of the mine infrastructure.

EXPLORATION AND MODELLING OF BASALTIC ROCKS AND A MAAR DEPRESSION

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Magnetic and gravimetric measurements have been carried out in Lusatia in Eastern Germany. Here an old geological massif comprising granodiorites, greywacks and lower Palaeozoic sediments exist. The boundaries are characterised by big tectonic faults in western, northern and southern parts. In the Tertiary basaltic vulcanism appears in connection with young movements.

The objective of our research was to explore known and hidden basaltic intrusions by magnetic methods. Gravity measurements were carried out to find the thickness of overlying loose sediments. An estimate of the magnetic susceptibility from basaltic rocks reaching the surface was made as well.

We found the shape and the depth of the basaltic intrusions by 2-3/4D forward modelling. Most of the rocks are showing remanent magnetic behaviour. A maar depression was detected and interpreted by joint inversion of gravity and magnetic anomalies.

SESSION 2 / STREAM 4
EM / ELECTRICAL MAPPINGS

RAPID ESTIMATION OF SEAWATER DEPTH FROM AIRBORNE ELECTROMAGNETICS

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Airborne electromagnetics (AEM) has been used on a test basis for bathymetric sounding, with both fixed- and rotary-winged aircraft systems. Applications are usefully restricted to shallow water (up to a few tens of metres), and the systems can be used through ice. Most processing methods to date have however involved extensive post-processing of data before bathymetric information can be extracted, with lag times of the order of months.

We have investigated a number of methods for rapid bathymetric depth estimation that could be used in real-time with AEM data acquisition. The fastest methods are all based on an initial rapid transform of data to conductance-depth sections. Once in conductance-depth space, it is possible to estimate depth from the maximum conductance encountered at each reading if the conductivity of seawater is known, and if the sea floor can be assumed to be electrically resistive.

Alternatively, it is possible to attempt to solve for both seawater conductivity and depth independently using a thick-layer approximation such as that developed by Singer and Green, but this is a slower and potentially unstable process, with the potential advantage that seafloor conductivity can be assessed. AEM and bathymetric sounding data has been used to assess the validity of the approximate methods. The data assessed has included the Helicopter based Dighem data collected over Sydney Harbour and Fixed-wing Geotem data collected over and near Geographe Bay, Western Australia.

INVERSION OF DATA FROM ELECTRICAL IMAGING SURVEYS IN WATER-COVERED AREAS

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Electrical imaging surveys that are now widely used in many environmental and engineering studies have also been carried out in water-covered areas. These surveys include conventional surveys with multi-electrode resistivity meter systems where part of the survey line crosses a river. In some surveys that are located entirely within a water-covered environment, the electrodes are mounted on a streamer that is towed behind a boat. The streamer is dragged along the river/sea bottom, or float on the water surface. The smoothness-constrained least-squares inversion method that is used to interpret the data from land surveys is adapted for underwater surveys. To accommodate the underwater topography, a distorted finite-element grid is used to calculate the apparent resistivity values for the inversion model. The first few rows of elements are used to model the water layer, while the lower part of the grid is used for the sub-bottom resistivity distribution. For an accurate

inversion, the water resistivity as well as the depth to the bottom surface must be accurately known since a large proportion of the current flows through the water layer. The section of the earth below the bottom surface is subdivided into a large number of rectangular cells. The water resistivity in the model is fixed, and the inversion program attempts to determine the resistivity of the cells that would most accurately reproduced the observed measurements. Examples from surveys in rivers, marine environments and across rivers are shown.

POST-PROCESSING CALIBRATION OF FREQUENCY-DOMAIN ELECTROMAGNETIC DATA FOR SEA ICE THICKNESS MEASUREMENTS

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Sea ice thickness measurements using electromagnetic (EM) instruments require accurate data. Calibration of sea ice thickness data acquired using a low induction number (LIN) EM sensor can be performed by conducting a geometric sounding at a range of heights over level sea ice of known thickness, and by comparing the observed data with the expected layered-earth response. Calibration corrections for scaling, phase-mixing and zero-offset errors can be derived using least-squares inversion to minimise the misfit between the observed data and the theoretical response, and can be incorporated in modelling algorithms used to determine sea ice thickness.

This paper presents a case history illustrating identification and correction of calibration errors in low induction number EM data for Antarctic sea ice thickness measurements. Comparison of coincident EM measurements made using three identical LIN instruments showed that measured apparent conductivities disagreed by up to around 100 mS/m, resulting in errors in the estimated sea ice thickness of up to 60%. Separate calibration corrections were determined for each instrument by analysis of geometrical sounding data acquired over level sea ice. Sea ice thickness at the calibration site was determined by making a large number of drilled thicknesses over the footprint of the EM instrument, and seawater and sea ice conductivities were determined using independent measurements. After application of the calibration corrections, sea ice thicknesses derived from the three instruments agreed closely with each other and with drilling results.

THE TIME-DOMAIN ELECTROMAGNETIC RESPONSE OF WEDGE-LIKE STRUCTURES

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Wedges are structures that vary in thickness from top to bottom over length. Despite their application to modelling the regolith, groundwater and bathymetric problems, wedges have not been studied in any great detail. We simulated the response of wedge-like structures using Tempest and HoisTEM-like AEM systems and a fixed-loop SIROTEM ground system.

We found that it was very difficult to distinguish between the responses of wedges with different dips until smoke rings had penetrated the conductive outcropping wedge. This means that thinner wedges are easier to see than thicker wedges. It also implies that a vertical block might be a useful approximation to thicker wedges.

Differentiation of wedge responses was best achieved using the vertical component of a fixed loop positioned off the wedge. Inline components of central-loop prospecting systems were useful as "bump detectors".

THEORETICAL TREATMENT OF AMPLITUDE CALIBRATION PROBLEMS IN HEM DATA

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A recent increase in the environmental usage of Airborne EM has shown the need to accurately provide values of depth and conductivity. Calibration problems in Helicopter EM data produce imprecise conductivity depth images (CDI's), maps and sections, which are essential requirements in order to target smaller, near-surface objectives, such as salinity outbreaks.

To ensure agreement between ground-truth such as conductivity logs and CDI's, data recalibration is often applied before processing. Ground-based methods, if available, have spatial limitations. An alternative statistical average method has been developed to provide theoretical consistency. In conductivity independent?aß domain, the median response of a variety of expected synthetic models based on expected geology is calculated and compared with the median of the larger amplitude field data. The data are then rescaled in the data domain so that the recalibrated median response lies exactly on the theoretical curve.

The amplitude rescaling was applied to an HEM data set, collected in the Riverland area in South Australia. The results were compared using maps and CDI images of the raw and recalibrated data. The original delivered data produced CDI images which were generally inconsistent with borehole conductivity data. However, rescaling to ensure 'thin-sheet' consistency has produced remarkable agreement between ground truth and the CDI sections.

SESSION 3 / STREAM 4
ELECTRICAL AND EM STUDIES

B-FIELD TEM DATA ACQUISITION FOR NICKEL EXPLORATION

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It has long been recognised that highly conductive bodies can be invisible to conventional TEM surveys using coil sensors. Such sensors measure the rate of decay of the magnetic field, dB/dT, associated with the induced current, which can be lower than instrument detection limits for highly conductive bodies. These same bodies may be detectable by the direct measurement of the magnetic field, B-field, as this is directly proportional to the amount of induced current in the body rather than its rate of decay.

A method of acquiring low-noise B-field TEM data has been developed using fluxgate magnetometer sensors. The method allows full time series B-Field and conventional dB/dT data to be acquired simultaneously in a cost-effective manner using otherwise standard TEM crews, instrumentation and procedures. A number of surveys have been successfully completed and acquisition of simultaneous B-field and dB/dT data is now routine procedure.

Field examples with concurrent dB/dT and B-field readings illustrate the advantages of acquiring B-Field TEM data, including several instances where conductive features not detected by conventional dB/dT measurements have been detected by B-field measurements.

SNMR SIGNAL CONTRIBUTION IN CONDUCTIVE TERRANES

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To correctly invert and interpret Surface Nuclear Magnetic Resonance (SNMR) data collected in conductive terranes, an accurate estimate of subsurface conductivity structure is required. Given such an estimate, it would be useful to determine, before conducting an SNMR sounding, whether or not the conductivity structure would prevent groundwater being detected. Here we use synthetic data to find the maximum depth at which water can be detected and the depth range from which most of the SNMR signal originates in conductive halfspaces.

The results of the investigation can also be used to estimate these parameters where conductivity structure is not well represented by a halfspace. It is also shown that for coincident loop SNMR soundings, increasing loop dimensions does not significantly improve depth penetration.

CROSSHOLE ELECTRIC SCANNING AND PROFILING OF A CYLINDRICAL CONDUCTOR: LABORATORY INVESTIGATIONS

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A 3-D laboratory tank model system was constructed and used to investigate the crosshole DC electric imaging possibilities of a conductive target using a bipole-bipole array, with one current electrode located in each simulated borehole. Both scanning and profiling measurements were made, for five different classes of cylindrical model, depending on the cylinder orientation relative to the plane of the boreholes and whether the target was continuous, terminating, or broken between the points of measurement, and whether the conductor was intersected by one of both boreholes. Each class of model produces a characteristic response, which can be used to identify the conductor and locate its upper and lower boundaries. Data were collected for different bipole separations. Very clear anomalies are produced for the scanning arrangement (both bipoles moved together) for models involving conductor intersection. Electric profiling, which entails one fixed bipole and one mobile bipole, produces a more subtle but nonetheless diagnostic pattern.

MONITORING ELECTRICAL PROPERTIES OF ROCKS IN TARGET ZONE OF CO2-SEQUESTRATION SITE

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We address evaluation of resistivity of a target zone of a CO2-sequestration site using a simple measurement made from inside metal-cased boreholes. An approximate analytical expression is derived for the admittance measured between two metal casings in a stratified formation. It is shown that in a highly conductive environment measurement electrodes should be positioned inside the target depth range. Charts and plots are produced for evaluation of the admittance as a function of the inter-casing separation and gas saturation in the target layer. The results indicate the possibility of monitoring the target zone using metal-cased borehole separated by distances of several hundreds metres.

SESSION 4 / STREAM 4

DATA MANAGEMENT AND EVALUATION

OPTIMIZING EARTH SCIENCE DECISION-MAKING THROUGH TECHNOLOGY INTEGRATION

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The emerging trends in geospatial technology are data management, software standardization and integration; and the underlying theme is one of synthesis and simplification.

Earth science decision-making is dependent on the ability to quickly, reliably, and efficiently gain knowledge from increasingly large and complex volumes of geospatial data. Yet, despite increases in the availability of data and sophisticated software, geoscientists are historically spending seventy percent of their time on 'data chores', such as data gathering, processing and manipulation, and only thirty percent on building the knowledge base for decision-making.

As a result, we are seeing new initiatives, within exploration and other earth science-related industries, to streamline workflows, standardise applications and integrate technologies in efforts to be more efficient and cost-effective.

As software becomes more integrated and seamlessly connected, geoscientists can process, visualise, and interpret data without spending excessive amounts of time finding, moving, and reformatting data.

In this presentation, we examine how an integrated technology environment, including data access and transfer technologies, data processing and analysis software, and 3-D visualization software can maximise efficiency and optimise knowledge development.

Ultimately, the integration of Knowledge Experts, workflow process, and software technologies enables organizations to optimize decision-making and maximize knowledge development to ensure successful investigation outcomes. Workflow efficiency improvements deliver savings through productivity gains and reduced project life-cycle costs.

VALUE CREATION IN THE DIGITAL AGE: AN INFORMATION MANAGEMENT APPROACH

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One of the biggest challenges in oil and gas exploration is accurately measuring the financial return on investments in technology. Metrics are evolving that allow the rigorous calculation of value added and the effect on ensuring discoveries. Information Management solution implementations provide value creation, which involves streamlining key elements of process, technology and data. They consist of workflow optimisation, technology mastery, and data ownership initiatives. No matter how large or small the business, to expand business opportunities, streamline processes, improve customer satisfaction, and increase profitability, companies need to take advantage of technology solutions that can transform the way they do business. At the same time, these technology solutions must be able to: 1) support the corporate vision, 2) be delivered via reliable, high-performance networks, 3) scaled with the growth of the company, and 4) offer maximum value at the best cost. Impacts on business objectives are calculated in reduced cycle time, improved quality of strategic decisions, and the value of standardised processes. Measures are provided of barrels of oil added to proven reserves, documented cost savings, and verifiable calculations of the value of time saved for geotechnical personnel working on exploration projects. The pressure will increase as producing fields mature and require more complex processes, tools, and data to be effectively managed.

The value of innovative technology solutions can be measured and demonstrated for exploration and development operations by objectively measuring reductions in cycle time due to workflow optimisation, barrels of oil added as a result of technology mastery, and cost reductions from data ownership initiatives.

XMML - A STANDARDS CONFORMANT XML LANGUAGE FOR TRANSFER OF EXPLORATION DATA

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eXploration and Mining Markup Language (XMML) is a GML-based catalogue of feature-types used in mineral exploration. XMML includes boreholes, observations, assay data, geophysical data, geological features (rock-unit, fault, etc) and supporting concepts (geological timescale). The GML basis ensures conformance with ISO standards, national Spatial Data Infrastructures, and compatibility with languages developed in other communities, within and outside the geosciences. GML languages are compatible with interfaces such as Web Feature Services (WFS), which provides a GML "view" of data sourced from GIS and DBMS.

GML was developed under the sponsorship of mainly Australian mining and service companies and agencies, who determined the requirements and initial priorities. However, further development of XMML is proceeding in collaboration also with the academic community, international geological surveys. XMML will be standardised through IUGS.

XMML provides an open, platform-neutral, standards-conformant means for transfer of exploration data between applications and between organisations. Using XMML and WFS provides for publication of data by data custodians at both fine and coarse-grained level. XMML and WFS/T provide a transactional interface. The Government Geologists Information Management Advisory Committee (GGIPAC), which has partly sponsored XMML, is considering that XMML be a technology for statutory reporting in the near future.

KNOWLEDGE FROM DATA - A NEW TOOL FOR ANALYSIS OF DIVERSE DATA

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Self Organizing Maps (SOM) are a tool for the visualization and interpretation of complex, multivariate data with many potential applications in geophysics.

We demonstrate the ability of the SOM method to analyse a data set with 50% missing data. This robustness of a SOM enables it to also be used to interpolate missing data and see through noise to underlying relationships between the data variables.

A study involving geophysical log data for the characterization and prediction of lithologies with anomalous levels of radioactivity in the Bowen Basins is used to illustrate the calibration of a SOM. In this case the SOM was used to identify the radioactive sandstones. This was then used successfully as a classification template for data from another mine site, >30km to north-east.

EXPLORATION, RISK AND THE VALUE OF GEOPHYSICS

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Developments in the application of statistical signal processing techniques to mineral exploration have shown that, in addition to providing a ranked set of targets, it is possible to make useful statements about the probability of successfully detecting a target and the probability of producing a false alarm. These probabilities can then be use to assist and assess exploration decision-making. This paper outlines a method to analyse the cost-effectiveness of a given geophysical technique as part of an exploration programme and demonstrate the increase in NPV that geophysics can provide.

I consider a simple model for the exploration process. The model accepts the probabilities produced from the target selection process and uses them with simple, generalised prospectivity information and exploration financial constraints to estimate the probability of exploration success. Then, using standard methods from financial analysis, this scheme has been generalised to a more complete study of the profitability of the exploration process. Thus, instead of modelling a single exploration scenario, we can model in a way that accommodates wide ranges of possible inputs and NPV outcomes.

Like most financial analysis, this type of analysis can't be rigorous in the same way we think of geophysical data analysis. However, it is an objective way of examining and justifying exploration expenditure that meshes well with many other types of financial analyses that are used to make decisions in most other aspects of the mining industry. In that sense it provides exploration management a quantitative way of evaluating exploration options and justifying exploration expenditure.

THURSDAY SYMPOSIA

INVERSION IN MINERAL EXPLORATION

KEYNOTE

KEYNOTE: INCORPORATING GEOLOGICAL INFORMATION INTO GEOPHYSICAL INVERSIONS

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TOWARDS 3D MAPS OF ALTERATION UNDER COVER: REGIONAL CONSTRAINED 3D INVERSION OF POTENTIAL FIELD DATA FROM THE OLYMPIC CU-AU PROVINCE, SOUTH AUSTRALIA

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Regional-scale constrained potential field inversions can be used to map rock types, alteration, and structure. This is particularly valuable when basement is obscured by younger cover. The methods outlined in this study have been applied to a 150 km × 150 km region around the giant Olympic Dam copper-uranium-gold deposit, where abundant haematite, sulphide, and magnetite alteration produce strong potential field signatures despite thick cover. The results are used to develop the first 3D map of magnetite and haematite/sulphide alteration for the Olympic Cu-Au province, and show that the alteration around known Cu-Au mineral occurrences can be detected using coarse regional-scale inversions.

The provision of a reference model in the inversion formulation permits geological observations to be introduced into the inversion process to guide the inversion towards more geologically reasonable results. This allows hypotheses regarding 3D geological architecture to be rigorously tested for compatibility with potential field data. An iterative procedure of inversion followed by updating the reference model allows 3D maps of alteration and structure that are consistent with both the known geology and observed potential field data.

EXPLORING THROUGH COVER - 3D INVERSION OF POTENTIAL FIELD DATA OVER THE PROMINENT HILL DISCOVERY IN SOUTH AUSTRALIA

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Prominent Hill is an Olympic Dam style copper gold breccia deposit. It is located in the central part of the Mt Woods Inlier, close to the eastern margin of the Gawler Craton. The deposit was discovered in 2001 after ore-grade massive sulphides were intersected in the initial drillhole test of a gravity anomaly, in an area that had previously been partially drill tested by other companies.

The residual gravity anomaly at Prominent Hill is in the order of 7 mGal, it derives from two principle sources, magnetite and hematitic breccias. Mineralisation is exclusively associated with hematite development. Thus, the causative body for the gravity anomaly needs to be resolved in detail, while at the same time using the magnetic anomaly to differentiate the non-magnetic portion of the gravity anomaly from the dense-magnetic fraction.

A high-resolution gravity survey (100 m stations) was acquired over the prospect. 3D inversion software from the University of British Columbia was used to construct detailed 3D models of both the gravity and magnetic data. Subsequent diamond drilling has verified that these inversions are extremely accurate in their ability to delineate the mineralised breccia. The vertical accuracy of the gravity inversion is particularly noteworthy.

Interpretation of gravity data is fraught with ambiguity, in order to minimise this petrophysical data from the boreholes has been used to constrain the gravity model. The constrained inversion is being used to assess the potential for additional mineralised horizons at Prominent Hill.

GeoExpress software has allowed the simultaneous visualization in 3D space of the 3D inversions, 2D filtered potential field data, geological and structural information etc. This has contributed significantly to the interpretation of the geophysics.

3D JOINT INVERSION OF ELECTRICAL AND MAGNETOMETRIC RESISTIVITY DATA

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The DC electrical resistivity (DC) and magnetometric resistivity (MMR) are two geophysical techniques applied in exploration of mineral resources and in solving environmental and engineering problems. Conventionally, these two techniques are used separately to infer the subsurface conductivity. As each of these methods has its own relative merits and limitations, a joint use is expected to provide complementary information, and possibly reduce the survey costs as well. In this paper, we present a unified algorithm to compute the potential and magnetic fields that arise from buried source electrodes. This is done in two consecutive steps by solving a Poisson's equation for a scalar electrical potential and a magnetostatic equation for a vector magnetic potential, respectively. The inverse problem is formulated as an optimization in which both observed potential and magnetic field data are fit to a certain degree, and at the same time, the recovered model has a minimum structure. The standard Gauss-Newton algorithm is used to obtain the model perturbation at each iteration. The code is verified with a synthetic model.

HUMAN INTERACTION IN GEOPHYSICAL INVERSION

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PRACTICAL 3D AIRBORNE EM INVERSION IN COMPLEX TERRANES

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Many AEM inversion techniques have been applied successfully to locating isolated, highly conducting targets in uniform hosts. What happens when these targets occur in complex hosts overlain by non-uniform regolith with topographic features? In principle, a full 3D inversion is possible due to the availability of forward modelling programs capable of accounting for the full geoelectric complexity of any terrane. In practice, the inherent non-uniqueness coupled with modelling and data errors plus the requirement of substantial computation times render this approach unappealing for all but the most academic of inverters. On the other end of the complexity scale, simple imaging methods such as CDIs can fail badly for dipping targets and Born style approximations produce wrong models for moderate to high conductivity contrasts. This can be demonstrated by using accurate forward modelling algorithms to compute the EM responses of models produced by these methods.

Practical AEM data interpretation requires a technique that is capable of recognising drill targets in a variety of terranes but one that doesn't require excess complexity or massive computing times. One such method, LeroiAir, is based on 3D thin sheet models in a layered, conducting host. The implicit forward model is fast, easy to set up and takes account of vortex and current gathering for any conductivity contrast. It is also capable of modelling the effects of other conductors such as faults and palaeochannels. As expected, the thin-sheet inversion works well for simple isolated targets. As complexity increases, the inversion quality degrades but still yields useful drill target information in many cases.

UNRAVELLING SOURCE SPATIAL PARAMETERS AND MAGNETISATION DIRECTION FROM INVERSION OF TMI, VECTOR COMPONENT AND TENSOR MAGNETIC FIELD DATA

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In this paper I investigate the level of error in magnetisation direction which might pass undetected in TMI inversions, and estimate the corresponding errors that this will cause in estimating the location and shape of source bodies. I also show that three-component and gradient tensor data can potentially provide increased sensitivity to source magnetisation direction. These studies are undertaken by forward computing magnetic anomalies for bodies with various magnetisation directions and then inverting those anomalies with the assumption of induced-only magnetisation. The misfit between input and output fields after the TMI inversions increases with error in source magnetisation direction. Up to 30°- 40° the misfit is likely to be undetectable. Up to 60° - 70° the misfit can be reduced by invoking a more complex distribution of magnetisation, but from 70° - 90° the inability to match an anomaly with any feasible distribution of magnetisation is diagnostic of error in the source magnetisation direction. The associated errors in location and dip of a source body increase with undetected error in its magnetisation direction.

Components of the magnetic field behave similarly but not identically to error in source magnetisation direction, and slight differences between component inversions provide additional sensitivity to source magnetisation for errors above 40°. Unfortunately, measurement difficulties for component data are likely to restrict the achievement of this improvement. Magnetic field tensor data also increase sensitivity to source magnetisation direction and enable better constrained inversions of the magnetic field.

THREE-DIMENSIONAL QUASI-ANALYTICAL INVERSION OF ELECTROMAGNETIC FIELDS IN MODELS WITH INHOMOGENEOUS BACKGROUND CONDUCTIVITY

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The traditional implementation of the integral equation (IE) method for three-dimensional (3D) electromagnetic (EM) modelling and inversion requires the background model to be horizontally layered. Any deviations from that background model must be treated as inhomogeneous inclusions. This can be very limiting when solving the 3D inverse problems where the background model is known to be inhomogeneous. To overcome this problem, we have extended the IE method for 3D EM modelling to include an inhomogeneous background conductivity distribution and applied this to rapid 3D inversion based on the quasi-analytical (QA) approximation. This allows for the inclusion of known inhomogeneous background geoelectrical information within the area of investigation when solving the inverse problem. We demonstrate this technique on the 3D inversion of a synthetic controlled source frequency-domain EM survey above a Kambalda-style nickel sulphide deposit beneath a complex regolith.

HOLISTICALLY CALIBRATING, PROCESSING AND INVERTING FREQUENCY DOMAIN AEM SURVEYS

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A holistic approach to the calibration, processing and inversion of airborne frequency domain electromagnetic data is proposed. This is achieved by simultaneously determining calibration corrections and a conductivity model. This would avoid the inevitable propagation of errors that occurs when calibration, processing and inversion are tackled in an independent and sequential manner.

The method is structured as a large non-linear inverse problem, the solution of which yields a set of parameters from which calibration correction factors and a three-dimensional (3D) conductivity model can be produced by summation of basis functions. The inversion ensures that the observed airborne data are consistent with data predicted from forward modelling of one-dimensional (1D) local conductivity models generated from the 3D model, and with the correction parameters. It also ensures that the conductivity model is consistent with independent observations of sub?surface conductivity, and with a priori knowledge of conductivity including the local spatial continuity or smoothness of these values.

A REVISED INVERSION MODEL PARAMETER FORMULATION FOR FIXED WING TRANSMITTER LOOP - TOWED BIRD RECEIVER COIL TIME-DOMAIN AIRBORNE ELECTROMAGNETIC DATA

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The conversion of data to conductivity for fixed wing transmitter loop - towed bird receiver coil time-domain airborne electromagnetic (AEM) systems, such as TEMPEST, would ideally utilise complete knowledge of the system geometry and measurements for all 3 mutually perpendicular components of the received signal. In practice, not all of this information is available.

We use a layered inversion that integrates TEMPEST survey data with a priori conductivity information from the survey area. Total (primary plus secondary) field data from both the X (horizontal in-line) and Z (vertical) components are used. Receiver coil pitch angle and transmitter loop to receiver coil horizontal and vertical separation parameters are included as unknowns in the inversion. Borehole conductivity data are used to build a reference conductivity model that acts as a constraint to stabilise the partitioning of the measured signal into primary field and ground response contributions. Smoothness constraints are applied to the conductivity values in the 1D model.

The quality of the inversion output was assessed through comparison of the conductivity predictions with borehole conductivity values and shallow single-frequency ground EM measurements. This showed that the new formulation more accurately predicted conductivity than two previous sets of conductivity predictions.

THURSDAY SYMPOSIA

SALINITY STUDIES

REVIEW OF METHODS FOR MAPPING DRYLAND SALINITY

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Dryland salinity, a growing problem over much of Australia, can only be mapped and predicted with a thorough understanding of the landscape in three dimensions and the hydrological processes that operate within it. Hydrology is the key for understanding how salt stores are mobilised through the earth, both in a vertical and horizontal sense.

Mapping techniques have important roles in delineating soils, landforms, water flow and pathways through subsurface topography, as well as detecting or inferring the presence of salt itself. Satellite and airborne remote sensing techniques are useful in delineating existing surface and near-surface salt, and tracking changes over time. Airborne geophysical techniques, combined with ground and borehole control, are important tools in understanding salinity and hydrology at depth, and essential tools for predicting future changes in salinity.

Salt is a hazard when it has the potential to be moved, usually by water, to a location where it can threaten an asset, which may include agriculture, infrastructure, water quality and biodiversity. Salinity risk is a measure of the chance that the salt hazard will cause harm to the asset at some time in the future. Cost-benefit analyses in salinity management should take into consideration total cost and total benefit in context with the value of the asset.

The optimum strategy for salinity hazard and risk mapping depends on the scale (farm, community or catchment) and resources available to the user. The best approach makes use of existing information and then integrates a range of the available mapping methods in such a way to best address the specific question at hand. No one method has primacy, nor is there a 'magic bullet' for salinity mapping or prediction. Effective use of mapping methods requires expert knowledge or access to trained personnel.

SOME OBSERVATIONS ON THE SEDIMENTARY FRAMEWORK OF THE LOXTON-BOOKPURNONG REGION, SOUTH AUSTRALIA AS DEFINED BY BOREHOLE, GROUND AND AIRBORNE GEOPHYSICAL DATA - IMPLICATIONS FOR INFORMING THE DEVELOPMENT OF GROUNDWATER INTERCEPTION SCHEMES

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The construction of salt interception schemes (SIS) in the Riverland region of South Australia forms an integral part of a broader strategy to manage saline groundwater intrusion into the River Murray. Results from the inversion of airborne electromagnetic data provided some insight into the distribution and variability of the Loxton sands aquifer. These data indicated regional facies variations associated with the main barrier

systems of this prograded strandline sedimentary sequence. The relevance of this information is being followed up in an examination of options for the Bookpurnong highland borefield. A program involving the acquisition and interpretation of neutron, gamma and inductive conductivity borehole logs, NanoTEM ground TEM traverses, and the analysis of HEM data was undertaken to better define the sedimentary and hydrogeological model of the area. This approach has been critical in explaining local scale changes in the sedimentary environment and elucidating reasons for the variable aquifer yield in the Loxton sands aquifer.

INVESTIGATION INTO SALINISATION IN SOUTH-WEST QUEENSLAND

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This study, combining geophysical and environmental approaches, was undertaken to investigate the causes of secondary salinity in the Goondoola Basin, in south-west Queensland.

A range of airborne and ground geophysical datasets were acquired, along with information on surface and subsurface materials and groundwater. Relationships established between various spatial and point datasets allowed us to generate predictive maps of surface materials, surficial salt stores and recharge potential. Investigation of groundwater and subsurface architecture identified subsurface salt stores and potential discharge areas.

Salinisation in this area occurs as a result of local- and intermediate-scale processes, controlled strongly by regolith architecture. Management strategies can now be tailored specifically to prevent excess recharge and further salt mobilisation.

AIRBORNE GEOPHYSICS FOR NATURAL RESOURCE MANAGEMENT, ANGAS BREMER PLAINS, SA

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Airborne electromagnetics (AEM), magnetics and radiometrics flown over the Angas-Bremer alluvial plain southeast of Adelaide, SA, provide information for natural resource management in an area of intense viticulture with a shallow saline water table, and a deeper fresh-water Tertiary aquifer at risk of salinisation.

A specific aim of the surveys was to delineate shallow palaeochannels that could be pumped to lower shallow saline water tables. These are not apparent in the data, either due to absence, or inability to image such features due to lack of contrast in physical properties.

The surveys give a new view of the landscape, geology and regolith framework of the area. There is no evidence for a fault (postulated from resistivity soundings 30 years ago) that has been modelled as a recharge conduit to the deep aquifer. However, several previously unrecognised faults have been interpreted from the data and drill information. These offset the Cenozoic aquifers by up to 80 m. AEM and drill data have helped to determine a new set of structure contours for the base of the aquifer system which will assist more robust groundwater modelling.

AEM response in the aquifers correlates loosely with measured water salinity, but the relationship is not tight enough to allow imaging of high quality groundwater from the AEM. The DEMs constructed from the surveys give better accuracy to landscape modelling in the area, and the radiometrics have the potential to form the basis for upgraded soil maps. Ten broad land management units across the area have been defined by reference to geophysical properties and drill hole information.

INTERPRETATION OF HELICOPTER AEM DATA FROM THE RIVERLAND AREA, SA

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RESOLVE frequency domain helicopter electromagnetic (HEM) data have been used to map the distribution of near-surface clay-rich sediments in and around the Riverland irrigation districts of South Australia.

The results of the inversion also allow us to reconstruct the strandline-dominated palaeo-topography left when the sea retreated from the Murray Basin in the Early-Mid Pliocene. The survey also revealed a hitherto unsuspected, deeper variability in conductivity following the Pliocene strand line pattern. The cause of this pattern is not clear, but could be due to variations in the porosity of Loxton Sands or to strandline-correlated variability in the elevation of the contact between the Bookpurnong Beds and the Lower Loxton sands.

THE VALIDATION OF RESOLVE AEM DATA IN THE RIVERLAND, SOUTH AUSTRALIA, TO DETERMINE THEIR VALUE IN MAPPING A REGIONALLY SIGNIFICANT, NEAR SURFACE HYDROGEOLOGICAL UNIT

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In the Riverland region, the South Australian Salinity Mapping and Management Support Project used the helicopter-borne RESOLVE EM system to map conductive fine textured materials (the Blanchetown Clay) in the unsaturated zone as a basis for groundwater recharge modelling. Ground validation of the AEM data included 14 boreholes, which target various observed conductivity responses that were present in the 106 kHz and 25 kHz apparent conductivity images. Evidence from down-hole induction logs, measurements of water and chloride content and texture from drill core, indicates that conductivity can be used to map near surface clay. However, ambiguity arises due to the presence of shallow conductive saline groundwater, which can be confused with the presence of clay.

A "Clay thickness map", produced from the constrained inversion of the HEM data effectively depicts the spatial distribution and thickness of clay, and eliminates problems of separating areas of clay from areas of conductive groundwater.

HYDROGEOLOGY AROUND JAMESTOWN, SOUTH AUSTRALIA, REVEALED THROUGH AIRBORNE GEOPHYSICS

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The farming communities around Jamestown in the Northern Agricultural District of South Australia have experienced periodic crop losses due to salinity and waterlogging. Detailed soil maps and localised studies had not provided a comprehensive understanding of the causes of salinity, and a larger-scale approach was required.

The area was flown with airborne electromagnetics (AEM - TEMPEST), magnetics and radiometrics in mid-2002 over three parallel N-S valleys with different expressions of salinity: Caltowie Valley suffers from surface scalding, infrastructure damage and very shallow, saline watertables. Jamestown/Bundaleer Valley has regions of crop failure across the valley floor, seasonal waterlogging and periodic shallow, saline watertables. In Belalie Valley isolated soil degradation and scalding occurs only on north-facing slopes, with minimal salinity issues on the valley floor.

Topography shows an increase in valley size from Caltowie to Jamestown to Belalie. Surface drainage is minimal (rainfall 400-500mm/a), but seasonal floods over thick clay soils result in almost yearly waterlogging, particularly at bottlenecks in the topography: in Caltowie and Jamestown Valleys.

Airborne magnetics reveal an extensive sub-surface drainage system, defining preferential groundwater pathways beneath broad, flat plains. This has important differences from the surface drainage, helping explain the observed patterns of salinity.

The AEM confirms these pathways adding the element of depth; explaining why and where salinity is, and is not, expressed at the surface.

Radiometrics highlight surface distribution of materials through and between valleys, particularly the association with salt-bearing waters.

Down-hole and groundwater chemistry confirms the relationships shown by the airborne geophysics, defining the scale of groundwater flow systems responsible for the salinity concerns of the region.

MAPPING 'NESTED' GROUNDWATER FLOW SYSTEMS, AQUIFERS, AND SALINITY SYSTEMS IN THE LOWER BALONNE, SW QUEENSLAND

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The Lower Balonne Airborne Geophysics Evaluation Project is the largest AEM (TEMPEST) survey acquired in Australia for natural resource management purposes. 28912 line-km of data were acquired in 2001 under the auspices of the National Action Plan for Salinity and Water Quality, in a project undertaken by the Queensland Department of Natural Resources and Mines (QNR&M), the Cooperative Research Centre for Landscape, Environments and Mineral Exploration (CRC LEME), and the Bureau of Rural Sciences (BRS). The survey area is located astride the Lower Balonne River, a tributary to the Darling River system in southern Queensland. The survey was flown to evaluate the use of airborne geophysics techniques for salinity mapping and understanding in an area of intensive cotton irrigation where there was little knowledge of sub-surface regolith architecture or groundwater and salinity processes and distribution.

In this paper we outline the results of an integrated geoscience approach that has mapped 'nested' groundwater flow systems and aquifers concealed beneath the modern alluvial floodplain. Borehole data, including sedimentological analysis, hydrogeological data including pore fluid analysis and isotopic data, have been used to identify groundwater flow paths and improve our understanding of groundwater and salinity processes.

The highlights of the project for environmental management include:

- An understanding of the 3-D nature of the regolith (to inform models of surface-groundwater interaction and groundwater movement);
- an understanding of the connectivity of the aquifers and 'nested' groundwater flow systems of different salt-water systems;
- the existence and extent of vertical and lateral flow;
- the size of the salt stores and the potential for mobilisation;
- the mapping of groundwater surfaces and preferential flow paths; and
- contributions to a dynamic water balance model.

These data are being used to better understand the salinity risk and water security issues in this area.

CONSTRAINED INVERSION OF HELICOPTER AEM DATA FOR MAPPING THE BLANCHETOWN CLAY

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A RESOLVE frequency domain helicopter electromagnetic (HEM) survey has been flown in and around the Riverland irrigation districts of South Australia. The purpose was to map the distribution and thickness of near-surface clay-rich sediments which impact on irrigation, groundwater and salinity management strategies.

The survey data were re-calibrated after their conventional processing by utilising independent ground geoelectric data.

Data were inverted using a five-layer 1D parameterisation of the earth. Reduction of the ambiguity in the unknown aspects of the geological section was sought by constraining the inversion with as much local geological and hydrological information as was available. Groundwater depth information was incorporated as an extra datum to constrain the upper layer thicknesses. A combination of drill hole lithologic, groundwater and downhole conductivity data were used to construct a spatially variable reference model and impose constraints on the estimated parameters in the form of prior probability information.

The resulting detailed map of the thickness of the Blanchetown Clay is more detailed than previous compilations based on drilling. The results also provide insight into other important hydrogeological features of the Riverland area.

RIVER-BORNE NANOTEM SURVEY FOR LOCATION OF SALT ACCESSION TO THE RIVER MURRAY AT LOXTON

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As part of an ongoing commitment to the reduction of salt accession to the River Murray in South Australia, the South Australian Department for Water, Land and Biodiversity Conservation (DWLBC) is engaged in a series of investigations to determine the feasibility of the construction of salt interception schemes (SIS). An integrated multi-disciplinary approach has been adopted to develop an understanding of the hydrogeological processes, which is essential for effective scheme design (Hill et al., 2004).

To assist in identifying areas of salt accession, a river-borne NanoTEM survey was conducted in September 2003. Previous work at the Waikerie SIS highlighted the success of the river-borne Transient Electro-Magnetic (TEM) technique (Barrett, 2003, Barrett et al., 2003). These systems can provide valuable information and understanding of salt accession to the River Murray.

Traditional methods such as river EC measurements and Run of River (RoR) EC surveys have revealed that the Loxton and Bookpurnong reaches of the river receive substantial salt loads. These techniques provide limited spatial resolution, whereas the river-borne TEM has exceptional spatial resolution with soundings every 5 - 10 m.

Zonge Engineering and Research Organisation collected a total of 80 km of data over a 37 km stretch of the River Murray near the townships of Loxton and Bookpurnong. The survey results correlate well with recent RoR data, sediment core ground-truthing and groundwater model flow budget results.

A COST REDUCTION METHODOLOGY FOR THE ACQUISITION OF TIME DOMAIN AIRBORNE ELECTROMAGNETIC SURVEYS IN THE CONTEXT OF SALINITY AND GROUNDWATER MAPPING

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CRC LEME

A methodology to acquire airborne electromagnetic (AEM) surveys to map key landscape elements relevant to salinity and groundwater quality has been developed to optimise survey acquisition cost-effectiveness. Considered an expensive technology for natural resource management (NRM) applications, significant optimisation of AEM survey parameters, namely flight line spacing, can be achieved prior to data acquisition.

The optimisation method is dependent on the scale of features to be mapped, however for catchment and sub-catchment characterisation, the use of broadly spaced flight lines is feasible. The method involves examination of all pre-existing data for a proposed area to identify the scale and resolution of the key landscape elements. Forward modelling is then performed to determine the optimal line spacings for the survey. Landscape elements that require detailed investigation can be targeted using closely spaced swath flight line sets.

Case studies presented for three time domain (TEMPEST) AEM surveys (GILMORE, NSW, Lower Balonne, Qld. and Honeysuckle Creek, Vic.) demonstrate that conductivity grids produced at 5 times the original line spacing can be used to resolve key landscape features relevant to salinity and groundwater mapping at sub-catchment to catchment scale. This equates to an average line spacing of 1 km for most surveys, which approximates to $0.7/ha for larger surveys.

For interpretation, a qualitative assessment of interpolation methods found triangular irregular network (TIN) gridding algorithms to be most appropriate for widely spaced lines. Additional improvements in conductivity predictions for each survey were demonstrated from reprocessing using an advanced version of EMFlow, increasing the conductivity model resolution. These improvements in the data processing and conductivity predictions will assist in reducing acquisition costs by an order of magnitude and potentially make the technology more affordable for future NRM applications.

The use of widely spaced flight lines combined with improvements in data processing can contribute to significant reduction of acquisition costs.

3D 3C SEISMIC REFRACTION IMAGING OF SHEAR ZONE SOURCES OF DRYLAND SALINATION

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Dryland salinity in the Spicers Greek catchment near Dubbo is considered to be caused, in part, by saline groundwater originating in major shear zones. This source of dryland salinity is different from the more common source of windblown salt deposited in the regolith. Three dimensional (3D) and three component (3C) seismic refraction, magnetic and resistivity imaging surveys were carried out over two sites of dryland salinity which correlated with a map fault, in the Spicers Creek catchment.

The magnetic surveys consisted of ten lines, 10 m apart and 300 m in length. The results show magnetic lows over the inferred locations of shear zones. These magnetic lows are consistent with weathering of the magnetite by the saline groundwater.

The resistivity image sections show low resistivity zones in the area of the inferred shear zones. However, the regions of low conductivity were quite extensive laterally and this together with the limited penetration did not facilitate precise the delineation of the shear zones.

In order to achieve penetration through the low resistivity regolith and to map a shear zones in greater detail, two 3D 3C seismic refraction surveys were carried out. They consisted of four lines 10 m apart, each comprising 29 3C detectors 5 m apart. The seismic source was a P- and S-wave MiniVibe.

The results show the shear zones as regions of low P- and S-wave velocities. At site 1 the shear zone is relatively narrow and it characterized by a single low velocity region. However, at site 2, the shear zone has a much larger lateral extend and it can be subdivided in to several zones based on the seismic velocities.

The measurement of the azimuthal anisotropy showed larger velocities parallel to the shear zones than in the perpendicular direction. The azimuthal anisotropy was much larger with shear wave data.

The results to date demonstrate the laterally varying structure of even simple faults and they have significant implications for predicting the most likely location for the occurrence of dryland salinity. It is anticipated that considerably more detail will be derived from the data in next six months.

SEISMOELECTRIC SURVEY RESULTS FROM THE SA RIVERLAND NEAR LOXTON

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The health of Australia's inland river systems is threatened by increasing salt loads from the landscape. At Loxton in South Australia's Riverland region a seismoelectric ground surface geophysical technique has been used to construct a series of 2D interpreted hydraulic conductivity sections. The sections are useful for illustrating the highly variable aquifer structure within the Loxton Sands, and to locate preferential sites for drilling interception bores.

Biographies

SECTION 5

KEYNOTE SPEAKERS

MIKE BAHORICH

Executive Vice President, Apache Corporation, USA

Mike Bahorich invented two technologies that are used extensively by oil industry geophysicists. He received the SEG 1998 Virgil Kauffman Gold Medal for his Coherence Cube TM patent. Years earlier, he patented interval/volume attribute mapping, now available on most geoscience workstation software platforms. He is Executive Vice President, E&P Technology for Apache Corporation. Mike serves on advisory boards at Vintage Petroleum Inc. and Stanford University, and was President of the SEG from 2002-2003.

PRAME CHOPRA

Reader in Geophysics, Department of Earth & Marine Science at ANU and Director, Geodynamics Limited

Prame Chopra has an honours degree in geology from the University of Newcastle (1975) and a PhD in geophysics from the ANU (1980). His previous research appointments included postdoctoral fellowships at the ANU and Cornell University in New York. From 1984-1996 he worked as a Research Scientist and Senior Research Scientist at BMR/AGSO. His research interests in rock mechanics, geophysics and information systems led him to work on hot rock energy in 1993. He and his colleague, Doone Wyborn, have been largely responsible for the resource evaluation, economic modeling and sub-surface design that have confirmed Australia's unique hot rock energy resource. He was a principal investigator in the $790,000 ANU-Pacific Power Hunter Valley geothermal project and a principal investigator of the $900,000 Energy Research & Development Corporation's hot rock energy project, which focused on the giant hot rock energy resources under NE South Australia and SW Queensland.

PETER M. DUNCAN

President, MicroSeismic, USA

Peter Duncan is founding President of MicroSeismic, Inc. a Houston based geophysical service company. He holds a PhD in geophysics from the University of Toronto. He began his career as an exploration geophysicist with Shell Canada before joining Digicon Geophysical, first in Calgary then in Houston. In 1987 he helped Digicon found ExploiTech Inc, an exploration and production consultancy. He was named President of ExploiTech when it became a subsidiary of Landmark Graphics in 1989. In 1992 he was one of three founders of 3DX Technologies Inc., an independent oil and gas exploration company where he served as Vice President and Chief Geophysicist. Duncan is 2003-04 President of the Society of Exploration Geophysicists (SEG).

PHILLIP HARMAN

Managing Director, Gravity Capital Ltd

Phil Harman holds an honours degree in geology and geophysics from the University of Sydney. He spent more than thirty years working for BHP Billiton in minerals exploration and related mine based activities. The early part of his career was spent as a field exploration geologist and geophysicist in Australia and Papua New Guinea leading up to his appointment as BHP Minerals' Chief Geophysicist in 1982. In this role he was part of the Exploration Department's leadership team and was responsible for bringing a number of new groundbreaking technical initiatives, particularly related to airborne geophysics, to the exploration group. In late 1988 he moved into exploration management, firstly as Exploration Manager WA for three years, then as Manager Exploration South America, based in Chile. Over a period of six years he introduced new geophysical and geochemical approaches to the South American programs, which led to the discovery of a number of new mineralised targets, including the as yet undeveloped Agua Rica deposit in Argentina. Phil led the development of BHP Billiton's deployment strategy for the FalconTM airborne gravity gradiometer that eventually led to his new career with Gravity Capital Ltd and its associated diamond exploration company, Diamond Mines Australia Pty Ltd.

MICHAEL LEE

Director of Lands and Resources Programmes at the British Geological Survey

Michel Lee is Director of Lands and Resources Programmes at the British Geological Survey and a member of the BGS Board and Executive Committee. He is responsible for BGS's strategic survey, energy and mineral resource programmes onshore and offshore. He joined BGS as a geophysicist in 1972 and, prior to his current appointment, was Manager of the BGS Regional Geophysics Group from 1991 to 2000. Originally a physics graduate, he switched to geophysics through an MSc at the University of Durham and gained a PhD from the Open University for work on the subsurface structure of the Lake District carried out at BGS. During the course of his career he has been involved in a wide variety of projects in the UK and internationally as a project geophysicist or manager. These include ground and airborne geophysical surveys, investigations of regional crustal structure and tectonic evolution, geothermal exploration, potential field interpretation for the hydrocarbons sector and research in support of the safe disposal of radioactive waste. A common theme throughout has been a strongly multi-disciplinary approach, bringing geophysicists and geologists together to understand and model concealed geology at all scales.

HELOISE B. LYNN

Lynn Corporated, USA

Heloise Lynn started working in reflection seismic in the oil/gas industry in 1975, processing seismic data at Texaco, in Houston, Texas. In 1978, she completed her MS in exploration geophysics, Stanford University, and in December, 1979, she completed her PhD in geophysics, also at Stanford University, in (post-stack) depth migration and interpretation issues within migration algorithms. From 1980-1984, she worked for Amoco, in Houston. In collaboration with Leon Thomsen and Rusty Alford, she worked on shear wave splitting, and anisotropy in SS reflection data. From 1981 onwards, she has been working on recognition and use of S-wave splitting in reflection SS data (mid-1980s), using multi-azimuth and multicomponent data to characterize naturally fractured gas reservoirs (mid-1990s). In the mid-1990s, the U.S. Department of Energy funded three projects, wherein she served as principal geophysicist, to document how to use reflection seismic to characterize naturally-fractured gas reservoirs. Her current interests include the co-rendering of high dimensional seismic datasets for interpretation (mid-2000s). Where you sit governs what you see, and subsequent two articles, by H. B. Lynn and Ping Chen and Chenyi Hu, in The Recorder, Canadian SEG, July 2003, discuss the visualization of high-dimensional datasets.

NEAL R. NEWMAN

NASA Representative to Australia and Southeast Asia

Neal Newman is NASA's representative to Australia and Southeast Asia. In this capacity, Mr. Newman serves as lead liaison for NASA's interests, including NASA's Canberra Deep Space Communication Complex located outside of Canberra, Australia. Mr Newman previously served NASA in Washington D.C., where he was responsible for establishing international agreements with foreign space agencies. He also served as a Space Shuttle Launch Services Manager and was responsible for coordinating shuttle launch services for a variety of complex flight missions, including the dedicated Shuttle flight of the German Spacelab D-2 research mission.

DOUGLAS W. OLDENBURG

Professor Earth and Ocean Science and
Director UBC Geophysical Inversion Facility
University of British Columbia, Canada

Doug Oldenburg received a BSc honours degree in physics in 1967, and an MSc in geophysics in 1969, from University of Alberta. He obtained a PhD in earth sciences from UCSD in 1974. After a 3-year post-doc he joined the Geophysics and Astronomy department at the University of British Columbia. He remains at UBC where he is currently Director of the Geophysical Inversion Facility (UBC-GIF) and holder of the TeckCominco Senior Keevil Chair in Mineral Exploration. He is an honorary member of CSEG and SEG. He, with students and colleagues at UBC-GIF, have developed forward modelling and inversion algorithms for seismic, gravity, magnetic and electromagnetic data. Doug's current research activities include: 3D forward modelling and inversion of time domain EM data, incorporating various types of geophysical and geological information into the inversion, development of software for unexploded ordnance discrimination, and the use of self-potentials for dam safety investigations.

TED TYNE

Director, Geological Survey of NSW

Ted Tyne was appointed as the Director, Geological Survey in July, 2002. He previously held the position of Assistant Director, Regional Geology and Geophysics. Ted has the overall responsibility of managing the State's geoscience mapping and resource assessment programs as well as directing the Government's Exploration NSW initiative. Ted is a BSc and PhD graduate from the University of NSW. He has more than 30 years government and industry experience across Australia and around the world in geoscience mapping, airborne and ground geophysics and mineral exploration. He joined the Geological Survey of NSW in 1971 as a new graduate and worked in the Geophysics group until 1983 when he was seconded to the University of NSW as Lecturer in Geophysics. He returned to the Geological Survey in 1987 after completing his Doctoral studies and was appointed as Principal Geophysicist in 1988. Ted joined Geoterrex in the early 1990's as Manager of the company's airborne data processing centre in Sydney and later moved to the consulting and exploration software group Encom Technology. Ted rejoined the Geological Survey in 1999 to take on the responsibility of managing the State's mapping projects.

PAUL WEIMER

Professor Geological Sciences
University of Colorado, USA

Paul Weimer has been a professor at the University of Colorado at Boulder since 1990. He holds the Bruce D. Benson Endowed Chair in Geological Sciences, and serves as Director of the Energy and Minerals Applied Research Center. His research has focused primarily on the petroleum systems of deep-water continental margins. Dr Weimer has published more than 100 papers on a variety of topics: sequence stratigraphy, biostratigraphy, reservoir geology, petroleum systems, 3-D seismic interpretation, structural geology and tectonics. In 1998, a special edition of the AAPG Bulletin was dedicated to the research done at the University of Colorado by Paul Weimer and colleagues on the petroleum geology of the northern deep Gulf of Mexico. He has also co-edited eight books, focusing on petroleum systems of deep-water, sequence stratigraphy, 3D seismic interpretation, and North Alaska Geology. Paul Weimer is currently writing a book for AAPG on the petroleum geology of deep-water deposits. He was an AAPG Distinguished Lecturer in 1998-1999, and the Esso Australia Distinguished Lecturer in 2001. Paul received his BA with honours in geology from Pomona College in 1978, and his MS degree from the University of Colorado in 1980. He worked as an exploration geoscientist for Sohio Petroleum (later BP) in San Francisco, CA, from 1980-1984. He received his PhD in 1989 from The University of Texas at Austin. He worked with Mobil Oil in Dallas, TX, from 1988-1990 as a research and exploration geoscientist.

ROBERT J WHITELEY

Senior Principal Geophysicist, Coffey Geosciences, NSW

Robert Whiteley has been a geophysical consultant to Coffey Partners International Pty. Ltd (now Coffey Geosciences) since 1974. In 1991 he joined the company as Principal Geophysicist and Manager of Coffey Geophysics. His career in engineering geophysics started with the BMR (now Geoscience Australia), he then worked in the mineral industry as a general manager and senior exploration geoscientist. In 1972 he joined the School of Applied Geology, University of NSW. From 1984 to 1986 he was Associate Professor in the Division of Geotechnical Engineering, Asian Institute of Technology, Bangkok and Senior Lecturer at the UNSW until 1988. Dr Whiteley has an extensive experience in engineering, groundwater and environmental geophysics with over 80 published scientific articles and one book. He was 2nd vice president of the ASEG from 1974 to 1976 and since 1995 has been a member of the Technical Committee of the International Society of Soil Mechanics and Foundation Engineering. Dr. Whiteley has worked on and managed projects throughout Australia and 16 overseas countries. He has been a consultant to Ausaid, the UN and the ADB. Robert obtained his BSc (Hons) and MSc in geology & geophysics, University of Sydney, and his PhD from the University of New South Wales.

TOM WHITING

Vice President of Minerals Exploration, BHP Billiton Vic.

Tom Whiting became Vice President of Minerals Exploration April 2000 and is based in Melbourne. In this role, he is responsible for BHP Billiton's global minerals exploration program. Dr Whiting joined BHP in 1988 as Chief Geophysicist based in Melbourne and then in Virginia, USA until 1995. That year, he returned to Australia in the capacity of Exploration Manager for Australia and subsequently General Manager Minerals Discovery Group for Australia and Asia based in Brisbane. He has extensive international exploration experience. Before joining BHP, he worked for CRA Exploration Pty Ltd based in Melbourne and Geoterrex Pty Ltd, an international geophysical contractor, in Australia and Canada. He started his career with Delhi Oil based in Adelaide, Australia. Tom obtained both his BSc (Hon) and his PhD from the University of Adelaide.

MARK WILSON

PNG Subsurface Manager
Oil Search Ltd

He graduated with Engineering Degree from Sydney University in 1982 and spent his first ten years working as a petroleum engineer in field operations and development projects, onshore and offshore, in Australia, UK North Sea, West Africa and Azerbaijan. He returned to Australia in 1992 and joined Ampolex where he was involved in reservoir development and new ventures activities for their interests in Western Australia, offshore China, and Venezuela prior to transferring to Argentina in 1995. Since joining Oil Search in 1998, he has been involved in all aspects of the company's business development activities. He has been in his current position since Oil Search commenced its transition to Operatorship of the PNG production licenses, in which he manages the geoscientists and engineers tasked with the exploration, development and production planning for the company's PNG assets.

Authors – Alphabetical Order

CRAIG ANNISON received a BSc in Applied Science - Exploration Geophysics, in 1987 and a Post-Graduate Diploma in Applied Science - Mineral and Groundwater Geophysics, in 1988, from Curtin University, Perth, Western Australia. He joined Tesla10 in 1989, and worked as a field geophysicist for the next 5 years acquiring and processing ground TEM, GPS Gravity, Magnetic, FEM, Seismic and Radiometric data. He then worked as Tesla10's Manager of Ground Geophysics from 1994 until 2001. Since late 2001 he has worked for Fugro Ground Geophysics, in a Sales, Marketing, and Technical Development role.

MICHAEL ASTEN is a Professorial Research Fellow at Monash University part-time, and is also a consulting geophysicist and Partner with Flagstaff Geo-Consultants, Melbourne. He majored in Physics, Geology and Geophysics at the University of Tasmania, and gained a PhD in Geophysics from Macquarie University on the topic of using microseismic waves as a tool for studying sedimentary basins. In 1977 he took up a two-year appointment lecturing and coordinating an MSc (Geophysics) program in Nigeria. He then joined BHP Minerals in 1979 and worked in coal and base-metal exploration in Australia, East Africa and North America, with particular emphasis on geophysical research issues, until 1997. Since joining Monash University, Michael has been Principal Investigator on two ARC-Industry research projects in EM methods, and is now collaborating with Geoscience Australia, University of Melbourne, and the US Geological Survey in the development of passive seismic methods for geotechnical and site classification tasks. He is a founding member of the Centre for Environmental and Geotechnical Applications of Surface Waves (CEGAS) at Monash University. He was a co-recipient of the CSIRO Medal for External Research in 2000 and co-recipient of the ASEG Graham Sands Award in 2001, (both of these for development of the "Falcon" airborne gravity gradiometer), and is author or co-author of 90 technical papers.

BRAD BANKHEAD joined Veritas DGC in 1999 as VP of Reservoir Technologies, where he directs and manages the technical operations of the groups AVO and reservoir characterization business. Prior to being at Veritas, Brad held a variety of positions with Sun Company/Oryx Energy during his 15 year tenure. As part of Brad's tenure with Oryx he managed the AVO/inversion group as well as built and managed the integrated reservoir characterization group. Brad worked on both exploration and reservoir development projects from around the world, including, Gulf of Mexico, Texas Gulf Coast, Indonesia, Kazakhstan, Algeria, Australia, North Sea, and others.

RHYS BARKER is responsible for Business Development activities for Tenix LADS Corporation. He has qualifications from the University of South Australia in Electronic Engineering (B Eng) and Business Administration. Originally employed by LADS Corporation Ltd, a subsidiary of Vision Systems Ltd, he was responsible for various areas of the LADS MKII design and development followed by a period of survey support. Following the acquisition of Vision Systems defence business by Tenix he was responsible for technical development in various defence projects before returning to the LADS business in 2002 to take up his current position.

STEVEN D. BATTY graduated with a BSc (Hons) in Geology from Liverpool University, UK, in 1988 and gained a PhD in Geology from the University of Edinburgh, Scotland in 1993. He moved to Australia to work with Australian Photogeological consultants from 1993 to 1996, being involved with interpretation of a broad range of image formats for mineral exploration. He joined World Geoscience Corporation in 1996 to pursue his interest in mineral exploration through the interpretation of potential field data. He has been responsible for significant interpretation projects across Australia, Southeast Asia, Africa, South America and the Middle-East. World Geoscience Corporation was acquired by the Fugro Airborne Surveys Group at the end of 1999. He is presently employed with Fugro Airborne Surveys in Perth as their Senior Geologist-Interpretation/Consulting.

GRAEME BEARDSMORE received his BSc (Hons) in Geophysics from Monash University in 1990, and his PhD in Geophysics (Monash) in 1996. He worked with geothermal researchers in China (Changsha Institute of Geotectonics) and Texas (Southern Methodist University) before returning to Monash University as a Lecturer in Geophysics. Graeme is the author or coauthor of over a dozen papers on many aspects of geothermal research applied to tectonics, petroleum exploration and geothermal energy, including a monograph on "Crustal Heat Flow" published by Cambridge University Press (Beardsmore and Cull, 2001). His main research interest is in identifying resources and opportunities for the exploitation of geothermal energy in Australia. He currently holds an honorary position at Monash University and consults to private industry and government organizations. Graeme is a member of PESA, the Geological Society of Australia, the American Association of Petroleum Geologists, the AGU and the International Geothermal Association.

SAEED AMIRI BESHELI received his MSc in Geophysics (Exploration Seismology) from University of Tehran (Iran) in 1999 and spent three years in the RIPI (Research Institute of Petroleum Industry) of NIOC (National Iranian Oil Company) and Exploration-NIOC, as researcher geophysicist before moving to Perth to do his PhD at Curtin University of Technology

VOLMER BERENS studied at Flinders University of South Australia completing an Honours degree in 2000. He majored in Geophysics with affiliated studies in Hydrogeology and a thesis project "Marine magneto-tellurics in the Gulf of Mexico". His career proceeded in 2001 at the Department of Water Land and Biodiversity Conservation of South Australia, with involvement in both geophysical and hydrogeological projects. Recent commitments have contributed to the development of river-borne transient electromagnetic surveys.

GREG BERESFORD has over 25 years experience working in seismic exploration and research. He is currently a consultant (On-Line Geophysics) with special interests in OBC acquisition and processing, full-waveform elastic modelling, survey design and AVO/attribute analysis. Greg's employment history includes: Senior Lecturer at The University of Melbourne and Research Geophysicist with G.S.I in Dallas, Texas. He has a PhD from the University of Oxford, U.K.

ROSS COLIN BRODIE graduated with a BSc App. (Hons) in Geophysics from the University of Queensland in 1990. After some short-term work chip and core logging on drill rigs in the Central Queensland coalfields, Ross turned his hand to seismic refraction processing for Velseis in Brisbane during 1991. In late 1991 he moved to Canberra to join the Airborne Geophysics Section of the Bureau of Mineral Resources Geology and Geophysics (now Geoscience Australia), where he remains until today. He spent most of his first seven years undertaking airborne magnetic and gamma ray data acquisition and processing. Since 1997, Ross has been predominantly involved with airborne electromagnetics through contract management and quality control for Commonwealth and State geophysical-based salinity mapping initiatives. In August 2004 Ross began studying for a PhD in Geophysics at the Centre for Advanced Data Inference, Research School of Earth Sciences at the Australia National University.

DOMENIC CALANDRO graduated in 1993 with a BSc in Geophysics from the Flinders University of South Australia. He is currently employed as a Senior Geophysicist with the Minerals and Energy Resources South Australia where he manages and coordinates the processing of Airborne Magnetic and Radiometric data acquired through the South Australian Exploration Initiative, Broken Hill Exploration Initiative, Target Exploration Initiative and company surveys. His expertise covers data acquisition, processing and interpretation of both ground and airborne geophysical data. He is currently managing the Mineral Resources - Geoscientific Information Management Group.

ROGER CLIFTON joined BMR's Observatory Section in 1968, did much field work in the western goldfields during the nickel boom, backpacked through Asia and Europe, programmed in assembler language with Nixdork Computers, kept vigil at the crisis desk at the Wayside Chapel in Sydney, worked as materials scientist in specialist concretes and ceramics, lectured physics at Curtin University, and has spent the last eleven years at NT Geological Survey, ... largely working with data. In his private life, Roger enjoys singing very badly; he has long been a member of the Rostrum Public Speaking Club and the Australian Parachute Federation, ... both of which want him to go jump! In early 2003 he completed a radiometric stitch of the Northern Territory which attracted much comment and is the subject of presentation at this Conference.

BOB CLOSE graduating as a Geologist from RMIT in 1968, and worked in exploration for seven years with BHP. He completed an MSc in Economic Geology at ANU in 1978. Bob worked as an exploration geologist in the mining industry for 35 years with Australian based companies throughout Australasia. He occupied technical and middle management positions up to Exploration Manager during 1980's and 1990's with Pan Continental Mining, Plutonic and Lachlan Resources. Bob was responsible for gold and VMS base metal discoveries and corporate acquisitions, mainly in Queensland. Since the year 2000, Bob has since lived in Oman as the General Manager for the National Mining Company, a subsidiary of MB Petroleum, exploring and developing Cu- Au deposits.

DAVE COCKSHELL completed his BSc (Hons) degree at The University of Adelaide in 1975 majoring in Geophysics. He was employed as a Grade Control Officer/Mine Geologist in Western Australia by Windarra Nickel Mines/Western Mining during 1975-76. He joined South Australian Department of Mines and Energy in 1977 as a geophysicist. He is currently the Chief Geophysicist - Petroleum. Dave has had experience with a wide range of geophysical techniques in the engineering, environmental, hydrological and petroleum fields. His expertise covers data acquisition and interpretation as well as environmental management and petroleum regulation. He is a member of ASEG, SEG, PESA and EIANZ.

GORDON R J COOPER has a BSc (Hons) in Physics from Manchester University (UK), an MSc in Geophysics and Planetary Physics from the University of Newcastle upon Tyne (UK), and a PhD in Geophysics from the University of the Witwatersrand, Johannesburg (South Africa), where he is currently a Senior Lecturer. He is a member of the AGU, ASEG, EAGE, SEG, the Institute of Physics (UK), and a Council Member and Past President of the SA Geophysical Association. His research interests focus on technique development mainly applied to potential fields, and include inverse theory, signal processing, wavelets, image processing, fractals, chaos, and cellular automata.

DUNCAN COWAN graduated from the University of Nottingham, England with BSc (Hons) in 1963 and a PhD in 1966. He has over 38 years experience in exploration geophysics and geology and has worked on all continents except Antarctica. Recent exploration experience includes projects in Australia, Botswana, Brazil, Chile, Finland and the United Arab Emirates. He works as a consulting geophysicist specializing in interpretation of magnetic, gravity, electromagnetic and radiometric data with emphasis on computer techniques for data enhancement, analysis and dataset integration. His research interests include kimberlites and lamproites, inversion of potential field data, aeromagnetic gradiometers, impact structures and rock and mineral magnetism. He lectured at the Royal School of Mines, Imperial College, London from 1978 to 1989. He is a member of the ASEG, SEG, EAGE, the International Association for Mathematical Geology and the Institution of Mining and Metallurgy.

RICHARD CRESSWELL joined Bureau of Rural Sciences in Canberra in 2000 to study groundwater trends on the SW slopes of NSW, and became involved with airborne geophysics applications to salinity. He was a member of the BRS Salinity Team working on projects related to the National Action Plan for Salinity and Water Quality. He is the Commonwealth Leader of the South Australia Salinity Mapping and Management Support Project. Recently, he joined CSIRO Land and Water in Indooroopilly, as a hydrogeochemist, with the newly formed node of the Salinity Directorate. Richard is currently funded through CRC LEME and is working on understanding the origins, transport and modification of salinity in the Australian environment, focussing on issues within Queensland.

VLADIMIR DAVID received a BSc (Hons) from the University of Zagreb in 1988. On completion of his degree he received a scholarship for postgraduate study at the Institute of Geology, Eingenossische Techniche Hochschule, Zurich, to work with John Ramsey. He then worked for the Institute of Geology, Zagreb as a structural geologist in a regional mapping team in the lithofacial mapping of the Adriatic carbonate platform. From there he worked in a number of mines in New Zealand and Australia as a mine and geotechnical geologist. From February 1997 until late 2001 he worked at the Elura mine, Cobar in mineral exploration as a senior geologist. He is currently employed at the New South Wales Department of Mineral Resources as a geophysicist where he is using his structural geological experience as part of a team interpreting geophysical data in the Lachlan Fold Belt and Broken Hill areas. He is also enrolled at the University of New England where he is studying for his PhD under title Structural Setting of Mineral Deposit in the Cobar Basin. The study compiles and analyses of basement architecture, lihofacies, structure history, paleohydrogeological modelling and mineral deposit genesis of the Cobar Basin in central-western NSW

PAOLO DELL'AVERSANA was born in Naples, Italy, in 1964. He obtained a Degree in Geology in 1988 and a degree in Physics in 1996 at Naples University. He worked in applied geophysics from 1988 until 1994. Successively he worked as a researcher in seismic tomography at Naples University until 1996. From 1996 until 2002 he worked for Enterprise Oil Italiana. He was responsible for inversion of seismic and electromagnetic data and for integration of seismic and non-seismic methods. He was leader of many research projects regarding seismic acquisition and imaging in difficult geological settings. In September 2002 he was employed in Eni S.p.A., Exploration and Production Division, with the responsibility of technical team leader for the non-seismic applications and their integration with seismic methods. During his career, he has held a variety of senior positions where he developed and applied new techniques for seismic acquisition, imaging, electromagnetic modelling

and joint inversion with seismic data. Dr. Dell'Aversana is author of papers and speaker at international conferences in the field of seismic acquisition, tomography, magnetotelluric inversion and quantitative integration between seismic, gravity and electromagnetic data. He is the main author of the "Global Offset" seismic approach that has been developed and applied successfully during the last decade by many oil companies and research institutes. His presentation at EAGE 2002 about the Global Offset methodology was included in the special session "Best of EAGE" of SEG 2002, confirming the increasing interest of the scientific community about this approach.

TANIA DHU commenced a BSc at Adelaide University in 1998, and subsequently majored in Geology and Geophysics. She then commenced an Honour's degree in Geophysics, looking at environmental problems, specifically whether electrical resistance tomography could be used in characterising subsurface contaminant flow. In April, 2003 she began a PhD at Adelaide University sponsored by CRC LEME, looking at electrical and EM signatures of the regolith. She is currently Branch Secretary of the SA Branch of the ASEG and a member of ASEG, SEG and AGU.

BRUCE DICKSON obtained his MSc from Wellington University, New Zealand, and received a PhD from Imperial College, London in 1973.He worked for CSIRO up until recently on a variety of aspects of application of radiation measurements to exploration. His work has covered aspects of uranium grade control, uranium exploration using ground waters, radioactive disequilibrium in uranium deposits and more recently, the processing and interpretation of aerial gamma-ray surveys. He is currently developing his new role as gentleman scientist and company director.

YVETTE H. POUDJOM DJOMANI is a geophysicist in the ARC National Key Centre for the Geochemical Evolution and Metallogeny of Continents (GEMOC) at Macquarie University, Sydney. After her undergraduate studies in Geology at the University of Yaounde (Cameroon), Yvette did her postgraduate studies at the University of Paris XI in France, majoring in Geophysics. She completed her PhD thesis (entitled "The mechanical behaviour of the continental lithosphere in Cameroon from gravity data") in 1993. In 1994, Yvette was appointed as a research fellow in the Department of Earth Sciences, University of Leeds (UK) where she worked on the processing and interpretation of potential-field data from West-Central Africa, East Africa (Tanzania) and West-Eastern Europe. Since July 1997, Yvette has been working as a research fellow at the GEMOC Key Centre in Sydney. Her research interests include geophysical (potential field) modelling of lithosphere terranes, thermal modelling, modelling of the density of different types and compositions of lithospheric mantle, estimates of the strength or flexural rigidity of the lithosphere, integration of geophysical and petrological data to delineate major lithosphere domains and their possible correlation with the location of large ore bodies.

JOHN DRAPER is Geoscience Manager, Coal and Petroleum Group in the Geological Survey of Queensland, Natural Resource Sciences, Department of Natural Resources, Mines and Energy. He has a BSc (Hons) in Geology from the University of Queensland, a BA in History from Deakin University, and an MSc in Exploration and Mining from James Cook University of North Queensland. John has been involved in sedimentology, petroleum systems analyses, basin analyses and regional mapping at the Bureau of Mineral Resources (1973-1978) and the Geological Survey of Queensland (1978-now). John has studied sedimentary rocks ranging in age from Proterozoic to Recent and has published on coal, petroleum and mineral geology. He is interested in the use of potential field data in petroleum and coal basins. Member: PESA and GSA.

KAREL G. DRIML is the Managing Director at Velseis Processing Pty Ltd. He graduated from the University of Queensland in 1980 with a BSc majoring in Physics and Mathematics. After a short period computing refraction statics on a field crew he started processing seismic data at Petty-Ray Geophysical. He moved to Digicon in 1989 where he became land-processing supervisor. In 1992 Karel participated in the formation of Velseis Processing becoming Managing Director. Since that time Karel has been actively involved in developing processing and interpretation methods critical to the adoption of 3D seismic to the coal industry. Throughout his career Karel has been processing and reprocessing seismic data from the Surat-Bowan Basin. This experience has given him an association with many of seismic surveys recorded in this area from the 1980's to the present day.

GUY DUNCAN obtained a BSc in Geophysics from Curtin University (formerly WAIT), a Post Graduate Diploma in Physics from Curtin University and a PhD from the University of Melbourne in Geophysics. From 1987 to 1995, he worked as a research scientist at BHP Billiton's research laboratories in Newcastle, Australia, where he was involved in the development of geophysical methods for resource exploration. Since 1995 he has worked for BHP Billiton's Petroleum Division, involved in lithology and fluid prediction, seismic processing and prestack depth migration. During that time he has worked in Melbourne, spent four years in Houston, and has recently returned to Australia where he is working in Perth. He is a member of the ASEG and SEG.

NADA C. DUTTA is currently the Chief Geoscientist at Schlumberger in charge of all technology related activities underlying Reservoir Services and Data Consulting Services. He has a PhD in Physics. He joined the oil industry about 28 years ago with Shell Oil Co. He left Shell, as a Staff Geophysicist, in 1986, and joined Arco's Technology Center as the Director of the Geoseismic Interpretation Group. During 1989, he joined the Deepwater Group of BP in Houston, where he stayed until 1999 as the Global Consulting Geophysicist. Dr Dutta left BPAMOCO and joined Baker Hughes' Inteq Division as the Sr. Science Advisor, in April 1999. Until October 31, 2001, he was the Strategic Business Development Manager and Worldwide Operations' Manager of Lithology, Fluid and Pressure Imaging area in WesternGeco's Seismic Reservoir Services Division (WesternGeco is a joint venture between Schlumberger and Baker Hughes). Nader Dutta has worked in various aspects of seismic wave propagation, including borehole geophysics, rock physics, basin modeling, seismic while drilling and pore pressure technology. He has over 28 years of experience in the oil industry, including 10 years in the Deepwater, both as a technology developer and manager. He authored over 60 publications in various professional and scientific journals, including a book entitled " Geopressure" and is a member of SEG, EAGE, AGU, APS and AADE.

DEREK FAIRHEAD is Professor of Applied Geophysics within the School of Earth Sciences, University of Leeds and Managing Director of the University spin-out company GETECH. He teaches gravity and magnetic methods to MSc students and researches into lithosphere structure (Tectonics of Africa, South America and the Atlantic Ocean) and developing gravity and magnetic interpretation methods for exploration (Extended- and 2D Constrained-Euler Deconvolution methods). GETECH has offices in Leeds and Houston and controls the world's largest gravity and magnetic database for oil and mineral exploration. It specialises in reprocessing, integrating and interpreting of gravity and magnetic data for regional and prospect structural evaluation. He was awarded the BGI medal for his work in global gravity in 1994 and the SEG commendation award for academic and innovative continental compilation studies for the oil industry. This work is ongoing and includes reprocessing satellite altimeter data and ~10 million line km of Russian aeromagnetic data.

IAN FERGUSON is a faculty member in the Department of Geological Sciences at the University of Manitoba, Winnipeg, Canada. His primary research interest is the application of electromagnetic methods in lithospheric studies and he has been involved in the Canadian Lithoprobe and POLARIS geophysical projects. Additional research interests include geomagnetically induced currents and environmental geophysical studies. Prior to arriving in Manitoba in 1990, Ian completed postdoctoral studies in marine electromagnetics at the University of Toronto, a PhD in marine magnetotellurics at the Australian National University, and a BSc (Hons) in geology at the Australian National University. He is a member of ASEG, SEG, AGU, CGU and EEGS.

GIOVANNI FLORIO was born in 1964 in Naples, Italy. He obtained a BSc in Geological Sciences and a PhD in Geophysics and Volcanology at Naples University. At present he is a Geophysical Researcher at the Department of Earth Sciences of the University of Naples 'Federico II'. His main research interest is in the study and development of interpretation methods for gravity and magnetic data. He is a member of the EAGE.

DAVID GIBSON graduated in Geology from ANU in 1972. Since then he has worked as a sedimentary geologist and mapper for BMR in Australia and PNG, and more recently as a regolith geologist with the Cooperative Research Centres for Landscape Evolution and Mineral Exploration and Landscape Environments and Mineral Exploration. Recent work has been regolith mapping for mineral exploration, and the interpretation of airborne geophysics for natural resource management.

ALEXEY GONCHAROV holds a PhD degree in Geophysics awarded by the St Petersburg Mining Institute in Russia. Alexey started his work processing and interpreting seismic data from the Baltic Shield, later he was involved in the seismic part of the unique super deep drilling project at the Kola Peninsula in Russia. Teaching geophysics to students was Alexey's primary occupation for a number of years. In 1994 Alexey came to Australia where his research interests outgrew the bounds of Precambrian crust and he expanded his original seismic orientation to petrological interpretation of seismic data and potential field analysis. Alexey's main research projects in Australia were deep crustal studies of the Mt Isa Inlier, ocean-bottom seismograph studies at the Australian North West Margin (NWAM), integration of reflection and refraction/wide-angle seismic results at the NWAM, production and analysis of unique gravity and magnetics grids for the margin of the Australian Antarctic Territory. Since 2001 Alexey has been a project leader of Basement and Crustal Studies in the Petroleum and Marine Division of Geoscience Australia.

HANS-JÜRGEN GÖTZE recently left the Free University in Berlin to become a Professor in Geophysics at Christian Albrechts University in Kiel (Germany). His scientific interests have centred around the interdisciplinary interpretation of potential field data, tectonics and the application and development of 3D open GIS. He received a Diploma and a PhD in Geophysics from the Technical University Clausthal (Germany) and was Professor in the Department of Geology at Bonn University before he moved to Berlin. As a member and vice-speaker of the Collaborative Research Centre 267 (Deformation Processes in the Andes), he gained substantial experience in geophysical data acquisition in the Central Andes where he has worked for more than 20 years. H.-J. Götze has been a guest professor at various universities in South America and has been a visiting fellow at the US Geological Survey and at Cornell and Stanford Universities. Between 1987 and 1995 he was an active member of the International Lithosphere Program and led the Global Geoscience transect program together with Jim Monger (Canada).

ANDY GREEN has been involved with airborne and space-borne geophysics and remote sensing for longer than he cares to remember. He started remote sensing and image processing research with CSIRO at high frequency and has migrated fourteen orders of magnitude down frequency until, with current research in airborne EM, he now is almost at DC. This progressive movement to a slower tempo has been reflected in is working life as he has now adopted the more leisurely life of a consultant working in private industry.

ANTONIO GUILLEN graduated with a Diploma in Advanced Studies from Université des Sciences et Techniques du Languedoc, Montpellier (Laboratory of Geology and Geophysics) in 1978, and joined the BRGM Geophysics Department in 1979 as a geophysicist, taking part in the development of software for geophysical data interpretation and processing of gravity and magnetic data. He participated in the interpretation of gravity and magnetic maps of France at various scales for mineral and petroleum resource assessment. Since 1991 he has been manager of various computer technology units within BRGM, and at the end of 1994 was appointed Head of Department of Geophysics and Geological Imagery, the unit responsible for research in 3D Modelling, GIS, Remote Sensing, Geophysics and Natural Hazards. In this position he was project manager for the National "GeoFrance 3D" program, responsible for the design and implementation of a national Geoscientific Database Management System and 3D modelling tools.

BORIS GUREVICH received his MSc in Exploration Geophysics from Moscow University in 1981, and PhD in Geophysics from the Institute of Geosystems in Moscow in 1988. From 1981 until 1993 he worked as a researcher for the Institute of Geosystems. He was a visiting scientist at the Geophysical Institute of Karlsruhe University (1992-1993) and at Birkbeck College of London University (1993-1994). In 1995-2000 he worked as a research geophysicist at the Geophysical Instute of Israel. He is currently professor of petroleum geophysics at the Department of Exploration Geophysics of the Curtin University of Technology in Perth, Western Australia. His research interests include petrophysics, theory of seismic/acoustic wave propagation in rocks and other porous materials, and seismic imaging. He is a member of SEG, AGU and EAGE.

RON HACKNEY started in Earth Science at the Australian National University where he received a BSc with 1st Class Honours in 1993. He began to specialise in geophysics, particularly gravimetry, when he undertook an MSc at Victoria University of Wellington in New Zealand. This work involved geophysical studies in Antarctica that were aimed at understanding the formation of the rift-flank Transantarctic Mountains. In 2001 he completed his PhD at the University of Western Australia, where he acquired and interpreted gravity data in the Hamersley Province. Since mid-2002, Ron has focused on integrating gravity data into multidisciplinary interpretations of the Andes in South America. This work is being conducted as a Postdoctoral Researcher at Free University in Berlin and within the German Collaborative Research Centre SFB267 "Deformation Processes in the Andes". From 2005, he expects to remain longer in Germany and take up a position as Junior Professor at the Christian Albrechts University in Kiel.

Biographies

MICHAEL HALLETT is a BSc and MSc graduate from the University of Sydney. He has over 15 years experience in Australia and worldwide in geophysical and geological mapping, airborne and ground geophysics. Mike spent 7 years working for Geoterrex in the 1990's, processing airborne EM and magnetic data through Canada, South America, South East Asia and Australia. He then moved on to become Senior Technical Geophysicist for Geoterrex, travelling through Australia and South East Asia. Mike joined the Department of Minerals Resources in 2003, as Acting Chief Geophysicist.

BENN HANSEN obtained a BSc (Hons) in Geophysics from Curtin University, in 2002, and joined Santos Ltd in 2003, working in the Western Australian Business Unit (WABU) Exploration, as a graduate geophysicist. After a short stint in the Santos Quantitative Reservoir Interpretation Group he is interested in doing further work in AVO analysis, inversion and other non-deterministic quantitative interpretation techniques. He is currently back in the WABU Exploration Group working as a seismic interpreter.

ANOUSHA HASHEMI was born in Tehran, Iran in September 1975. She completed a BSc in Geology in 1998 from Tehran University and an MSc in Geophysics in 2002 from Curtin University of Technology. Anousha became PhD candidate in Geophysics at Curtin University of Technology in 2003. Her career in geophysics began in late 1997 with the Geological Survey of Iran. She started work there as a geophysics expert in 1997 and became Head of airborne geophysics project in 1999. Anousha's main duty was processing and interpreting airborne geophysical data, especially magnetic and radiometric. She published 24 geophysical reports and two books during her service at the GSI. Since she became student at Curtin University of Technology she has continued to process and interpret airborne electromagnetic data. was born in Tehran, Iran in September 1975. she completed a BSc in Geology in 1998 from Tehran University and an MSc in Geophysics in 2002 from Curtin University of Technology. Anousha became PhD candidate in Geophysics at Curtin University of Technology in 2003. Her career in geophysics began in late 1997 with the Geological Survey of Iran. She started work there as a geophysics expert in 1997 and became Head of airborne geophysics project in 1999. Anousha's main duty was processing and interpreting airborne geophysical data, especially magnetic and radiometric. She published 24 geophysical reports and two books during her service at the GSI. Since she became student at Curtin University of Technology she has continued to process and interpret airborne electromagnetic data.

PETER HATHERLY is a Principal Research Scientist with CSIRO Exploration and Mining. His work mainly involves the development and demonstration of geophysical methods for use in coal and metalliferous mining. Current interests include high resolution 3D seismic surveying methods, microseismic monitoring of the ground failure associated with mining, and geotechnical evaluation of the rock mass based on geophysical logging. He holds a BSc (Hons) from the University of Sydney and a PhD from Macquarie University. He has worked at the Geological Survey of NSW (1975-1983), ACIRL (1983-1993) and CSIRO (1993-). He is currently based at the University of Sydney.

PETER HAUSKNECHT is geoscientist who has worked for over 14 years in the fields of multispectral and hyperspectral remote sensing using satellite and airborne data. He graduated in 1988 from Munich University with an MSc in Geophysics submitting a dissertation about 'Reflectance Spectroscopy of Minerals and Rocks'. After spending almost two years with CSIRO, Exploration and Mining in Sydney, Australia working on the MIRACO2LAS thermal IR profiler he went back to Germany to join DLR (German Aerospace Research Center) in 1991 to work in the airborne hyperspectral remote sensing group. In 1996 he received his PhD from Munich University with a thesis about the Australian laser system. In late 1997 he joined World GeoScience Corp. (now Fugro) in Perth, Australia as project leader for the geophysically integrated hyperspectral airborne profiler called ARGUS. Since October 2002 he has worked for HyVista Corp. as a Senior Applications Scientist covering all hyperspectral applications and data processing issues.

STEVE HEARN received Applied Science (Hons I) and PhD degrees in Geophysics from the University of Queensland in 1975 and 1981. He has worked for Australian and international seismic companies, and as a consultant. Steve is currently Chief Geophysicist with Velseis Pty Ltd, and has a fractional appointment at the University of Queensland. He is a member of ASEG, EAGE, and SEG.

PHILIP HEATH is (hopefully) about halfway though a PhD in Geophysics at the University of Adelaide. His interests include potential field theory, inversion methods and Geostatistics. His PhD project is based around Potential Field Tensor data and its use as a tool for regolith exploration. His honours project was entitled Algorithms for the three-dimensional inversion of potential field tensor data. He has worked with PIRSA (Primary Industries and Resources South Australia), Ecophyte Technologies, and often works as a demonstrator for undergraduate field practicals for both Flinders University and the University of Adelaide. He enjoys fieldwork and trying to get all the field equipment to work. As well as a geophysicist, Philip is also a musician, playing piano, guitar, organ, and any other musical instrument he can get his hands on.

NATASHA HENDRICK graduated from the University of Queensland in 1993 with an Applied Science (Geophysics) Honours degree. She was awarded a University Medal and an Australia-at-large Rhodes Scholarship. Following a year at the University of Oxford, Natasha joined Veritas DGC. In 1997 Natasha returned to the University of Queensland to undertake her PhD on multi-component exploration seismology. Throughout her studies she received financial support from Veritas DGC and APPEA. Since completing her PhD Natasha has worked as a Senior Geophysicist with the Coal Geophysics Group of MIM Exploration. She is currently employed as a Research and Development Geophysicist with Velseis Pty Ltd. Her main areas of research include vector processing and converted-wave imaging. Natasha is a member of the ASEG, SEG, EAGE and PESA.

RICHARD HILLIS is the State of South Australia Professor of Petroleum Geology and Mawson Professor of Geology and Geophysics at the University of Adelaide. He graduated BSc (Hons) from Imperial College (London, 1985), and PhD from the University of Edinburgh (1989). His research interests are in petroleum geomechanics and sedimentary basin tectonics. He leads a group of nine researching these topics at the University of Adelaide. He has published approximately 80 papers, edited two books and has consulted to and run short courses for many Australian and international oil companies. Richard is a non-executive director of JRS Petroleum Research Pty. Ltd. and Petratherm Ltd. He is a member of AAPG, AGU, ASEG, EAGE, GSA, GSL, PESA, SEG and SPE.

JAMES DONALD HINKS Gained a BSc in Geology from the University of Glasgow in 1991 and an MSc in Exploration Geophysics from the University of Leeds in 1995. Since then he has been employed by Rio Tinto Mining & Exploration Ltd as a geophysicist in their Africa/Europe Region.

FIONA HOLGATE graduated from the Australian National University with an Honours degree in Geology in 1995. She then went to work in industry, spending several years in hard rock economic geology. During this time she worked both in exploration and on mine sites around Australia including North Queensland, Tasmania and WA. In 2001, following an 18-month hiatus overseas, Fiona returned to Australia and to geology, taking up a PhD project with Prame Chopra at ANU. Her current research interests include geothermics and the distribution of temperature in the Australian crust. She is currently involved in the development of the Australian Hot Dry Rock project near Innamincka in South Australia.

PETER HOUGH completed his Bachelor of Applied Science in Applied Geology at the South Australian Institute of Technology in 1975. From 1975-1977 he was employed as a Field Assistant at the South Australian Department of Mines. Since 1978 he has been employed as a geophysicist with the same department gaining experience in a wide range of geophysical techniques in the petroleum and minerals fields. He is currently employed as the Seismic Data Manager at PIRSA responsible for the transcription of legacy data plus the receipt, storage and supply of petroleum seismic data recorded in South Australia. He is a member of ASEG.

DON HUNTER graduated from Curtin University in 1994 with first class honours in Computer Science and GIS. He joined the Cooperative Research Centre for Mineral Exploration Technologies, compiling GIS databases and developing software for the application of airborne electromagnetic methods to mapping regolith. In 2000, he joined CSIRO-Exploration and Mining's environmental geosciences group using airborne and space-borne remote sensing methods to monitor the effects of mines and mine-site rehabilitation on the environment. Currently he is undertaking PhD studies and is investigating the Surface Nuclear Magnetic Resonance (SNMR) geophysical technique.

ROBERT IASKY graduated from the Western Australian Institute of Technology with a BAppSc (1978), a Grad Dip Sc in Physics (1979, Geophysics major) and, in 1991, a MappSc in Geophysics from Curtin University of Technology. After a short period with Scintrex in 1980 and CSIRO in 1981, Robert joined the Geological Survey of Western Australia in 1982. His main interest is structural interpretation by integrating seismic, potential-field and geological data sets, and he has worked in most WA basins. Since 1995 he has carried out structural interpretation and investigated petroleum prospectivity of the Southern Carnarvon Basin and associated tectonic units. He is a member of ASEG and PESA.

DRAGAN IVIC graduated with a BSc from the University of Adelaide in 1983. Upon graduation he joined the Department of Mines and Energy of South Australia as a geophysicist. He is currently a senior geophysicist with the Petroleum group of Primary Industries and Resources. After spending 8 years applying electrical and electromagnetic techniques to hydrological and minerals exploration projects he pursued his interest in computer systems to develop GIS applications for managing petroleum exploration data. His current professional interests are GIS data integration, analysis and visualisation in geoscience applications. He develops in-house GIS database systems for petroleum exploration and provides advice for spatial data management. Most recently he has applied his skills to developing spatial applications and integrating field instrumentation for navigation and data capture during airborne monitoring of seismic operations. Dragan is a member of the ASEG.

LEONIE JONES has a BSc (Hons) in Physics (1972) from the University of Queensland and a PhD in Geophysics (1976) from the Australian National University. She has worked as a geophysicist in the petroleum industry, in the academic sector and in government. Her initial research interests in laboratory studies of elastic properties of minerals and rocks at ultrasonic frequencies have evolved into seismic reflection and refraction investigations of the Australian continent from deep crustal to shallow scales. In 1998, she was employed by the Australian Geological Survey Organisation to work on seismic projects within the Australian Geodynamic Cooperative Research Centre (AGCRC). She currently works at Geoscience Australia as a Research Seismologist with the Australian National Seismic Imaging Resource (ANSIR).

RICHARD KELLETT has a BSc from Victoria University of Wellington (New Zealand) and a PhD from the Australian National University, both in Geophysics. After working in the mining industry in Australia, Richard moved to Canada in 1990 and spent 6 years in various research positions at Ecole Polytechnique de Montreal, the University of New Brunswick, and the University of Calgary. He moved into the environmental and engineering consulting business in 1996. While working at Komex International Ltd., he was involved in environmental and exploration geophysical projects in Canada, the US, North and Southern Africa, the Middle East, and South America. A specialist in the integration of remote sensing, magnetic, electrical, electromagnetic, logging, and shallow seismic methods, Richard is continuing to consult for the exploration side of the oil and gas industry in Canada.

BRIAN KENNETT is Professor of Seismology at the Research School of Earth Sciences of the Australian National University. He gained his PhD in theoretical seismology from the University of Cambridge in 1972, and after a postdoctoral Fellowship at the University of California, San Diego, was a University posts in Cambridge until he moved to Canberra in 1984. His research interests are in the determination of seismic structure and seismic wave propagation. He has conducted extensive studies of large scale seismic structure in the Australian region using portable instruments (particularly broad-band) recording regional and distant earthquakes. He is the current Director of the Australian National Seismic Imaging Resource (ANSIR) a Major National Research Facility and past-President of the International Association of Seismology and Physics of the Earth's Interior (IASPEI).

KLAAS KOSTER is head quantitative interpretation for Woodside. Previously, he worked in quantitative interpretation for Norske Shell in Stavanger and Shell International in The Hague. Before joining Shell in 1994, he worked for Amoco in Tulsa and Denver on seismic acquisition and special processing. Klaas holds a PhD in Geophysics from Delft University of Technology.

MATTHEW G. LAMONT received a BSc (Hons) and a PhD in Geophysics from Curtin University of Technology. He has worked for Philips Petroleum Company and Woodside Offshore Petroleum. He joined BHPBilliton in Houston where he focused on seismic depth migration, especially velocity model building. He is currently employed by BHPBilliton in Perth, Australia.

RICHARD LANE obtained a BSc (Hons) in Geology and Geophysics from the University of Melbourne in 1983. He worked with CRA Exploration from 1984 to 1997, and was involved in a broad range of mineral and petroleum exploration activities across Australia and Southeast Asia. He joined World Geoscience Corporation (now Fugro Airborne Surveys) in 1997 to work with the Product Development Division. He was Program Leader of the Airborne EM

Systems Program of the Cooperative Research Centre for Australian Mineral Exploration Technologies from 1997 to 2000. In 2001, he joined Geoscience Australia where he assists geophysicists working in the Regional Studies and Mineral Systems Research Group, pmd*CRC and CRC LEME.

LAURENT LANGHI is currently doing a PhD at the University of Lausanne (Switzerland) on the seismic analysis of Western Australian sedimentary basins. His work is mainly based on 2D/3D seismic interpretation integrated with attributes analysis/classification in order to enhance the seismic patterns definition and improve sedimentary basins analysis. Recent work includes depositional system characterisation of the Palaeozoic glacial deposits of the Dampier Sub-basin and analysis of Neogene tectonics in the Timor Sea. He holds a double MSc from the Earth Sciences Department of the University of Lausanne. Upon graduation he undertook a period of training with Norsk-Hydro Energy in Oslo (Norway). In 2001 he was a visiting researcher at the Tectonic Special Research Centre of the University of Western Australia and later he joined the Seismic Interpretation and Analysis Group of the University of Lausanne where he is currently working.

A. YUSEN LEY-COOPER was born to an Australian mother and a Mexican father in one of the biggest and most polluted cities of the world; Mexico City. Here he studied at UNAM (National Autonomous University of Mexico), known as the most important of Latin America. He graduated as a Geophysical Engineer with a research project in salinity tracing with electrical methods and worked for a few years in Mexico's government department of environment and natural resources. He is currently, into the 2nd year of research into: "High resolution EM applied to environmental studies" as PhD student under the supervision of Jim Cull (MONASH) & James Macnae (RMIT). He believes that Geophysics, which has played an important role in the extraction of the natural resources, should now have an active part to play in the identification and remediation caused by bad management and unconstrained extraction resources.

F. E. M. (TED) LILLEY grew up in Hobart, and was educated at Hutchins School. Awarded a cadetship in Geophysics by the Australian Atomic Energy Commission, he studied science at the University of Sydney, graduating BSc (Hons). After experience in aeromagnetic surveying with the Bureau of Mineral Resources (now Geoscience Australia) he undertook graduate study in geophysics at the University of Western Ontario, Canada, where he obtained an MSc and a Ph.D. Postdoctoral work on dynamo theory for the cause of Earth's magnetic field followed at the University of Cambridge in England. He then took up a research fellowship at the Australian National University in Canberra, and, 35 years later, retired at the end of 2003 as a Senior Fellow in the Research School of Earth Sciences (RSES). He has worked particularly in geomagnetism, and on measurements of natural electromagnetic induction in the Earth. He is now a visiting fellow at RSES.

HARALD LINDNER was born in 1938. He finished his period of study at the University of Leipzig in 1961, as a diploma-geophysicist (MSc British equivalent). After that he worked in VEB Geophysics until 1978. During this time he performed several jobs, including seven years as the 'field leader' in gravimetric and magnetic field groups. He also gained essential experience in sea-bottom gravimetry and spent several excellent years developing new interpretation techniques for potential fields. In 1970 Harald received his PhD and became the Head of the Department for well log analysis in lignite exploration. Since 1978 he has worked at the Freiberg University of Mining and Technology. His main activities were lecturing in gravimetry, magnetics, potential theory, well log analysis and geodynamics. He also carried out research in potential field modelling, monitoring methods, archaeology and well log analysis. In 1985 he received his qualification of office (habilitation) and in 1992 the appointment to Professor for Petrophysics and well log analysis. From 1999 to 2003 he was head of the Institute for Geophysics, and has been retired since October 2003.

M. H. LOKE graduated with a PhD in Earth Sciences from the University of Birmingham, UK in 1994. He is presently an Associate Professor in the School of Physics, Universiti Sains Malaysia, where he has taught courses in Geophysics for over 20 years. His field of research is in inversion methods for 2D and 3D electrical imaging surveys and he has published papers in several journals including Geophysics, Geophysical Prospecting, Exploration Geophysics and Journal of Applied Geophysics. He is a member of the Editorial Board of the Journal of Applied Geophysics. He has also acted as a reviewer for a number of geoscience journals including Geophysics, Geophysical Prospecting, Geophysical Journal International and Journal of Applied Geophysics. He is a member of the SEG, EAGE and EEGS.

MIKE LONERGAN received a BSc (Hons) in Geophysics and Pure Mathematics from the University of Adelaide in 1984. He worked for Delhi Petroleum, Gas and Fuel Exploration and Oil Company of Australia before joining Origin Energy in 2002, where he is currently a Senior Staff Geophysicist working on the offshore Otway and Bass Basins. Mike is a member of ASEG, SEG and PESA.

ANDREW LONG has PhD in Geophysics, and 15 years of experience in both the seismic industry and academia. He joined PGS Technology (Perth) in 1997, where he is currently Geophysical Manager, being responsible for all geophysical support to PGS throughout the Asia-Pacific region. He is also international project manager for the PGS High Density 3D (HD3D) Task Force. He is a member of SEG, EAGE, ASEG, PESA, and SEAPEX. His main interests are seismic modelling, seismic survey design, seismic imaging, seismic technology, and rock physics.

BILL LYONS is Product Manager for GeoGraphix, which is based at Highlands Ranch Colorado, and provides exploration and development solutions that are designed to provide revolutionary interpretation capabilities - integrated workflows, accessible technology and great value - all on the Windows® desktop! Geology was his background. He trained as Geophysicist for 8 years and has been working for various Oil and Gas Industry and services for almost 10 years.

JAMES MACNAE is currently Professor of Environmental Geophysics as RMIT University, Melbourne, after spending most of his working life as a transient. Previous positions have included appointments in Sydney at Macquarie University (CRCAMET), Lamontagne Geophysics in Australia and Canada, University of Toronto, Geoterrex in Africa and Canada. Jim has worked on mineral exploration projects on all continents except Antarctica. His main research interests have focussed on the use of conductivity derived from electromagnetics as a mapping tool. Applications include mineral exploration, salinity and contaminant mapping, UXO and plastic landmine detection, bodily fluid and cancer imaging. Second order effects using EM data are also of interest, where developments have the potential to map fresh water and improve shallow sounding. Jim maintains expertise in EM sensor technology, with recent experience in the development of Low Temperature SQUIDS for geophysical application. Jim has authored or coauthored over 160 publications.

JAYSON MEYERS is an Associate Professor in the Department of Exploration Geophysics at Curtin University, a researcher with the CRC-LEME, and consults through Resource Potentials Pty Ltd. He specialises in applied geophysical technologies and processing methods for integrated mineral exploration and mining applications. He has worked in the resources and environmental industries for over 12 years, and has been involved in a wide range of mineral commodity, energy, and environmental projects in Australia and abroad.

BRIAN MINTY received a BSc (1976) from Rhodes University, a BSc (Hons) (1977) in Geophysics from the University of the Witwatersrand, an MSc (1982) in Exploration Geophysics from the University of Pretoria, and a PhD (1997) from the Australian National University. He worked for the Geological Survey of South Africa before emigrating to Australia in 1982 to join Hunting Geology and Geophysics Ltd. He is now a Principal Research Scientist with Geoscience Australia in Canberra, Australia. His research interests relate mainly to the acquisition, processing and interpretation of airborne magnetic and gamma-ray spectrometric data.

PETER MILLIGAN graduated from The Flinders University of South Australia in 1975 with a BSc (Hons) in Geophysics and Geology, and a Diploma in Education. He subsequently studied for a PhD in Geophysics in the School of Earth Sciences at Flinders University. Since 1974 he has also taught science and mathematics in South Australian high schools before joining the then Bureau of Mineral Resources in 1985, initially with the Geomagnetism Section. From 1986 to 1999 he has worked with the Airborne Group, and now works as a geophysicist within the Minerals Division. Research interests commenced with Geomagnetic Deep Sounding using magnetometer arrays, in particular delineating and modelling the Eyre Peninsula Conductivity Anomaly. They are now focussed on enhancement, image processing, modelling and visualisation of geophysical data.

IAN MOORE joined Western Geophysical (now WesternGeco) in London as a research geophysicist in 1996 after completing a degree in mathematics at Cambridge University, England, and a PhD in the same subject at Leeds University, England. After 4½ years based in the UK, he moved to Perth, where he has been based for the last 3½ years. His main research interest is in multiple attenuation and as such he provides worldwide processing and R&D support. Recently, he has been working on 2D and 3D surface multiple prediction algorithms, and on high-resolution Radon transforms. He has also spent a considerable amount of time in the Middle East, focussed mainly on addressing the interbed multiple problems that are typical of that region.

BJØRN MÜLLER received his MSc (1990) in Geophysics from the University of Pretoria in South Africa. He joined SOEKOR in 1990 as a seismic data processor. In 1997 he joined Schlumberger (Geco-Prakla) in Norway, where he supervised data processing. In 1999 he was appointed as Area Geophysicist in Houston to look after the technical aspects of data processing projects. He is currently Area Geophysicist for WesternGeco in Australia.

TIM MUNDAY is employed with CSIRO Exploration and Mining, and working in the CRC for Landscapes, Environment and Mineral Exploration, Tim has over 20years research experience in the application of remote sensing and geophysical technologies to exploration and the environment. His interests concern the application of geophysical and remote sensing methods for the exploration of concealed ore deposits in regolith dominated terrains; and more recently the role of geophysical data in providing an improved biophysical foundation for natural resource management. More recently he has been involved in the planning and conduct of the successful South Australian Salinity Mapping and Management Support Project which concludes at the end of this year.

COLM A. MURPHY has a BSc (Hons) in Geology and a PhD in Geophysics from the National University of Ireland. From there, he worked with the Geological Survey of Canada on their North Atlantic Magnetic Data Compilation project. He then moved to the UK in 1996 taking up a position as Senior Geophysicist with World Geoscience Corporation. Colm joined Bell Geospace in 1999 as a Senior Geoscientist mainly responsible for interpretation and market awareness of FTG technology. After a brief spell working successfully as an independent consultant Colm rejoined Bell Geospace in 2003 to help steer Air-FTG™ in the market place.

EMMA NELSON obtained her BSc (Hons) in Petroleum Geology and Geophysics from the National Centre of Petroleum Geology and Geophysics in 2002. She began studying for her PhD at the Australian School of Petroleum in 2003. Her project concentrates on determination of the in situ stress tensor from oilfield data, and the pre-drill prediction of local and near-wellbore in situ stresses using finite element modelling techniques. She is also interested in application of the in situ stress tensor to issues of wellbore stability, hydraulic fracturing and waterflooding. She is a member of ASEG, AAPG, SPE and PESA.

MARGARITA NORVILL is a doctoral candidate at the Department of Exploration Geophysics at Curtin University of Technology; she is currently investigating "The use of distributed sen or arrays in electrical and electromagnetic imaging".

KYOSUKE ONISHI is a doctoral student at the Geophysical Prospecting Laboratory, Department of Geosystem Engineering, at the University of Tokyo. His specialities are: GPR for hydrogeology, oil contamination and tree roots. In 2003 he received a best paper award from the Remote Sensing Society of Japan.

MARCUS PARISH graduated from Leeds University with a first class honours degree in Geology and completed his PhD studies on Structural Geology ay Oxford University in 1985. He joined British Petroleum in 1986 initially working on the North Sea. In 1989 he was transferred to BP in Melbourne, where he worked extensively on PNG for four years. He returned to London and worked in Algerian New Ventures prior to leaving BP and joining MIM Petroleum in Brisbane, which was later bought by Santos where he worked on PNG and Indonesia as Senior Structural Geologist. He joined Oil Search Limited in 1998 as a senior Geologist and continued to work on the structural Geology of PNG before transferring to the Middle East and North Africa Group within Oil Search. Marcus has published widely on the tectonics of the Alps, Pyrenees and hydrocarbon aspects of PNG.

INGO A. PECHER is a senior scientist at the Institute of Geological & Nuclear Sciences (GNS), specialising in marine active-source seismology, in particular wide-angle and multi-component seismology. His current research focus is on studying gas hydrates and the crustal structure of New Zealand. Before joining GNS, Ingo was a research associate at the University of Texas at Austin from 1998-2001 and a post-doctoral researcher at the Woods Hole Oceanographic Institution (USA) from 1995-1998. Ingo received his PhD from the University of Kiel (Germany) in1995.

MARK PIL KINGTON received a PhD from McGill University in 1985 in Geophysics. After working for Urquhart Dvorak in Toronto he joined the Geological Survey of Canada in Ottawa in 1987. Since then he has worked on interpretation methods for potential field data, using fractal earth property models in inversion and investigating the geophysical characteristics of terrestrial impact craters. He is currently involved with projects on high-resolution magnetic data from the Mackenzie River, Northwest Territories and developing remote predictive mapping techniques for Canada's northern regions. He is a member of SEG, EAGE, AGU, GAC and IAGA.

TIMOTHY PIPPETT received a BAppSc in Geology and Geophysics from Canberra College of Advanced Education (now Canberra University) in 1974. From 1975 to 1981 he worked as a geophysicist with Layton Geophysical International on gravity recomputations with the BMR and other geophysical contract survey work throughout Australia. In 1982 he took up a position with Geometrics International Corporation, running their airborne geophysics group in Sydney. With the demise of the airborne geophysics group he moved to the sales of geophysical instruments in Geometrics. He continued with the group after the sale of the company and the formation of GeoInstruments Pty. Ltd. In 1994 he moved to ADI Limited to become the Manager Sub Surface Imaging with a particular emphasis on ordnance detection in Australia and around the world. In 1997 he left ADI to form Alpha Geoscience Pty. Ltd., working in the areas of near surface geophysics and continuing to be involved in the ordnance detection area. He is a member of ASEG, EEGS, AIG, SEG, EAGE and is a Registered Geoscientist in Geophysics and Environmental Geoscience. He has held a number of posts in the Federal Executive of the ASEG include President (in 2001) and is presently the Co-chairman of the ASEG - PESA Conference.

PETRO DU PISANI completed a BSc (Hons) in Exploration Geophysics at the University of Pretoria, South Africa, in 1994. She worked for two years as an exploration geophysicist for BHPBilliton. She is currently a geophysicist for CSIR Miningtek, where she coordinates and interprets radar projects.

PIERRE PLASTERIE obtained an MSc in Earth Sciences in 1992 and a Post-Graduate Diploma in applied Geophysics in 1993, both at the Pierre & Marie Curie University, Paris. Pierre started employment in 1994 at CGG. After 6 months of conventional processing he was transferred to the "special project" department where he started work on depth imaging projects. In 1998 he transferred to the CGG's Paris office in the R&D department, where he is responsible for the industrialisation of the depth imaging softwares designed within R&D. At the same time Pierre undertook further studies for a civil engineering degree. In 2001 a new transfer within CGG brought him to Perth, where he is now in charge of the depth imaging department. When he is not working for CGG he participates in Windsurfing, Jogging, Tennis, Aviation, Photography and Music.

DAVID PRATT, Managing Director Encom Technology Pty Ltd graduated in 1967 from the University of Sydney with a BSc (Hons) in Geology and Geophysics. While working with the NSW Geological Survey he went on to complete his MSc in 3D electrical modelling. In the early 70's he worked for the Canadian seismic processing company Digitech and Layton Geophysical Consultants. In 1975 he started work at the University of Newcastle on remote sensing applications for groundwater exploration and lectured in geophysics to 3rd year Physics and Geology students. In 1979 after completing a PhD in remote sensing and some post doctoral research he started a geophysical and remote sensing consulting company Geospex Associates. In 1984 he co-founded Encom Technology to develop advanced geoscience software and services for the mineral and petroleum exploration industries. Encom now exports its GIS and geophysical software products and services throughout the world.

CARSTEN PRETZSCHNER received an MSc in Applied Geophysics at the Freiberg University of Mining and Technology in 1990 and a PhD in 1993 in Electromagnetics. From 1993-1999 he was working as a research geophysicist in borehole logging for Western Atlas Wireline Services, Houston TX, USA, Ministry of Science and Arts of Saxony, Dresden, Germany, Ocean Drilling Program at University Jena, Germany and Columbia University New York, USA and Institute for Earth Sciences and Disaster Prevention, Tsukuba, Japan. 1999 he received a DSc and started research work for a consortium of German oil companies. Carsten is currently teaching Borehole Geophysics, Applied Gravimetry and Applied Geophysics at the Freiberg University of Mining and Technology. His research interests are borehole sonic logging interpretation, gravity methods, engineering geophysics. He is a member of SEG.

ART RAICHE worked during the 1960's, for the US defence industry on problems associated with shock waves, gas dynamics, EM compatibility, anti-submarine warfare and other such anti-social topics whilst pursuing a PhD in theoretical nuclear physics at night. Upon completing his PhD in 1970, he migrated to Australia, finding work as an operations research analyst for Caltex. A year later, he joined the fledgling Mineral Physics Division of CSIRO, where he began working on a variety of approaches to modelling the electromagnetic response of the earth excited by geophysical survey methods. He was a pioneer in 3D controlled source EM modelling and the development of inversion methods for time-domain electromagnetic survey data. In addition to several papers on various EM modelling and inversion methods, he has published on neural nets and pattern recognition. In 1980 he worked with AMIRA to establish a consortium of industry partners to develop software that could be used by industry to plan and interpret EM surveys. The interaction with industry proved very fruitful for research guided by real problems rather than by academic conjecture. One three-year AMIRA project led to another so that the EM Modelling Group is now working on P223E, their eighth AMIRA project. Currently a Chief Research Scientist in the CSIRO Division of Exploration & Mining, Art is married to Sydney artist and poet, Rosemary Raiche. They live with a formerly feral cat and two Dobermanns one of whom occasionally sings along during his bouts of flute playing. Art is currently working on writing a sonata for flute and dog.

JAMES E REID received his BSc (1991) and MSc (1994) in Geophysics from the University of Sydney and Ph D (1999) from Macquarie University, Sydney. He is currently a Lecturer in Geophysics at the University of Tasmania, and is a member of ASEG, SEG and EEGS. His research interests are in application of electromagnetic methods to mineral exploration and environmental problems.

JAMES ROBERTS graduated from Monash University with a combined BSc (Hons)/BE (Hons) in 2001. His honours project involved the use of geophysics, particularly GPR, for the detection of subsurface utilities. He then gained experience in geotechnical and geophysical site investigation in the Melbourne office of Coffey Geosciences Pty. Ltd. With the support of a Monash Graduate Scholarship, James returned to Monash in July 2003 to begin a PhD in Geophysics. The current focus of his research under the supervision of Michael Asten, is the application of the microtremor survey method to engineering scale studies.

DAVID ROBINSON is a geophysicist with the Urban Risk Research Group at Geoscience Australia. His main roles include the development of the earthquake hazard model and its application to urban centres around Australia. He has a BSc (Hons) with majors in Mathematics and Geophysics from Flinders University of South Australia. He has worked at the Woods Hole Oceanographic Institute and the CRC for Soil and Land Management. David is an active member of the ACT Branch of the ASEG.

MOHAMMAD S. ROSID is a PhD student working on "Groundwater Investigations using the Seismoelectric Method" at the Department of Exploration Geophysics, Curtin University of Technology, Perth. He obtained his Master of Applied Geophysics in 1994 at the Bandung Institute of Technology, Indonesia, and was Lecturer at Department of Physics, University of Indonesia, Jakarta, from 1988-2000. His research interests include:

- The seismoelectric method to probe for groundwater and near surface exploration;
- Electrical and electromagnetic method for groundwater engineering studies;
- Gravity and magnetic method for near surface and engineering studies; and
- Geothermal exploration using integrated geophysical methods.

He is a member of the SEG.

ERIK H. SAENGER received his diploma in Physics in March 1998 and his Ph.D. in November 2000 from the University of Karlsruhe (Germany). Since January 2001 he has been a research associate at the Freie Universität Berlin. Currently, he focuses on Finite Difference modeling of fractured materials at the Geophysical Institute, Free University Berlin. He is member of the DGG, DPG, SEG, and EAGE.

PEANGTA SATARUGSA received a BSc (1983) in Geology from Khon Kaen University, Thailand, an MSc (1987) in Engineering Geology from Asian Institute of Technology, Thailand, and PhD in Geosciences from University of Arizona, USA. She worked as geophysical assistant and geophysicist at Unocal Thailand Company from 1988-1992. Currently, she is an Associate Professor of Geophysics and Structural Geology in Faculty of Technology, Khon Kaen University, Thailand. Her research interests include applied near-surface high-resolution seismic and resistivity surveys for solving geotechnical, geohydrological, and environmental problems, deep and shallow seismic investigation, and structural and tectonics evolution in the South Asia.

DANIEL SATTEL received his Vordiplom from Universitaet Karlsruhe, Germany in 1986 and an M.Sc. from Oregon State University, U.S.A. in 1990, working on the interpretation of seismic refraction data. He holds a Ph.D. in geophysics from Macquarie University, where he specialized in electromagnetics. In 1996 he joined World Geoscience (now Fugro Airborne Surveys) in Perth where he was mostly involved in the development of EM software and the interpretation of airborne EM data. He left Fugro Airborne Surveys in 2004, moved to Denver and now works as a consulting geophysicist specializing in the modelling and interpretation of electromagnetic data.

PHIL SCHMIDT gained his BSc (Hons) from UNE in 1972 and a PhD in Geophysics from ANU in 1976 specialising in palaeomagnetism. After a post-doctoral position in Ottawa with the Earth Physics Branch he returned to Australia in 1978 to take up a position with CSIRO Mineral Physics. Since then he has collaborated with colleagues in research organisations and industry on many magnetic exploration projects developing instruments and software tools for interpretation.

SABINE SCHMIDT recently moved from the Free University in Berlin to become a senior geophysicist at Christian Albrechts University in Kiel (Germany). Her scientific interests are centred on the interdisciplinary interpretation of potential field data, the application of 3D open GIS, and the development of interpretational software. She received a Diploma and a PhD in Geophysics from the Technical University Clausthal (Germany) and for many years worked as a senior scientist at the geophysical department at Free University Berlin. As a member of the Collaborative Research Centre 267 (Deformation Processes in the Andes), she gained substantial experience in geophysical data acquisition in the Central Andes where she has worked for more than 20 years.

SHAUN STRONG graduated in 2003 from the University of Queensland with a B.Sc. (First-Class Honours) in the field of Exploration Geophysics. His honours project was supported by the ASEG Research Foundation. Following graduation he worked as a contract field geophysicist in central Australia. Recently he joined Velseis as a processing geophysicist.

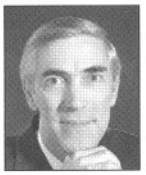
DON SHERLOCK graduated with a BSc. (1st class Hons) in Geology from the University of Western Australia in 1995. He subsequently went on to complete a PhD in Geophysics from Curtin University of Technology in 1999 where he developed some innovative techniques to image fluid flow within unconsolidated sand models using time-lapse ultrasonics. He is now with the geophysics group at CSIRO Petroleum in Perth, where he is developing his analog reservoir modelling (ARM) research program in collaboration with reservoir engineers and geophysicists from Curtin University of Technology. He is a member of ASEG, FESWA, SEG, SPE and AAPG.

ZHIQUN SHI received her BSc degree in geophysics from Changchun University of Geology, China in 1976 and a Ph D from Adelaide University, South Australia in 1992. From 1976-1988, Zhiqun worked as a geophysicist with the Beijing Computer Centre of the Chinese Ministry of Geology and Mineral Resources. After researching at Adelaide University, from 1993 to1995, Zhiqun had a Post-Doctoral Fellowship with WMC Corporation and SADME, and then worked for MIM Exploration as Senior Research Geophysicist until 1998. Since 1998 Zhiqun has worked as Senior Consulting Geophysicist at Encom Technology. At the Beijing Computer Centre of the Chinese Ministry of Geology and Mineral Resources Zhiqun was one of a group

that won two second prizes in the Science and Technology Ministry for developments in frequency domain potential field interpretation and for interpretation and processing of aeromagnetic data over the whole of Pan-Northern China. Following these prizes Zhiqun was awarded a four year scholarship from the South Australian Department of Mines and Energy to develop airborne magnetic interpretation methodology and software. Zhiqun has more than 28 years experience in the acquisition, processing and interpretation of potential field data. She has been involved in all aspects of potential field data management, including survey quality control, signal enhancement, spectral analysis, modelling, inversion, imaging and depth to basement mapping. In addition Zhiqun has participated in software development and development of new techniques in data analysis and interpretation. Zhiqun's developments of the AutoMag depth estimation technique are used widely in the petroleum and mineral exploration industries.

JOVAN SILIC is a director and principal consulting geophysicist with Jovan Silic and Associates, a member of the Flagstaff Geoconsultants Group in Melbourne Australia. He has had a successful association with a mineral exploration industry over a period of twenty years in a wide range of geological environments spanning five continents. He graduated from University of Western Australia with a BSc (Hons) First Class, and in 2000 was granted a PhD in Geophysics by Macquarie University, New South Wales on the topic of interpreting TDEM data from geophysical/geological complex areas. As an exploration geophysicist he has played a leading geophysical role within exploration groups and has introduced a number of important geophysical innovations to numerous base metal, gold, porphyry copper, mineral sands and diamond mineralized discoveries. These include the crucially important contributions to the discoveries of the world class Hellyer (Tasmania) and Anjing Hitam (Sopokomil, Indonesia) base/precious metals deposits, and to some recent promising diamond exploration projects in Canada. His industry experience includes working with government organisations on regional data compilations, major resource companies such as Cominco Ltd (Canada) and 12 years as Chief Geophysicist with Aberfoyle Resources (Australia). In 1998 he left Aberfoyle Resources and since that time, as a consulting geophysicist, has worked on major mineral and oil and gas exploration (and research) projects within Australia, Canada, South East Asia, South America and Europe. A number of major resource companies use his consultancy services. He is an active participant within the exploration community and between 1992 and 2001 has been a member of the Advisory Board to the Australian Mineral Exploration Technologies CRC. Currently he also holds an Honorary Research Fellow position at Monash University. He is very widely traveled and speaks a number of languages including I

ANELIA SIMEONOVA received MSc in Geology from the Sofia University, Bulgaria in 1992, and began her career as a petroleum geologist with the Research and Services Group (RS Group), dealing with geological consulting and technical evaluations for the oil industry. In 1997 Anelia worked as a research geologist at the University of Geneva, focussing on seismic and sequence stratigraphy and computer stratigraphic modelling. In 2001 she moved to Australia and worked with Saitta Petroleum Consultants. In late 2002 Anelia joined the Geological Survey of Western Australia working as a petroleum geoscientist. Anelia has over 11 years experience as a petroleum explorationist, experienced in seismic interpretation and mapping, structural and stratigraphic analysis and petroleum play assessment. She is a member of PESA and AAPG.



BRIAN SPIES was recently appointed Science Manager at the Sydney Catchment Authority, and is responsible for science programs relating to drinking water, catchment management, ecosystems and environmental management. Brian has 30 years experience in research and management in the Australia and the USA, covering minerals, petroleum and environmental fields. He holds a BSc (U NSW) and PhD (Macquarie). Brian was an early advocate of TEM at the BMR, later moving to USA to work in research laboratories at Arco Oil and Gas Company and Schlumberger-Doll Research, on multicomponent seismic, non-destructive testing and cross-well imaging. Brian returned to Australia in 1996 to take up the role of Director of CRC for Australian Mineral Exploration Technologies, which developed the TEMPEST AEM system. He then served a 3-year secondment to ANSTO as Director of Physics Division, returning to CSIRO to work on policy-related and business development projects, as well being co-project leader of a national salinity mapping review. Brian is an tireless promoter of the science and profession of geophysics and holds numerous editorial and honorary positions. He was elected a fellow of the Australian Academy of Technological Sciences and Engineering in 1998, and is past-president of the ASEG. Brian is currently 1st Vice President of the 20,000-member SEG where he champions global issues.

KYLE SPIKES is a PhD student at Stanford University in the geophysics department working the Stanford Rock Physics Laboratory. His current research focus includes the integration of basin modelling with rock physics and the associated seismic responses to predict rock properties away from well control. Before attending Stanford University, Kyle earned a BSc in Geology (2001) and an MSc in Geophysics (2002) from the University of Kansas. At the University of Kansas, he worked on near-surface seismic data acquisition and processing problems. He has authored or coauthored eighteen published papers, expanded abstracts, and abstracts in various areas of geophysical research.

VICKI STAMOULIS has worked in the Geological Survey of South Australia since the mid 1990's, when she graduated from Adelaide University. She has worked with various forms of remotely sensed data, applying them directly to mineral exploration. Currently she is a member of the Musgrave Province Team where her role in the group is to analyse geophysical data and use these to produce interpretive maps. Her focus is the application of gamma-ray spectrometry and where available, high resolution reflectance data such as HyMap. In 2002 she was awarded a Churchill Fellowship to examine the applications of hyperspectral data overseas particularly with major exploration companies and educational institutions in Canada, US, The Netherlands and Republic of South Africa. She has presented her research at various national and international conferences. She is actively involved in promoting South Australia's diamond potential and looks forward to finishing off her masters thesis in her spare time.

EDWARD (NED) STOLZ graduated from the University of Adelaide in 1985 with honours in Geophysics. For the following five years he was employed by CRA Exploration, and worked on base-metal, gold and diamond exploration in Western Australia, Queensland, and the Northern Territory. Between 1992 and 1997 he completed a PhD at the Cooperative Research Centre for Australian Mineral Exploration Technologies (CRCAMET), Macquarie University, on the topic of automatic interpretation of EM data. In 1997 he joined WMC Resources Limited at the Leinster nickel mine, where he lead an intensive geophysical exploration program utilising surface and downhole TEM methods. Ned has been senior geophysicist at St Ives Gold Mining Company since 2001, and also manages the project generation team. Ned's main focus is interpreting structures in 3D from detailed gravity, magnetic, electrical, and seismic data, and using innovative technology to generate new targets in mature exploration provinces.

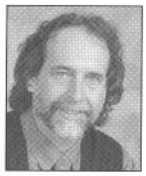
GREG STREET received a BSc (Hons) in Geology from UNE in 1974 and an MSc (Geophysics, London) in 1980. Following 8 years with Scintrex Australia he joined the Geological Survey of WA in 1983 where he applied geophysics to dryland salinity. This interest lead to the joint work between Aerodata and the WA Department of Agriculture to develop airborne geophysics for land salinisation studies. From 1992 to 2000 he was Director of Environmental Services at World Geoscience Corporation where he further developed the processes used to apply airborne geophysical methods for environmental applications. In 2000 he joined SKM Pty Ltd where the work in this paper was carried out. Greg has recently formed his own consultancy company Geoag Pty Ltd. He is also a part-time PhD student and lecturer at Curtin University. Greg is a former president of the ASEG and recipient of the inaugural Lindsay Ingall Memorial Award.

MITUHIKO SUGIHARA was born in 1957 in Japan. He is a geophysicist and a senior researcher at the Geological Survey of Japan/AIST and is mostly interested in precision gravimetry for geothermal reservoir monitoring.

PETER SWIRIDIUK has been involved, for the past three years, with geophysical and GIS consulting for copper and gold projects in Oman, coal projects in the Bowen Basin and other gold and base mineral projects based from Brisbane. He received his BSc (Hons) in Geophysics and Dip.Ed., mid-way through 1990 from the University of New England. He then joined the DeBeers Diamonds organisation as a geophysicist for six years based in Melbourne where he was directly involved with the exploration for diamond bearing rocks throughout Australia. After DeBeers in 1996 he worked on the Solomon Islands Helimagnetic surveys in the search for porphyry related minerals for two years. After a brief stint at Frieda River in PNG, he undertook a GIS role at Caledonian Pacific Minerals for two years where geophysics and GIS knowledge helped in project generation work for diamond, gold and base metals.

GEOFFREY R TAYLOR graduated from the University of Birmingham with BSc (Hons) in Geology and an MSc in Mineral Chemistry in 1968. After stints in industry in the UK, a six year period as a geochemist in the Solomon Islands lead him to undertake a PhD at the University of New England in Armidale, NSW, which was completed in 1977. His head was firmly brought below the clouds with a three year spell as a geologist in the quarry industry before he was appointed to the University of New South Wales in 1980 as a Lecturer in Economic Geology. Having admitted at his interview that once he had looked at a Landsat image he was encouraged to become the School's remote sensing expert. His main activity is now teaching and research into geological and environmental applications of remote sensing.

TROY THOMPSON has a first class honours degree in Petroleum Geophysics from Curtin University of Technology. During his undergraduate studies he was awarded the Royal Society of WA Universities Science Medal, the Deans Prize and the Australian Institute of Physics Prize. He is currently completing his final year of doctoral studies in petroleum geophysics at Curtin University. He was the recipient of the John Curtin Postgraduate Scholarship and a MERIWA Supplementary Scholarship. He is also working as a geophysicist for DownUnder GeoSolutions. He is a student member of the SEG, ASEG and the EAGE.



JULIAN VRBANCICH joined the Defence Science and Technology Organisation (DSTO) at Pyrmont (Sydney) in late 1984 and investigated EM emissions and DC electric fields arising from corrosion currents in ships. Since about 1997, Julian began investigating the use of airborne EM methods to explore shallow water marine environments to measure sea depth and map seafloor resistivity. This work has also extended to include use of AEM for sea ice thickness measurements in Antarctica.

IAN WANG joined the Sydney Gas technical team as its senior geologist in August 2001. He is an expert in coal seam methane geology and is responsible for all geological activities conducted by Sydney Gas in relation to its CSM exploration and production operations in the Sydney Basin. Ian graduated with a Bachelor of Science degree from the Nanjing University, China in 1982, and holds MSc and PhD degrees in Structural Geology and Rock Mechanics from Imperial College London. Ian has worked with several Australian companies on major CSM projects in China. He has also worked as a research scientist and Associate Professor with the Institute of Geology, Chinese Academy of Sciences; exploration geologist with Ausmindex Mineral Exploration; Senior Geologist and Regional Manager Asia with In-Situ Australia Pty Ltd; Operations Manager with Lowell Petroleum NL; and Manager with Molopo Australia NL. In 1991, Ian was awarded the Chinese National Young Scientist Prize for his work in the areas of faulting behaviour, tectonic evolution and crustal structures in China and Tibet. He is a Member of SPE (USA) and PESA.

XIUMING WANG received his PhD in Acoustics in 1995 from the Institute of Acoustics, Chinese Academy of Sciences (CAS). He received his MSc and BSc degrees from Research Institute of Petroleum Exploration & Development and University of Petroleum of China in Geophysics in 1987 and 1984, respectively. From 1988 to 1997, he worked with Daqing Petroleum Institute in China. From 1998 to 1999, he worked at Stanford University as a Post-Doc. in Geophysics. Presently, he is a Senior Research Scientist and a project leader of geophysical numerical modelling in CSIRO Petroleum, Australian Resources Research Centre (ARRC). He also holds an adjunct research professorship in Institute of Acoustics, CAS. His interests include theory of elastic waves and waveguides, elastic wave modelling & imaging, acoustic resonance spectroscopy, and borehole geophysics.

JOHN T. WEAVER is Professor Emeritus of Physics and Earth & Ocean Sciences at the University of Victoria in British Columbia, Canada. He was born and raised in England, where he obtained an honours degree in Mathematics from Bristol University. On graduation, he moved to Canada for post-graduate study in upper atmospheric physics and geomagnetism at the University of Saskatchewan. Shortly after receiving his doctorate he was appointed as a Defence Scientist at the Pacific Naval Laboratory (later the Defence Research Establishment Pacific) in Victoria, British Columbia to conduct research in marine electromagnetics. In 1966 he joined the Physics Department at the University of Victoria, where he continued his research in geo-electromagnetic induction. Later he became Chair of the Department and for the five years up to his retirement he was Dean of the Faculty of Science. Dr. Weaver has spent sabbatical leaves at Cambridge University, where he was a Visiting Fellow of St. Edmund's College, the University of Edinburgh, the Observatoire Cantonal in Neuchâtel, Switzerland, and at ANU in Canberra where he was a Visiting Fellow in 1996.

Biographies

STEVE WEBSTER has a BSc in Geology and MSc in Geophysics from Sydney University and 40 years experience as a geophysicist, having worked in industry, academia and the Public Service. He has been employed in active exploration for several mining companies, also as Principal Geophysicist for the NSW Geological Survey and as General Manager of Austirex International Ltd. Steve has been involved in regional airborne surveys in Australia and overseas in such diverse countries as Sarawak, Papua New Guinea, Ireland, Czechoslovakia and the Sultanate of Oman. In the latter country, where mining has a history dating back 5,000 years, he was involved in exploration that led to the discovery of several new copper-gold deposits. In July 1976 he established his own company, Steve Webster Pty. Ltd., to consult as a geophysicist in mining exploration. Steve has been active in the ASEG Executive and was President of the NSW Branch for several years, but this year is Past-President.

RICHARD WEINDEL is the Asia Pacific Account Manager at The KINGDOM Company, (SMT), and has been with SMT since 2001. Richard's primary responsibilities are to develop opportunities and support clients throughout Asia Pacific, Denver, Colorado, and Canada. Richard holds a Masters Degree in Geophysics from the University of Tulsa in the USA, and his experience includes work in Europe, Africa, North America, and the Asia Pacific region.

MARTIN WIDMAIER is a geophysical manager at PGS Research (a Division of PGS Geophysical). He joined PGS Research in 1996. His professional interests include 4D and 4C seismic, seismic processing and seismic modelling. He received his MSc (1993) in Geophysics and a PhD (1996) from University of Karlsruhe, Germany. He is a member of the SEG and EAGE.

CHRIS WIJNS obtained a BSc (Hons) in Geophysics in 1993 at McGill University in Montreal, Canada, and subsequently completed an MSc in Geophysics in 1996 at the University of British Columbia, in Vancouver, Canada. These degrees were focused on planetary scale thermal evolution and theoretical modelling of volcanism. After graduating from UBC, Chris did an about-face from planetary science and worked in the gold industry for three years as an exploration geophysicist with Placer Dome in Africa, doing field collection of data and on-site processing and inversion in order to locate drill targets. Wishing to return to studies and undertake a PhD Chris arrived in Australia as a visiting researcher with UWA and CSIRO in June 1999. He enrolled at UWA 18 months later, and has now completed a dissertation testing conceptual geodynamic models for the genesis of large-scale ore deposit systems, with applications to the Yilgarn in Western Australia and the Carlin trend in Nevada.

KATE WILKINSON graduated from Sydney University with a BSc (Hons) in Geophysics in 1996. She then worked as worked as an exploration geophysicist for Newmont Mining (formally Normandy Mining) based in Adelaide and then Perth. In late 1999 she joined the Queensland Department for Natural Resources, Mines and Energy and has specialised in investigating the use of geophysics for salinity studies. Last year she also completed an MScEng (groundwater studies) at UNSW.

NICHOLAS WILLIAMS undertook most of his undergraduate study in California but completed his BSc at Monash University in 1999 and his BSc (Hons) in Geology at the Centre for Ore Deposit Research at the University of Tasmania in 2000. Although his background is in ore deposit geology he has worked on a wide range of problems in his three years at Geoscience Australia, including controls on lode gold mineralisation, neotectonics, regolith geochemistry, and phosphate deposits. His current research interests are focussed on developing techniques for using regional-scale constrained potential field inversions to understand and map geology in covered terranes.

DENIS WINCH is an Honorary Associate Professor in the School of Mathematics and Statistics. He has received ARC funding for research on the analysis of satellite magnetic data, with particular emphasis on the Australian region. His research work deals with the mathematical aspects of spherical harmonics, and application to the analysis of the earth's main magnetic field and its daily changes. Professor Winch's interests include the regular daily changes resulting from dynamo ac-tion of atmospheric movements caused by from solar heating and lunar tides. The results provide data for the modeling of the conductivity and the movement of the ionosphere, of atmospheric modes of free and forced oscillation, and electrical conductivity models of the Earth. More recently he has worked on the analysis of lithospheric magnetic anomalies as de-termined from satellite magnetic data, as well as the determination of sets of coefficients to model the Earth's main magnetic field. His work is now on the analysis of daily mag-netic variations directly from satellite magnetic data.

KEN E. WITHERLY has been involved in minerals exploration for over 30 years, having explored for essentially all commodities around the globe. During this time, he has been able to contribute directly to the success of a number of economic deposits, including the discovery of diamondiferous kimberlites in the Canadian NWT. In 1999, Ken helped form a technology-focused service company, Condor Consulting, Inc., that specialises in the application of innovative processing and data analysis to help drive discovery success.

ANTON WOLMARANS obtained a BSc (Hons) in Exploration Geophysics from the University of Pretoria in 1994. After roughly four years with Anglo American, exploring for base metals and gold in West Africa, he transferred to De Beers - Group Exploration in 1998. Here he formed part of a highly skilled team of geophysicist, delivering support to the exploration projects in various countries in Africa, as well as Australia and South America. In mid 2003 he moved to the Mineral Resource Management Group in De Beers, responsible for the mining geophysics discipline at all operations.

MICHAEL S. ZHDANOV is Professor of Geophysics, Director of the Consortium for Electromagnetic Modelling and Inversion (CEMI) at the University of Utah since 1993. He received PhD in Physics and Mathematics in 1970 from Moscow State University. He was previously the Director of the Geoelectromagnetic Research Institute of the Russian Academy of Sciences, Moscow. In 1990 he was awarded an Honorary Diploma of Gauss Professor by the Gettingen Academy of Sciences, Germany. In 1991 he was elected full member of the Russian Academy of Natural Sciences, in 1997 he became an Honorary Professor of China National Center of Geological Exploration Technology, and in 2002 he became a member of the Electromagnetic Academy, USA. His research interests are forward and inverse problems in geophysics. He is the author of more then 300 papers, including ten monographs.