Preview

Australian Society of Exploration Geophysicists

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CONFERENCE HANDBOOK

ASEG 2003
GROWTH THROUGH INNOVATION

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

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16TH GEOPHYSICAL CONFERENCE & EXHIBITION

ADELAIDE CONVENTION CENTRE
ADELAIDE . SOUTH AUSTRALIA
16 - 19 FEBRUARY . 2003

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Conference Handbook

Section 1

ASEG 2003

GROWTH THROUGH INNOVATION

Welcome to ASEG 2003 from the Conference Organising Committee

Richard Hillis

Mike Hatch

On behalf of the Organising Committee, it is a great pleasure to welcome delegates, sponsors, exhibitors and speakers to the Australian Society of Exploration Geophysicists 16th Conference and Exhibition at the Adelaide Convention Centre, South Australia. We extend a special welcome to members of our co-host societies, the EAGE, SEG and SEGJ.

The conference theme is ***Growth Through Innovation***. Growth of reserves, corporate growth, professional growth - all are underpinned by innovation. We believe this meeting will provide you with the innovative ideas required for growth.

At the core of ASEG 2003 lie the dynamic trade exhibition and a technical program, with five parallel streams of oral papers. However, there are many additional innovative aspects to ASEG 2003, including an enhanced keynote speaker program, special technical discussion forums, a major program of workshops, and of course the 'latest and greatest' equipment innovations.

The Gerald Hohmann Third International Symposium on 3DEM will be held immediately after the meeting. We thank the organisers of the 3DEM Symposium for their close collaboration with the ASEG 2003 Organising Committee and welcome delegates attending ASEG 2003 in conjunction with the 3DEM Symposium.

Do check the final conference program for the papers schedule because there have been some changes from the program in the registration brochure. As at Brisbane 2001, extended abstracts of the papers are available on the conference CD (with the exception of some specially-invited, hot-off-the-press papers). A selection of authors will be invited at a later date to submit full papers to Exploration Geophysics.

Social events such as the happy hours and the conference dinner at the Adelaide Oval complement the technical aspects of the meeting. For those who like to organise their table for the conference dinner, sign-up sheets will be available at the registration desk.

In a healthy sign for the geophysical industry in Australia, sponsorship for ASEG 2003 has broken all records and we thank all of our sponsors. We would like to again take this chance to thank our Platinum sponsor, Santos and our two gold sponsors, Newmont and Schlumberger/WesternGeco.

The broader promotion of geophysics is an important aspect of the Conference and the now-traditional high school student day is being complemented by a day for undergraduate students from South Australia and an evening reception for all postgraduate students attending the Conference.

We hope you enjoy the newly redeveloped Adelaide Convention Centre with the exhibition hall adjacent to the technical program venues. Furthermore we hope you will also have time to revel in the best of the Adelaide lifestyle, not least the relaxed outdoor dining and South Australia's superb wines.

In addition to thanking the sponsors, we would like to thank the exhibitors and speakers at ASEG 2003. We would also like to thank the conference organisers, Sapro, for their excellent logistical support. The co-chairs would especially like to thank the Conference Organising Committee and the Technical Papers Committee, whose enormous voluntary efforts underpin the success of the meeting. We look forward to meeting old friends and making new ones this week.

On behalf of the Organising Committee,

Richard Hillis and Mike Hatch
Co-chairs, Organising Committee
ASEG 16th Conference and Exhibition, Adelaide,
South Australia, 2003

Conference Organising Committee

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Richard Hillis
NCPGG, University of Adelaide
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ASEG

Welcome to ASEG members, to the guests and potential members who have come for the technical value the Adelaide Conference will provide. I especially welcome on behalf of the Conference Committee and ASEG members, the international visitors and representatives of sister societies and sponsors, SEG, SEGJ and EAGE. The Conference Committee has worked extraordinarily hard to provide a technical program that encompasses the wealth of expertise that comprises the Australian mineral and petroleum exploration industry, complemented by an array of international keynote speakers and a comprehensive workshop program.

The industry, whether minerals or petroleum, has been going through changes in the last few years, to put it mildly. Perhaps we are emerging from this with an increase in the price of some commodities such as gold, although exploration is still down as noted recently. On the petroleum side, the price of oil is high, but there is still stagnation in the surface seismic business with cutbacks and the effects of mergers still noticeable.

I was struck recently by parallels between geophysical contributions to exploration and aspects of the invasion of Egypt by Napoleon. When Napoleon prepared and executed his invasion, having eluded a powerful British fleet, he landed 38 000 troops near Alexandria on 400 transports. Amongst this vast expedition were 167 members of the National Institute, of which Napoleon was proud to be a member, at the time called "savants": engineers, astronomers, linguists, painters, poets amongst others. Prime amongst this party were Gaspard Monge who invented descriptive geometry, Claude-Louis Berthollet the Chemist, Nicholas Conte who invented the graphite pencil, Deoderat Gratet de Dolomieu mineralogist after whom the Dolomite Mountains were named and lead by Jean-Baptiste Fourier the mathematician whose mathematical work is central to our industry. These savants were the intellectual elite of France, who were invited and readily accepted on what was described as a 'tropical voyage'. At the time Egypt had not been well explored culturally, having been the preserve of the Ottoman Empire, and hence was of prime interest to this group.

The troops landed, beach-heads were established, expeditions to Cairo mounted and battles fought. Great hardships were met in the heat and aridness, contested each step by the Marmelukes and harassed by Bedouin, with one man dead for every 200 metres travelled. Then the British under Nelson discovered the fleet in Aboukir and the resultant battle of the Nile did for Napoleon's fleet and cut off any retreat.

Through all this the savants were kept on the ships until the beach-head was established and then abandoned to their task with little support both of transport and accommodation. Additionally all their instruments were lost in the naval battle. Despite this they went ahead and reconstructed their instruments and conducted such an extensive study of the Egyptian monuments and geography, including the discovery of the Rosetta Stone, that it took 20 monumental volumes to describe their work.

From a military viewpoint Napoleon's adventure proved to be an abject failure, as they were forced to abandon Egypt in three years. The real success belonged with the savants who returned to France in triumph. Their records and collections would overshadow the enormity of the defeat, and prove to be beneficial to Napoleon in the eyes of the French public.

Not to stretch the analogy too far, you should be proud that the contributions geophysicists have made to the industry and continue to be of critical importance within the battle for the discovery of new resources. Your contributions and discussions are certain to achieve the aim of this conference: ***Growth Through Innovation***.

Reference: "The Keys of Egypt: The Race to Read the Hieroglyphs" Lesley and Roy Adkins, HarperCollins 2000.

Kevin Dodds
President of the Australian Society of Exploration Geophysicists

Kevin Dodds
ASEG

SEGJ

Yuzuru Ashida
SEGJ

It is a great honour for Society of Exploration Geophysicists of Japan (SEGJ) to participate in the ASEG's 16th Conference and Exhibition. Taking this opportunity, I would like to introduce recent activities of the SEGJ.

SEGJ was founded in 1948, and we have 1531 members as of May 2002. Its strength is the application of geophysics to the civil engineering and the 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 publication of SEGJ. In January 2003, we held the 6th International Symposium in Tokyo in association with the four overseas societies. Nearly 100 papers were presented and it was a great pleasure to receive assistance of the ASEG for the symposium. We hope to hold a forum any geophysicist joins in.

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, authorized 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; and
3. Establish guidelines for geophysical practice responding to the community demand.

We address not only domestic issues but also international activities. We have established close relationships with the ASEG, SEG, EAGE and KSEG of Korea. There are many geophysicists in Asia, but unfortunately we have not yet had a good channel to communicate with them. We have started discussions with Chinese and Vietnamese societies towards better communication and collaboration. We hope to extend cooperation with them 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

Paul van Riel
EAGE

Mike Bahorich
SEG

engineers of other countries, especially of Asia. Responding to this demand, we decided to publish this book in English. The contribution from ASEG in refining the English of our translation has been great. We would like to express our gratitude to the Society.

ASEG and SEGJ started a discussion towards a possible joint publication. The first meeting was held in Florence at EAGE 2002. Andrew Mutton, Chairman of Publication Committee of ASEG; Satoru Ohya, the former President of SEGJ; Yasukuni Okubo, Chairman of International Relation of SEGJ and myself attended the meeting and discussed several issues such as strategy, contents, frequency, cost and support of the publication. We reached an agreement that we make a unique publication with a focus on the Western Pacific region, incorporating practical applications of geophysics to all areas of resources exploration and engineering. We hope that this new unique publication starts new friendship and extends new fields of application. We will jointly submit our ideas to the both board meetings soon.

As Australia and Japan are located in the same Western Pacific region, there are many issues we can cooperate on. The environmental issues of the Southeast Asia and the Pacific region are one example. We would like to collaborate with ASEG for the issues in our region at all times.

Yuzuru Ashida
President of the Society of Exploration Geophysicists of Japan

EAGE

On behalf of the EAGE I would like to take this opportunity to extend our best wishes to the ASEG.

The EAGE's objectives are to promote the development and application of the geosciences and related engineering subjects, and foster the communication, fellowship and cooperation between those active in these fields. Though our roots may be in Europe, the geosciences business is a truly global, and this is reflected in our membership. We have many members residing in Australia, whom we are proud to serve.

The theme of this year's ASEG's Conference and Exhibition is 'Growth through Innovation'. There are many drivers that spur innovation. In the geosciences a key one is the truly global nature of our profession. There is no doubt that the nature of the activities of the societies serving the geoscience community and the many interactions between them form the backbone of the global geoscience network. The global links provided through this network facilitate the rapid spread of new ideas, novel technologies and new applications. We are pleased to contribute to the ASEG event, so supporting the global geoscience network and the platform it provides to support and stimulate innovation.

The EAGE's membership is largely from the oil and gas business, as the main geoscience application area (as measured by expenditure) is in hydrocarbon exploration, development and production. However, geoscience know-how and technology is increasingly applied in areas such as mining and the environment, and many innovations originate from meeting the demands in mining, environmental and other near surface applications. Australia has a leading role in the development and application of near surface geoscience know-how and technology with its large mining business and focus on the environment. A development we therefore expect to be of particular interest to our members and potential members in Australia is that the EAGE has now formed the Near Surface Geoscience Division. This Division originates from the merger of the Environmental and Engineering Geophysical Society - European Section (EEGS-ES) into the EAGE. This Division publishes its own international journal: Near Surface Geophysics, has its own annual conference and exhibition, and will significantly contribute to the EAGE's annual and other events. We invite and look forward to increased interaction with Australia based geoscientists who are active in the near surface geosciences.

I would like to close with thanking you for the opportunity to contribute, and to wish all attendees a most worthwhile and successful ASEG Conference and Exhibition.

Paul van Riel
President, European Association of Geoscientists and Engineers

SEG

On behalf of over 18 000 members of the SEG, I wish you every success with the ASEG 2003 Conference. The ASEG and SEG have been associated for over thirty years and continue to mutually benefit from the relationship.

With the current ease of electronic communication, the world is becoming smaller, providing additional opportunities to link geophysicists across the globe. Together we are better equipped to face the geophysical challenges of this new millennium.

Although the SEG began as an American organisation, within the next few years more than half of our members will be from outside the United States. If you are not currently an SEG member I encourage you to visit www.seg.org to sign up for membership and begin receiving the benefits available to SEG members across the globe. Students can sign up for free, due to a generous grant from Halliburton.

I am very fond of the great nation of Australia, and first visited on holiday in 1985. I became enchanted with the pristine beaches, turquoise waters, and the friendly Australian people with "no worries". I correspond to this day with friends met on that first trip. I now have the opportunity to visit about twice a year, as my employer, Apache Corporation, is very active here. I have found Australian geophysicists to be curious and technically astute.

With advances in geophysical technology, computing, and electronics, our field of geophysics continues to offer more to near surface investigation and hydrocarbon exploration. Together we will meet the challenges ahead.

With warm regards I look forward to a fruitful conference.

Mike Bahorich
President of the Society of Exploration Geophysicists

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91 King William Street
ADELAIDE SA 5000 Australia
Tel: +61 (8) 8224 7952
Fax: +61 (8) 8224 7258
Website: www.santos.com.au
Email: John.Hughes@santos.com
Contact: John Hughes

Santos Ltd, a major Australian energy company is pleased to be the Platinum Sponsor of the 16th ASEG Conference and Exhibition. The Company has interests in every major Australian petroleum province, and interests in South-East Asia and the United States. Geophysics is a significant contributor to the success of the petroleum exploration and production industry and Santos considers it important to support events such as these which promote the innovative use of geophysical methods.

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Contact: Katrina Moore

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Tel: +61 (8) 8291 2400
Fax: +61 (8) 8291 2499
Website: www.newmont.com
Email: mike.sexton@newmont.com.au
Contact: Mike Sexton

Newmont Mining Corporation, founded in 1921, is the world's largest gold producer with significant assets and operations on five continents. Newmont is also engaged in the exploration for and acquisition of gold properties in and around its preeminent global land position, the equivalent size of the United Kingdom, in some of the world's best gold districts. The company is the largest private sector precious metal royalty owner in the world. Newmont also produces and sells copper and zinc, and has a 50-percent interest in downstream precious metal refinery in Australia.

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GENERAL CONFERENCE INFORMATION

Conference Venue

Adelaide Convention Centre
North Terrace
ADELAIDE 5000 AUSTRALIA
Tel: +61 (8) 8212 4099
Fax: +61 (8) 8212 5101

Conference Office

Registration will be at the conference office located on the ground floor in the main foyer of the Adelaide Convention Centre. The office will be staffed at the following times:

- Sunday 16 February 2003
  1400 - 1900 hrs
- Monday 17 February 2003
  0730 - 1730 hrs
- Tuesday 18 February 2003
  0730 - 1730 hrs
- Wednesday 19 February 2003
  0730 - 1700 hrs

Speaker's Support Room

The speaker support room will be located in Meeting Rooms 8 and 9, located on the 1st floor of the Adelaide Convention Centre. The room will contain a full range of the equipment available in the meeting rooms. All electronic presentations must be downloaded onto the Centre's server. Individual laptops cannot be used in the rooms. Opening hours are:

- Sunday 16 February 2003
  1500 - 1900 hrs
- Monday 17 February 2003
  0730 - 1630 hrs
- Tuesday 18 February 2003
  0730 - 1630 hrs
- Wednesday 19 February 2003
  0800 - 1600 hrs

Name Badges

Name badges must be worn at all times and will be required to gain admission to lunches, morning and afternoon teas and the trade exhibition. If you misplace your badge, please see the registration staff for a replacement. Please note that ribbons on name badges signify:

blue - conference committee member,
burgundy - keynote speakers.

Admission Tickets

Attendance at the welcome reception and the dinner are by ticket only. These tickets are in your registration envelope. If these tickets are misplaced or missing, or you wish to attend, please see the registration staff.

Catering

Morning & afternoon teas and lunches are included in the registration fees will be served in Halls F & G. Access is via the main entrance of the trade exhibition. Delegates who have advised special dietary requirements should identify themselves to the service staff.

Messages

A message board will be located adjacent to the registration desk. The numbers at the registration desk are:
Telephone: +61 (8) 8210 6600
Facsimile: +61 (8) 8210 6601

No guarantee can be given to deliver messages personally. Please ensure your personal mail is sent to your accommodation address.

Parking

Parking is available at a number of locations adjacent to the Convention Centre including EziPark on the Terrace - entry opposite the Exhibition Hall. Cost $7.50 per day maximum.

Smoking

The Adelaide Convention Centre is a smoke free facility.

Cancellation Policy

Optional or additional tickets to social functions will not be refunded if attendance is cancelled less than 72 hours prior to the event.

Disclaimer

The conference host body, organising committee and Sapro Conference Management and their agents act only as organisers of these activities and do not accept responsibility for any act or omission on the part of the service providers. No liability is accepted for inaccuracy, misdescription, delay, damage, personal injury or death.

Please note conference and program details were correct at the time of printing. The organisers will accept no responsibility if details have been changed since that time.

Privacy Statement

In addition to administering the event, unless you advise otherwise in writing, the personal information you provide to us may be disclosed in the event delegate list made available to sponsors, speakers, exhibitors and delegates.

Dress

Business attire is appropriate for conference sessions and other social functions. Dress for the conference dinner is smart casual.

Climate

February is summer in Adelaide and daytime temperatures could reach mid - high 30°s with evening temperatures ranging between 14° and 20°.

Sightseeing

Both the concierge at your hotel and the conference secretariat office will be more than happy to suggest sightseeing in Adelaide and in surrounding areas. The secretariat will have brochures and maps to help you explore South Australia.

Restaurant Dining

Please see the secretariat office for suggestions on dining in Adelaide and maps of the city. Popular dining precincts in Adelaide are located in Gouger Street, Rundle Street East and Hindley Street.

Accommodation

- Hyatt Regency Adelaide
  Tel: +61 (8) 8231 1234
- Townhouse on Hindley
  Tel: +61 (8) 8211 8255
- Adelaide Riviera
  Tel: +61 (8) 8231 8000
- Adelaide Paringa Motel
  Tel: +61 (8) 8231 1000
- Saville Park Suites
  Tel: +61 (8) 8217 2500
- Corus Grosvenor hotel Adelaide
  Tel: +61 (8) 8407 8888

High School Student Day

Proudly supported by Apache Corporation, OMV, and Newmont Mining.

Tuesday 18 February 2003
Meeting Room 4 - 1st floor

A special session for secondary students and teachers will be held during the conference. A range of geoscientists will address students and teachers to convey their experience in the fields of mining, petroleum and the environment, followed by a tour of the trade exhibition.

Undergraduate Student Day

Wednesday 19 February 2003

Sponsored by Barrick Gold

Aimed at undergraduates in 2nd/3rd year in areas of Physics/Maths/Geology/Computer Science, this event provides an opportunity for students to visit the conference and exhibition and attend selected technical and careers presentations.

Conference Secretariat

Sapro Conference Management
PO Box 6129 Halifax St
ADELAIDE SA 5000 Australia
Telephone: +61 (8) 8227 0252
Facsimile: +61 (8) 8227 0251
Email: scm@sapro.com.au
Internet: www.sapro.com.au

Sapro is a leading conference management company with over 10 years experience in managing a wide range of events for government, associations and corporate clients.

Welcome Reception

Sunday 16 February 2003
1800 - 2000 hrs
Trade exhibition Hall H

Sponsored by Beach Petroleum

The event for delegates and partners will provide the opportunity to meet in a relaxed setting. The Trade Exhibition will be officially opened during the event. Included in the full registration fee. Additional tickets available at a cost of A$40.00.

Monday 17 February 2003
Happy Hour 1700 - 1800 hrs

View the latest technology advances in the industry during a relaxed happy hour in the trade exhibition area. Additional tickets available for $20.

Postgraduate Reception

Monday 17 February 2003
From 1830 hrs

Staff Club of the University of Adelaide. Sponsored by AGIP Australia Postgraduate students who are attending the conference are invited to attend an informal BBQ at the Adelaide University. Sponsors and local committee members have been invited to attend and talk about opportunities in geophysics in a relaxed atmosphere.

Conference Dinner

Tuesday 18 February 2003

Sponsored by
Schlumberger/WesternGeco

Pre-dinner drinks at 1900 hrs,
dinner commencing at 1930 hrs

The highlight of the conference social program provides an opportunity for networking over some great food and fine South Australian wine at the Adelaide Oval Function Centre. The dinner includes a three course meal, beverages and a special presentation by Ray Crowe, one of Australia's leading contemporary magicians.

Conference Farewell

Wednesday 19 February 2003
1700-1800 hrs

Sponsored by ITG

At the conclusion of technical sessions, farewell friends at an informal closing function. Additional tickets are available.

Time					
SUNDAY FEBRUARY 16					
18.00 - 20.00	Welcome Reception - Sponsored by Beach Petroleum				
MONDAY FEBRUARY 17					
8.35	Opening Ceremony				
9.10	John Ellice-Flint - Technical issues and challenges for the geophysical industry in Australia				
9.40	Roy Woodall - The geophysicist and the manager: A 50-year experience.				
10.10	Chairperson's closing remarks				
10.15	Coffee break - Sponsored by BHP Billiton Petroleum				
	Keynote / Seismic Technical Forum 1: Seismic Amplitudes. Sponsored by Santos Ltd	EM / Res Case Studies	Potential Fields - Acquisition	Induced Polarisation	Mine / Coal Geophysics
10.45	Pore - Fluid and Lithology Predictions: Will it be with long - offset PP or converted P waves? ***Hilterman, F (Keynote Speaker)***	AEM Bathymetry near Busselton, Western Australia - Comparison of 25 Hz and 12.5 Hz GEOTEM in areas of high conductance ***Vrbancich, J, Sattel, D & Wolfgram, P***	Airborne gravimetry: A new gravimeter system and test results ***Joseph, EJ, Segawa, J, Kusumoto, S, Ishihara, T, Komazawa, M & Nakayama, E***	Cole-Cole inversion of Telluric cancelled IP data ***Rowston, P, Busuttil, S & McNeill, G***	Surface roughness and borehole radar imaging in three-dimensions ***Osman, N, Simmat, C, Hargreaves, JE & Mason, I***
11.10	Key geotechnical challenges facing Santos ***Cooke, D***	Application of electrical resistivity prospecting for geo-environmental investigation ***Park, M, Takeuchi, M & Nakazato, H***	Airborne vector magnetics mapping of remanently magetised banded iron-formations at Rocklea, WA ***Dransfield, M, Christensen, A, Liu, G***	Intrinsic negative chargeability of soft clays ***Brandes, IM & Acworth, RI***	High resolution 3D seismic reflection acquisition applied to coal mining ***Fallon, G, Reveleigh, M, Peters, T & Kenny, T***
11.35	Incorporating uncertainty in the quantitative interpretation workflow ***Koster, K***	New developments in high resolution airborne TEM instrumentation ***Sorenson, K & Auken, E***	Drape related problems in aeromagnetic surveys: The need for tight-drape surveys ***Cowan, DR & Cooper, GRJ***	Reduction of noise in Induced Polarization data using full time-series data ***Paine, J & Copeland, A***	Smart solution to a sticky problem: In-mine clay mapping using high-resolution geophysics ***Burnham, GF & Hawke, PJ***
12.00	Panel discussion		Magnetic signals generated by ocean swells ***Pedersen, T, Lilley, T & Hitchman, A***	Benefits of large channel capacity systems in electrical geophysics ***Kingman, J & Garner, S***	
12.25	Lunch				
	Seismic Attributes. Sponsored by Origin Energy	Seismic Acquisiton 1	Anisotropy / Seismic wave inversion	Keynote: Environmental	Mineral Case Histories: SA/NT/BH Session 1
13.35	Application of the radial basis function neural network to the prediction of log properties from seismic attributes ***Russell, B, Hampson, D & Lines, L***	3D strike vs dip streamer shooting direction comparison ***Long, AS & Hoffmann, J***	Frequency dependent anisotropy of porous rocks with aligned fractures ***Brajanovski, M & Gurevich, B***	Mapping salinity and groundwater systems- a multi-disciplinary approach integrating geophysics and regolith geoscience ***Lawrie, K (Keynote Speaker)***	Challenges in mineral exploration ***Isles, D & Harman, P***
14.00	Fluid & lithology prediction within a coal sequence using seismic attribute modelling and analysis (Gippsland Basin) ***Kim, M, Dunne, J & Gurevich, B***	The effect of sea swell on seismic data ***Shepherd, A & McDonald, J***	Application of amplitudes in shallow seismic refraction inversion ***Palmer, D***	Geophysical investigation of River Murray salinity: A case study using fast-sampling TEM ***Hatch, M, Hopkins, B, & White, G***	Challenges in mineral geophysics-exploration for uranium in Arnhem Land (NT) ***Beckitt, G & Bisset, A***
14.25	Reservoir monitoring with continuous acoustic measurements ***Leslie, DM & Hartley, BM***	In pursuit of the ideal 3D streamer symmetric sampling criteria ***Long, AS, Ramsden, CRT & Hoffmann, J***	Shallow surface wave inversion - research and applications in WA ***O'Neill, A, Dentith, M & List, R***	Ground-based geophysical measurements in salinity-affected areas prior to AEM surveys ***Buselli, G, Hunter, D, Munday, T & Wilkinson, K***	The geophysical responses of the Prominent Hill Fe-Cu-Au-U deposit ***Hart, J***
14.50	Coffee break				
	Keynote / Seismic Technical Forum 2: The drive for better bandwidth	EM: Noise reduction	Poster Presentations	Environmental: Salinity	Mineral Case Histories: SA/NT/BH Session 2 Sponsored by MIM Exploration
15.20	The drive for better bandwidth ***Egan, MS (Keynote Speaker)***	100% duty cycle TEM: Faster acquisition and less noise ***Kepic, A & Adams, B***	Authors of posters numbered ***1 through 10*** will be in the poster display area to present their posters and answer questions.	Groundwater exploration with AEM in the Boteti Area, Botswana ***Sattel, D & Kgotlhang, L***	The IP response of sedimentary copper deposits at Kapunda, South Australia ***Stuart, R & Dentith, MC***
15.45	Recent seismic acquisition trials in the Cooper Basin ***Hughes, JR & Brew, SR***	Characterisation of cultural noise in the AMT band ***Pellerin, L, Alumbaugh, D & Cuevas, N***	Authors of posters numbered ***11 through 20*** will be in the poster display area to present their posters and answer questions.	Large scale TEM investigation for groundwater ***Auken, E & Sørensen, K***	Magnetic modelling and petrophysical data from the Musgrave Ranges, SA ***Shearer, A & Gum, J***
16.10	Open Forum: Several oil companies present their key objectives/challenges	Estimating noise levels in AEM data ***Green, A & Lane, R***		A geophysical investigation of dryland salinity at Cressy, Tasmania ***Peters, G & Reid, J***	Mapping mineralogical and structural relationships with satellite borne aster and airborne geophysics at Broken Hill ***Hewson, R, Mah, A, Dunne, M & Cudahy, T***
16.35	Panel discussion	Optimising AEM technology for salinity applications ***Green, A***			
17.00	Happy hour				

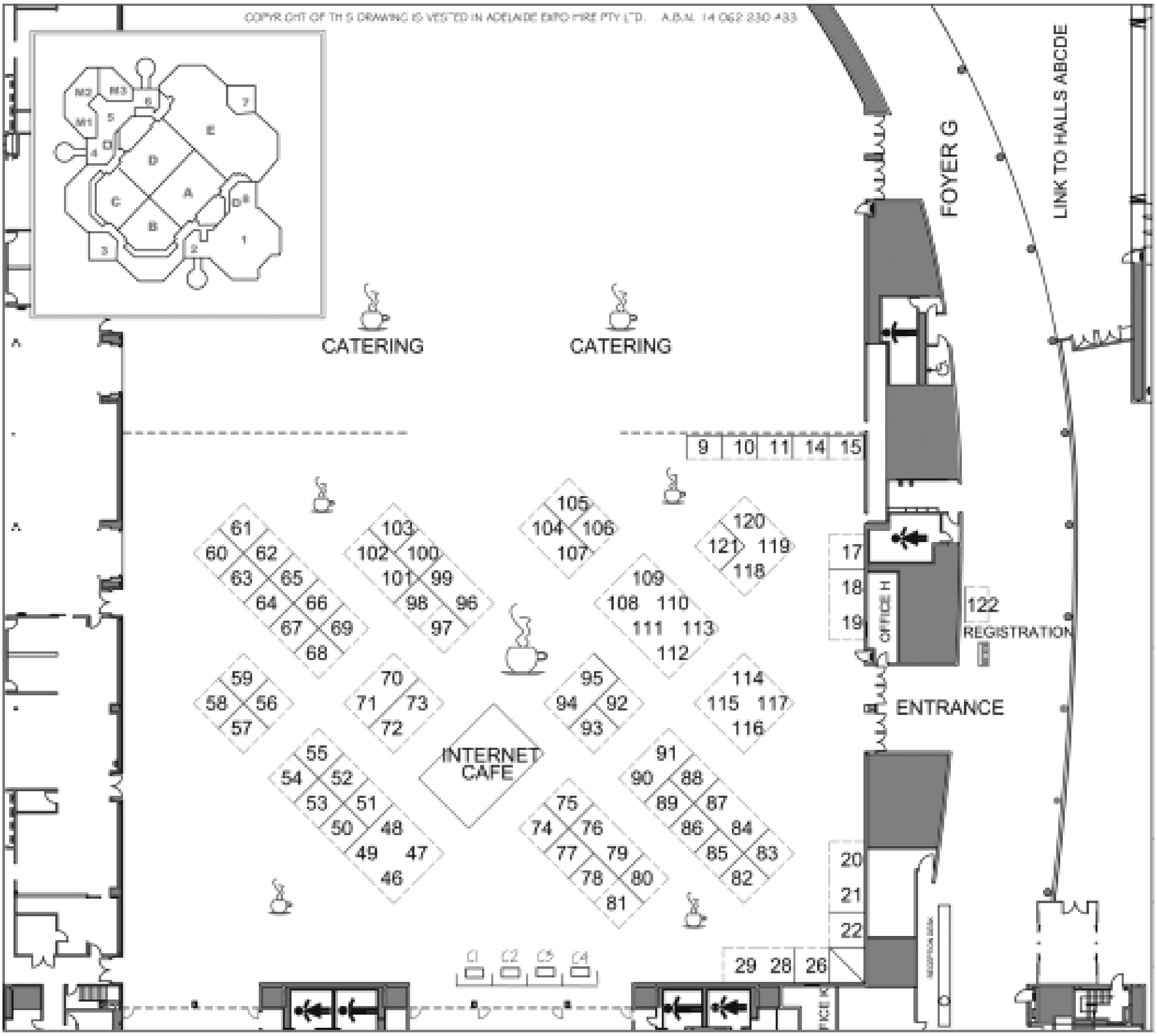
TUESDAY FEBRUARY 18

	Seismic Attributes 2 Sponsored by Stuart Petroleum	Seismic Processing 1	Prospect / Basin Evaluation Sponsored by AGIP Australia	Keynote: Electrical Inversion	Non-petroleum Seismic
8.35		Detailed refraction statics with the GRM and the RCS *Palmer, D & Jones, L*		Crustal scale controls on gold ore fluid movement and deposition as revealed from electrical resistivity structure: Examples from compressional and extensional regimes *Wannamaker, P et al (Keynote Speaker)*	Tau-p velocity imaging of regolith structure *Barton, PJ & Jones LEA*
9.00	Quantification of fluid phase probability in prospect evaluation using a Bayesian approach *Andersen, T, Martin, P & Koster, K*	High resolution coherent noise removal *Hargreaves, N & Whiting, P*	The origin of overpressure in the Cooper Basin, Australia *van Ruth, P, Hillis, R, Swarbrick, R, Tingate, P & Mildren, S*	A comparison of 2D and 3D IP from Copper Hill, NSW *Webb, D , Rowston, R & NcNeill, G*	A geophysical survey of the Derwent Estuary *Roach, M & Gibbons, M*
9.25	Using VSP data to evaluate the response of seismic attributes for reservoir characterisation *Urosevic, M & Gerhardt, A*	Model-based deconvolution for dominant, thin-bed seismic reflections *Hearn, S & Voss, D*	Integrated evaluation in the Mauritanian Frontier *Lawson, K, Boss, P, Enman, T, Freer, G, Lavin, C & Reimann, K*	Resistivity & IP arrays, optimised for data collection and inversion *White, RMS, Collins, S & Loke, MH*	Seismic imaging of steep dips with low fold data: Case studies for Broken Hill and the Lachlan Fold Belt *Jones, L, Fomin, T & Drummond, B*
9.50	Surface seismic imaging with multi-frequency full waveform amplitude inversion *Greenhalgh, S & Zhou, B*	Signature after predictive deconvolution *Parrish, J*	Models for continental breakup and deep-water basin formation: Insights from integration of potential field modelling and deep seismic data on conjugate continental passive margins *Direen, NG, Symonds, PA, Sayers, J, Stagg, HMJ & Colwell, JB*	Case histories in the use of three dimensional inversion of induced polarisation and resistivity surveys *Collins, S & White, RMS*	A 3D 3C shallow seismic refraction survey across a shear zone at Bungendore *Palmer, D*
10.15	Coffee Break - Sponsored by Anglogold				
	Keynote / Seismic Technical Forum 3: Global Geophysical Trends. Sponsored by Woodside Petroleum	Potential Fields: Analysis	Mineral Case Studies: Gold Sponsored by Newmont Mining	AEM: Difficult targets	EM / Resistivity: Problems
10.45	Energy globalization and the emerging technology renaissance *Shoham, Y (Keynote Speaker)*	On the use of magnetics and gravity to discriminate between gabbro and iron-rich ore-forming systems *Hanneson, J*	Direct detection of gold bearing structures at St Ives, WA - DHEM vs DHMMR *Stolz, N*	Finding targets in complex hosts using airborne EM *Raiche, A, Sugeng, F & Annetts, D*	Maximising the use of induced polarisation 2D smooth-model inversion *Robertson, W & Hart, J*
11.10	Global geophysical trends *Bahorich, M (Keynote Speaker)*	Spatial and directional analysis of potential field gradients - New methods to help solve and display three-dimensional crustal architecture *Milligan, P, Lyons, P & Direen, N*	Geophysical characterisation of the Trident Gold Deposit, Western Australia *Hall, B & Bourne, B*	The Cawse nickeliferous laterite deposits, Western Australia - A case study on the application of airborne geophysics, in targeting zones of supergene enrichment in a complex regolith setting *Munday, T, Meyers, J, Rutherford, J, Green, A, Macnae, J & Cooper M*	Some positive thoughts about negative TEM responses *Bishop, JR & Reid, JE*
11.35	A desert seismic crew of the future *Hughes, JR*	The application of fractional calculus to potential field data *Cooper, GRJ & Cowan, DR*	Geophysical exploration of the Pajingo epithermal system *Hoschke, T & Parks, J*	The application of airborne electromagnetics to the search for high conductance targets *Witherly, K, Irvine, R & Raiche, A*	The effect of dipole position errors on E-field measurements in electrical geophysical surveys: Is close enough good enough? *Hatch, M & Mutton, AJ*
12.00	Panel Discussion	Analytic signal vs. reduction-to-pole: solutions for low magnetic latitudes *Rajagopalan, S*	Magnetism - key to Wallaby gold deposit *Coggon, J*	The resolution of shallow horizontal structure with AEM *Sattel, D*	Two- and three-dimensional resistivity imaging in a shallow coastal sand aquifer *Dasey, G & Acworth, I*
12.25	Lunch *"Feedback from the last two rounds of the ARC Competitive Grants Scheme" by Barry Drummond (ARC Expert Advisory Committee on Physics, Chemistry and Geoscience) and Lawrence Cram (Program Director, Physics, Chemistry and Geoscience) (duration 20-25 mins)*				

TUESDAY FEBRUARY 18					
	SEISMIC MIGRATION	NON-SEISMIC PETROLEUM EXPLORATION	ENVIRONMENTAL: TOWED ARRAY	RADIOMETRY / SPECTROMETRY	SOLID EARTH: DEEP STRUCTURE
13.35	A visual based connection between seismic inversion and seismic migration *Bancroft, J*	*In situ* stress field, fault reactivation and seal integrity in the Bight Basin, South Australia *Reynolds, S, Hillis, R & Paraschivoiu, E*	A floating electrode array for continuos geo-electrical imaging *Allen, D & Merrick, N*	Accurate noise reduction for gamma-ray spectrometry *Minty, B*	Three-dimensional extension of the Hill End Trough based on the modelling of the regional gravity data *David, V, Glen, D & Spencer, R*
14.00	Anisotropic prestack depth migration in practice *Whiting, P, Klein-Helmkamp, U & Notfors, C, Khan, O*	Is there any room for gravity in petroleum exploration? *Shevchenko, SI & Iasky, RP*	Salinity monitoring of the Murray River using towed TEM array *Barrett, B, Heinson, G, Hatch, M & Telfer, A*	Calibration, processing and interpretation of hyperspectral data over the Broken Hill region *Robson, D, Cocks P & Taylor, G*	Wide-angle reflection experiment with vibroseis source as part of a multidisciplinary seismic study of the Leonora-Laverton Tectonic Zone, Northeastern Yilgarn Craton *Fomin, T & Arcidiaco, M*
14.25	3D Prestack depth migration by wavefield extrapolation methods *Sun, J, Zhang, Y, Gray, S, Notfors, C & Young, J*	Augmenting satellite altimeter data with ship and land gravity data in the Northwest Shelf of Australia *Kirby, J*	Irrigation channel seepage investigations *Street, G, Parsons, S, Allen, D & Hatch, M*	Improving the quality of aerial gamma-ray surveys *Dickson, BL & Taylor, GM*	
14.50	Coffee break				
	KEYNOTE / SEISMIC TECHNICAL FORUM 4 : CONVERTED WAVE / AZIMUTHAL SEISMIC SPONSORED BY: WOODSIDE PETROLEUM	POTENTIAL FIELDS: FEATURE EXTRACTION	AEM ACCURACY	DOWNHOLE RESISTIVITY / EM METHODS	MINERALS CASE STUDIES: BASE METALS SPONSORED BY NEWMONT MINING
15.20	Converted-wave Seismic Exploration: Methods and Techniques *Stewart, R (Keynote Speaker)*	DAP - Large volume spatial data discovery and distribution over networks *MacLeod, IN & Amorim, R & Valleau, N*	An assessment of the accuracy of boundaries picked by AEM sounding with application to salinity mapping *Macnae, J, Grant, A & Lane, R*	Crosswell electromagnetic imaging in three dimensions *Zhdanov, M & Yoshioka, K*	The electrical properties of the Scuddles VHMS deposit *Roach, M & Fitzpatrick, A*
15.45	The Technology Race *Lynn, W (Keynote Speaker)*	Semi-automated magnetic image retrieval *Buckingham, A, Dentith, M & List, R*	Correcting drift errors in HEM data *Green, A*	Inversion of cross-hole radio frequency data in a layered earth *Fullagar, PK & Zhou, B*	Electrical imaging of peridotite weathering mantles as a complementary tool for nickel ore exploration in New Caledonia *Savin, C, Robineau, B, Monteil, G, Beauvais, A, Parisot, JC & Ritz, M*
16.10	Cooper Basin azimuthal seismic *Djamaludin, I & Brew, SR*	Semblance filtering of airborne potential field data *Christensen, A*	The importance of accurate altimetry in AEM surveys for land management *Brodie, R & Lane, R*	Using the Loki 3D edge-finite-element program to model EM dipole-dipole drill-hole data *Raiche, A, Sugeng, F & Soininen, H*	
16.35	Panel Discussion	Feature enhancement using sunshading *Cooper, GRJ & Cowan, DR*			
19.00	Conference dinner - Sponsored by Schlumberger/WesternGeco				
WEDNESDAY FEBRUARY 19					
	SEISMIC PROCESSING 2	ANISOTROPY / MULTICOMPONENT	MODELLING	KEYNOTE: EM INVERSION	GENERAL INTEREST
8.35	Prestack migration concepts for AVO measurements on horizontal and dipping layers *Bancroft, JC & Sun, S*	3-D fracture assessment using AV Az and layer-stripping approach *Luo, M & Evans, B*			What if your inversion has no numerical target *Wijns, C, Boschetti, F & Kowalczyk, P*
9.00	Seismic multiple attenuation based on pre-stack reflectivity modelling *Voss, D & Hearn, S*	An approach to computing the dispersion of wavespeed for the most general 3D anisotropic media *Zhou, B & Greenhalgh, S*	The development of synthetic CIPS sandstones for geophysical research *Sherlock, D & Siggins, F*	New advances in geophysical inversion in mineral exploration *Zhdanov, MS (Keynote Speaker)*	A conceptual framework for interpretation of airborne geophysical data *Anderson-Mayes, AM & Street, G.*
9.25	Managing the three p's of seismic data: proliferation, pervasiveness and persistence *Kozman, J*	A new model for fluid substitution in fractured reservoirs *Gurevich, B*	Seismic noise modelling in the Dampier Sub-Basin *Dunne, J, Ridsdill-Smith, T & van der Veen, M*	Improving the accuracy of shallow depth determinations in AEM sounding *Macnae, J*	Application of SAR interferometry to a geothermal field *Okubo, Y, Watanabe, H Shiga, N, & Rokugawa, S*
9.50	Optimum focusing from filtered dense velocities picking *Le Meur, D, Delorme, A, Mudge, N & Herrmann, P*	Experimental verification of the anisotropic Gassmann model for fluid substitution in fractured reservoirs *Brown, L & Gurevich, B*	Thin-layer scaling effects on AVO modelling *Du, B & Long, AS*	A comparison of shipborne and airborne electromagnetic methods for Antarctic sea ice thickness measurements *Reid, JE, Vrbancich, J & Worby, AP*	Geophysical monitoring tree root zones *Kepic, A & Campbell, T*
10.15	Coffee break				

WEDNESDAY FEBRUARY 19					
	Keynote / Seismic Technical Forum 5: Structural Integrity	Mineral Case Studies: Other	Potential Fields: Inversion	AEM Interpretation	Groundwater: New Technologies
10.45	On structural integrity in seismic data ***Jakubowicz, H (Keynote Speaker)***	A geophysical signature for tin deposits in south-east Australia - revisited ***Webster, S***	A case study in the resolution of depth extent in modelling of magnetic anomalies over shallow sources in rugged terrain ***Foss, C***	Approximate 2D inversion of AEM data ***Wolfgram, P, Christensen, NB & Sattel, D***	Groundwater exploration with the magnetic resonance method ***Bernard, J & Legchenko, A***
11.10	Seismic imaging under the Darai Limestone in the PNG Thrust Belt ***Nicholson, F & Beresford, G***	Evaluation of multifrequency airborne EM for opal prospect definition at Lightning Ridge, NSW ***Moore, M, Macnae, J & Burton, G***	3D gravity and aeromagnetic modelling, Pillara region, WA ***Fullagar, P, Pears, G, Hutton, D & Thompson, A***	Western Tasmanian Regional Minerals Program (part 2): airborne electromagnetic data - quality control and interpretation ***Reid, JE, Bishop, JR, Richardson, R, Fullagar, P. Fitzpatrick, A & Griggs, DL***	An auger tool to estimate hydraulic conductivity using a resistivity analogy ***Sorensen, K, Pellerin, L, Auken, E & Efferso, F***
11.35	From depth migration model building, to redepthing to tie wells, through to structural uncertainty analysis: An integrated workflow ***Lamont, MG***	Three Springs Talc Mine: A new view on an old deposit ***Vella, L, Evans, B, Urosevic, M & Emerson, D***	Origin of magnetic anomalies associated with the Yallalie impact structure, Perth Basin, Western Australia ***Hawke, PJ, Buckingham, AJ & Dentith, MC***	Modelling and matching the airborne EM response of Harmony and Maggie Hays ***Annetts, D, Sugeng, F & Raiche, A***	Nuclear magnetic resonance: Applications for groundwater exploration in Queensland ***Dippel, S, Golden, H & Jenke, G***
12.00	Panel Discussion		A methodology study in determination of depth to basement by inversion of selected discrete magnetic field anomalies ***Foss, C***	Topographic modelling and correction in frequency-domain airborne electromagnetics ***Sasaki, Y & Nakazato, H***	Environmental monitoring using electrical resistivity tomography ***Dhu, T, Heinson, G, Simmons, C , Greenhalgh, S & Halihan, T***
12.25	Lunch				
	Seismic Processing 3	Stress / CO_2 Sequestration Sponsored by: ChevronTexaco		Keynote: UXO, Forensic Arch.	Solid Earth Geophysics: Seismic Hazards
13.35	Seismic reprocessing and preSDM in the Gippsland Basin ***Dunne, J, Folkers, T & Webster, P***	Velocity-effective stress laws and hysterisis in Carnarvon Basin sandstones ***Siggins, AF, Dewhurst, D & Gurevich, B***		Minerals exploration methods modified for environmental targets ***Carlson, NR (Keynote Speaker) & Zonge, KL***	Geophysical study of a palaeofault scarp near Hyden, Western Australia ***Dentith, M***
14.00	Introduction to vector-processing techniques for multi-component seismic exploration ***Hendrick, N & Hearn, S***	Predicting the change in the seismic response as a consequence of CO_2 sequestration into saline aquifers ***McKenna, J, Gurevich, B, Urosevic, M & Evans, B***		Archaeological geophysics: 3D imaging studies at Muweilah, United Arab Emirates ***Evangelista, R & Wedepohl, E***	Recent advances in the modelling of earthquake hazard in Australia (part 1): source, attenuation and site response models ***Dhu, T, Jones, T, Sinadinovski, C, Jones, A, Robinson, D & Schneider, J***
14.25	Anisotropic semblance analysis and NMO corrections for long offset data ***Zhang, F & Uren, N***	Geophysical monitoring of subsurface CO_2 ***Sherlock, D & Dodds, K***		Dramatic improvements in UXO detection using discrimination and dual-mode sensor technology ***Stanley, J & Billings, SD***	Recent advances in the modelling of earthquake hazard in Australia (part 2): Estimating the hazard ***Robinson, D, Mendez, A, Fulford, G, Dhu, T, Jones, T & Schneider, J***
14.50	Coffee break				
	Seismic Processing 4: Multiple Suppression		Groundwater: Case Studies	UXO, Forensic Arch.	Solid Earth Geophysics
15.20	Highlights from recent Multiple Suppression Workshop ***Crook, C***		Geophysical evaluation of potential refuse disposal sites: A case study from George Town, Northern Tasmania ***Carpenter, N, Roach, M & Reid, J***	Detecting buried bodies using near-surface geophysical instruments ***Powell, K***	PlatyPlusPlus - reconstruction software with a difference ***Duboz, C, Tan, SC, Quenette, S, Lister, GS, & Appelbe, B***
15.50	Amplitude preserving v(z) pre-stack Kirchhoff Migration and Demigration ***Zhang, Y, Karazincir, M, Notfors, C, Sun, J & Hung, B***		Crosshole electrical imaging of aquifer properties and preferential flow paths at the Bolivar ASR site ***Zhe, J, Greenhalgh, S & Zhou, B***	Locating pioneer graves with GPR ***Kepic, A & Howman, D***	Expected improvements to regional gravity field determination from the GRACE, CHAMP and GOCE satellite missions ***Featherstone, WE***
16.15	Seismic imaging: Science and Art ***Zhou, B & Hatherly, P***		3D geophysical processing, visualisation and interpretation of rice irrigation impacts ***d'Hautefeuille, F, Merrick, N, McLachlan, M & Hodson, A***	Trial geophysical surveys at the Port Arthur historic site, Tasmania ***Roach, M, Links, F, Dorn, N, Gibbons, D, D'Andrea, L & Jackman, G***	
16.50	Closing Ceremony				
17.30	Farewell Function				

	POSTER	AUTHORS		POSTER	AUTHORS
1.	A comparison of electrical methods for detection of hydraulic pathways in a fractured rock aquifer, Clare Valley, South Australia	*Skinner, D & Heinson, G*	11.	P-S converted wave survey in Quaternary plains with severe Statics problems	*Kano, N, Yokokura, T & Yamaguchi, K*
2.	A time-lapse reflection survey for the geothermal reservoir monitoring in Akinomiya geothermal area, Akita pref. Japan	*Yokota, T, Matsushima, J, Okubo, Y, Yamaguchi, K, Kano, N, Rokugawa, S, Koike, H & Onishi, K*	12.	Microseismic observation of fault reactivation at underground coal mines	*Luo, X*
3.	Closed form transient solution for a layer of finite thickness on resistive half-space	*Singer, B & Green, A*	13.	A high resolution gravity survey near McArthur River Uranium Deposit, Athabasca Basin, Canada	*Thomas, M D & Wood, G*
4.	Constrained grid matching of large magnetic databases - the magnetic anomaly grid of Queensland	*Milligan, PR, Franklin, R & Meixner, T*	14.	Inversion of induced polarisation data over the Beruang Copper-Gold deposit in Kalimantan, Indonesia	*Elliott, P J*
5.	Detecting sub-surface groundwater flow in fractured rock using self-potential (SP) methods	*Fagerlund, F & Heinson, G*	15.	Airborne 3D FTG data proves utility for both minerals and oil & gas exploration / exploitation	*Mumaw, G & Murphy, C*
6.	Shallow marine electromagnetic measurements for defence applications	*Vrbancich, J, Donohoo, A, de Sousa, M, Heinson, G & White, A*	16.	Velocity database for Australian Southern Margin Basins	*Petkovic, P*
7.	The three-dimensional inversion of magnetic and gravity gradient tensor data	*Heath, P*	17.	Exploration for deep Paleozoic sediments in Uzbekistan using MT: Project "Paleorift"	*Fox, L, et al*
8.	Wavelet analysis of detailed drillhole magnetic susceptibility data, Brockman Iron Formation, Hamersley Basin, Western Australia	*Cowan, DR & Cooper, GRJ*	18.	Some "cross-cultural" GPR applications in Western Australia	*O'Neill, A*
9.	Developing recharge reduction strategies in the Riverland of South Australia using airborne electromagnetic data - a case study in tailoring airborne geophysics given a particular target and a desired set of outcomes	*Munday, T, Green, A, Brodie, R, Lane, R, Sattel, D, Cooke, P & Dodds, S*	19.	Application of airborne gravity gradiometer technology in coal exploration	*Mahanta, A*
10.	South Australian salt mapping and management support project - an example of the considered application of airborne geophysics in natural resource management	*Munday, T & Walker, G*	20.	GPS-Geodetic Monitoring of the South West Seismic Zone of Western Australia: Epoch One	*Leonard, M, Clark, D, Featherstone, W, Kirby, J, Kuhn, M, Dentith, M, Kennedy, D, Darby, D, McCarthy, B, Schuiling, L & Hugessen, B*



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Section 2

ASEG 2003

GROWTH THROUGH INNOVATION

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ADVANCED LOGIC TECHNOLOGY (ALT) STAND 85

Batiment A, Route de Niederpallen
L-8506 Redange- Sur-Attert, Luxembourg
Luxembourg
Tel: 352 23 649 289
Fax: 352 23 649 364
Email: sales@alt.lu
Contact Person: Annick Henriette

Advanced Logic Technology is a dynamic software and hardware development company introducing new concepts to the geoscience industry since 1993.

ALT is well known in the design and manufacture of high-end slimhole imager tools and the ALTlogger data logging system.

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ALPHA GEOINSTRUMENTS STAND 76

Suite 1, 23 Gray Street
SUTHERLAND NSW 2232 Australia
Tel: (02) 9542 5266
Fax: (02) 9542 5263
Email: sales@alpha-geo.com
Website: www.alpha-geo.com
Contact Person: Timothy Pippett

Alpha GeoInstruments, a division of Alpha GeoScience Pty. Ltd. was setup for the distribution of geophysical instruments in the Australian and New Zealand markets. The following manufacturers are represented by Alpha GeoInstruments:

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- Geovista - Borehole Logging Systems
- Geophex - Electro-Magnetics Systems
- Advanced Logic Technology - Well Logging Software
- Roadscanner - GPR Road Scanning Software

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AUSTRALIAN PETROLEUM COOPERATIVE RESEARCH CENTRE STAND 62

PO Box 136
NORTH RYDE NSW 1670 Australia
Email: David.Collins@csiro.au
Contact Person: David Collins

The APCRC, a consortium of industry, government and universities, provides the Australian oil and gas industry with cost-effective problem solving in key sectors of exploration and production. The Centre undertakes research in the following topics: developing a better understanding of seals to reduce exploration risk; improving oil production by improved reservoir characterisation; decreasing drilling risk in areas with abnormally high formation pressures; improving understanding of liquid hydrocarbons source rocks and migration pathways; decreasing exploration and production costs through enhancing seismic imaging; and defining the technical, environmental and economic feasibility of geological storage of CO_2.

ARCHIMEDES CONSULTING PTY LTD STAND 100

605B Greenhill Rd
BURNSIDE SA 5066 Australia
Tel: (08) 8234 0511
Fax: (08) 8234 2637
Email: ikivior@archimedes-consulting.com.au
Contact Person: Irena Kivior

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 and deep crustal studies. The company has developed proprietary software for special processing and interpretation of magnetic data.

The company provides services for several large firms across Australia and internationally.

BAIGENT GEOSCIENCES PTY LTD STAND 66

174 Cape Three Point Rd
AVOCA BEACH NSW 2251 Australia
Tel: (02) 4382 6079
Fax: (02) 4382 6089
Email: mark@bgs.net.au
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 LTD. STAND 68

Unit 5a Crombie Lodge
ASTP Bridge of Don
ABERDEEN AB22 8GU
UK
Tel: 44 0 1224 227728
Fax: 44 0 1224 227702
Email: gmumaw@bellgeo.com
Contact Person: Gary Mumaw

Bell Geospace Ltd (BGL), Aberdeen, Scotland is a subsidiary of the parent company Bell Geospace Inc. (BGI), Houston Texas. BGI is responsible for the Americas and BGL for all other international operations. Since 1998 Bell has been the soul source provider of marine high precision moving platform 3D full tensor (gravity) gradient (3D FTG) data to the international oil and gas industry. However during 2001, An Airborne version was developed, tested and introduced principally to satisfy demand from the minerals industry. FTG data contains mass geometry and lineament information utilized for prospect level density contrast definition and delineation.

CGG AUSTRALIA STAND 74

PO Box 371
WEST PERTH WA 6872 Australia
Tel: (08) 9226 2233
Email: dgoldspink@cgg.com
Contact Person: Debbie Goldspink

Compagnie Generale de Geophysique (CGG) is a leading supplier of geophysical products and services to the worldwide oil and gas industry.

CGG Australia offers state-of-the-art seismic processing, Reservoir Geophysics and Borehole seismic processing.

CRC LEME STAND 14

Department of Geology & Geophysics
Adelaide University
ADELAIDE SA 5005 Australia
Tel: (08) 8303 5519
Fax (08) 8303 4347
Email: maureen.blake@adelaide.edu.au
Contact Person: Maureen Blake

The Cooperative Research Centre for Landscape Environments and Mineral Exploration has a vision to seek new mineral exploration methods and better environmental management through knowledge of the regolith. Regolith exerts an enormous and largely underestimated influence over critical aspects of Australian society, especially those pertaining to the minerals industry and natural resource management. Our eight core partners including Universities, government agencies and CSIRO provide more than one hundred staff and around eighty postgraduate students to work on projects of vital significance to the geoscience sector. We are based strategically across all of the southern States of Australia, with Geophysics acquisition, exploration, evaluation and analysis a core activity in many individual research projects.

LIST *of* EXHIBITORS

CSIRO EXPLORATION & MINING STAND 82
PO Box 136
NORTH RYDE NSW 1670 Australia
Tel: (02) 9490 8957
Fax: (02) 02 9490 8921
Email: judy.thomson@csiro.au
Contact Person: Judy Thomson

CSIRO is working with the minerals and petroleum industries to develop new geophysical instruments, techniques and interpretation methods. This new technology is designed to increase exploration success and improve operational efficiency and safety, while decreasing environmental impact. In particular, the Glass Earth project aims to 'see' into the Earth's crust to discover the next generation of ore deposits. As part of this project, superconductors developed by CSIRO are being incorporated into geophysical prospecting tools to give improved target detection and identification. In and around mines, automated core logging and 3-D pit mapping are increasing efficiency and safety. Work with the petroleum industry includes pore pressure prediction, reservoir characterisation and geophysical simulation of saturated reservoir rocks.

CURTIN GEOPHYSICS STAND 61
Curtin University of Technology
GPO Box U1987
PERTH WA 6845 Australia
Tel: (08) 9266 3565
Fax: (08) 9266 3407
Email: deirdre@geophy.curtin.edu.au or
enq@geophy.curtin.edu.au
Website: www.geophysics.curtin.edu.au
Contact Person: Deirdre Hollingsworth

The DEPARTMENT OF EXPLORATION GEOPHYSICS specialises in education and research in Minerals, Groundwater and Petroleum Geophysics. In 2002 the Department has 16 Staff and 72 Students. Since the inception of a geophysics program at Curtin, over 500 persons have been awarded degrees at all levels. The Department is a member of three CRCs; APCRC, CRCLEME, CMTE and a State nominated Centre of Excellence for Exploration and Production Geophysics. The annual operating budget of the Department is approx. $2 million, most of which is received via research grants.

DAISHAT PTY LTD STAND 15
PO Box 766
MURRAY BRIDGE SA 5253 Australia
Tel: (08) 8531 0349
Fax: (08) 8531 0684
Email: david.daish@daishsat.com
Contact Person: David Daish

Daishsat is the leading provider of GPS positioned gravity surveys in Australia, having surveyed in excess of 250,000 gravity stations over the last 11 years since the introduction of precision GPS techniques to the exploration industry. The company also offer precision GPS surveys, ground magnetic surveys, image processing and gravity terrain corrections.

DEPARTMENT OF MINERAL AND PETROLEUM RESOURCES STAND 10
100 Plain Street
EAST PERTH WA 6004 Australia
Tel: (08) 9222 3719
Fax: (08) 9222 3633
Email: andrew.goss@mps.wa.gov.au
Contact Person: Andew Goss

The mission of the Geological Survey of Western Australia is to develop regional geoscientific, resources and related policy information systems by acquiring, enhancing, archiving and disseminating data to promote the potential for successful mineral and petroleum resource exploration in Western Australia and to assist in land use planning and State development.

DYNAMIC SATELLITE SURVEYS STAND 88
PO Box 713
YEPPOON QLD 4703 AUSTRALIA
Tel: (07) 4939 2866
Fax: (07) 4939 2867
Email: lisal@dss.com.au
Contact Person: Lisa Lilleboe

Dynamic Satellite Surveys (DSS) is an Australian based Global Positioning System (GPS) surveying company which offers a diverse range of services including borehole surveys, pipeline routing, seismic surveys, asset management and photogrammetry. DSS has been involved in over 80% of seismic exploration projects in Australia since 1989 and pioneered the use of GPS in this area.

DSS is Quality Assured (ISO9001:2000) and has an excellent safety record. DSS' management team is capable of assessing, planning and managing complete projects.

EARTH RESOURCE MAPPING/MERIDIAN STAND 60
Level 2, 87 Colin St
WEST PERTH WA 6005 Australia
Tel: (08) 9388 2900
Fax: (08) 9388 2901
Email: darren@ermapper.com.au
Contact Person: Darren Mottolini

Formed in 1989, Earth Resource Mapping is committed to making image processing easier so that professionals at all skill levels and disciplines can effectively utilize the power of geoprocessing and remote sensing technologies. Earth Resource Mapping is totally committed to open software standards for imagery.

Meridian GIS is an independent Geographic Information Systems (GIS) company formed in Perth, Western Australia in 1997 to provide mineral and petroleum exploration companies with broad-based GIS services. Initially providing software sales and mapping services, Meridian GIS has broadened its scope to include training, system implementation and software development, offering these services to a wider range of markets.

ENCOM TECHNOLOGY PTY LTD STAND 104 & 107

Level 2, 118 Alfred St
MILSONS POINT NSW 2061 Australia
Tel: (02) 995 74117
Fax: (02) 9922 6147
Email: grant@encom.com.au
Contact Person: David Pratt

Encom Technology is a leading developer of geoscience data integration and modelling software and provides specialist software engineering services, advanced consulting services and geoscience data supplies.

The integration of Encom's modelling and visualisation tools provides seamless access to standard industry data formats (*ER Mapper, Intrepid, Geosoft, ArcGIS, UBC-GIF, DXF and Microsoft databases*) and delivers the ability to "mine and model geoscience data" with effective 2D and 3D visualisation tools, thereby increasing staff productivity through the life of the project. Productivity and quality go hand in hand with Encom's technology: the ability to link data domains assures data integrity through the project team and allows geoscience professionals to make least risk, informed decisions.

Encom's software products include Discover for MapInfo, GPINFO, Profile Analyst, QuickMag, ModelVision, AutoMag, NODDY, EM Flow, and EM Vision. Encom is a MapInfo Strategic partner and an accredited service and software provider for ER Mapper and UBC-GIF inversion software. Encom also provides petroleum and mineral tenement data services, satellite imagery, airborne geophysical data and many other public domain data sets.

ESRI AUSTRALIA STAND 55

PO Box 659
SPRING HILL QLD 4000 Australia
Tel: (07) 3031 0800
Fax: (07) 3031 0888
Email: Skempson@esriau.com.au
Contact Person: Susan Kempson

ESRI Australia is the major supplier of Geographic Information Systems (GIS) in Australia with offices across the country. Our business consists of sales, technical support, consulting and training of the leading ESRI GIS and ERDAS software; from desktop to enterprise GIS and Internet mapping solutions. We continue to set the standard for high quality GIS implementation projects, backed by staff with a wide range of industry and technical experience. Our technical knowledge and experience will help in the successful implementation of GIS in your organisation.

Industry groups using ESRI software solutions include: utilities, local, state and federal government, resource management, environmental management, defence, mining, facilities management, transport and business.

FUGRO AIRBORNE SURVEYS STAND 70 & 71

65 Brockway Rd
FLORIAT WA 6014 Australia
Tel: (08) 9273 6460
Fax (08) 9273 6466
Email: mlees@fugroairborne.com.au
Contact Person: Michael Lees

Fugro Airborne Surveys (FAS) is a multi-disciplinary geoscience 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.

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 GROUND GEOPHYSICS STAND 72 & 73

65 Brockway Rd
FLORIAT WA 6014 Australia
Tel: (08) 9273 6460
Fax: (08) 9273 6466
Email: mlees@fugroairborne.com.au
Contact Person: Michael Lees

FUGRO GROUND GEOPHYSICS, FGG, provide high quality ground geophysical data acquisition, processing and interpretation services for mineral and petroleum exploration, for geological mapping and for environmental and engineering investigations.

We work for government and private sector clients throughout the world, from offices in Perth, Sydney and Lima, Peru. We are a member of the Fugro worldwide group, and utilise this extensive network to allow us to work efficiently and competitively across the globe.

FGG are experts in a full suite of high resolution geophysical techniques including;

GPS gravity	GPS magnetics
TEM	FEM
Induced Polarisation	Resistivity
MMR/MIP	CSAMT
NMR	Shallow Seismic
Radiometrics	

GEOIMAGE PTY LTD STAND 93

PO Box 789
INDOOROOPILLY QLD 4068 Australia
Tel: (07) 3871 0088
Fax: (07) 3871 0042
Email: sylvia@geoimage.com.au
Contact Person: Sylvia Michael

Geoimage Pty Ltd is a privately owned Australian remote sensing company specializing in general image processing, the production and sales of satellite and geophysical imagery, and spatial analysis and interpretation of remotely sensed imagery.

Founded in Brisbane in 1988, our Australian and overseas client base spans a number of industry sectors, including mineral exploration, petroleum and oil, land management/ environmental, primary production, and spatial information.

LIST *of* EXHIBITORS

Geoimage has been the leading Australian satellite remote sensing data supplier since 1990 and are a value added reseller for a number of the earth observation satellite operators with access to both Australian and overseas archives.

GEOPRO STAND 77

MOI, 4th floor France Center
Victoria Ave Quatre Bornes
MAURITIUS
Tel: 230 427 4428
Fax: 49 40 303 99578
Email: jleven@intnet.mu
Contact Person: Jim Leven

GeoPro GmbH, with the head office located in Hamburg, Germany, is an international operating exploration service company which since late 1994 has offered a variety of geophysical services to the oil industry and government institutions. It employs an experienced staff of 12 geophysicists and instrument engineers supported by up to 30 qualified field technicians.

Beside other geophysical technology including potential field methods, with regard to seismic technology, GeoPro GmbH is a leader in WARRP technology (Wide Angle Reflection and Refraction Profiling) with a record of 2D and 3D projects both on- and offshore. Dedicated tomography and migration workflows for the full evaluation of WARPP data have been developed by our company.

GEOSCIENCE ASSOCIATES AUSTRALIA STAND 26

PO Box 697
MOUNT BARKER SA 5251 Australia
Tel: (08) 8391 2865
Fax: (08) 8398 2411
Email: dennis@geoscience.biz
Contact Person: Dennis Stevens

Geoscience Associates Australia is a wire line service company that has been operating in Australia since 1972. We are proud to be celebrating our 30th year in 2003. GAA operates a fleet of wire line logging vehicles based out of Mt Barker South Australia and Blackwater Central Queensland. These API calibrated units are equipped to handle all types of geological and engineering applications. Whilst most of the work involves coal, coal bed methane, oil, uranium, mining, exploration work and environmental applications, we are more than equipped to handle a variety of other mineral work. We offer a complete range of down-hole probes, which include a variety of surveys such as multi spaced density, Natural gamma, Neutron, electric logs (both a range of resistivity and induction logs) as well acoustic logs (full wave form sonic and 360 degree acoustic scan). Geoscience also offers both magnetic and gyroscopic deviation analysis of the borehole. Other surveys are also available with new cutting edge technology being continually addressed and implemented. All of these surveys can be passed on to third parties for further analysis or worked up in house by our geophysicists on staff, using our WellCAD computer capabilities.

For all of your down-hole needs, see us, because at Geoscience we are always "Probing the Depths".

GEOSCIENCE AUSTRALIA STAND 9

GPO Box 378
CANBERRA ACT 2601 Australia
Tel: (02) 6249 9263
Fax: (02) 6249 9990
Email: ian.hone@ga.gov.au
Contact Person: Ian Hone

Geoscience Australia is Australia's national geoscience research and spatial information agency.

Our research and information contribute to enhanced economic, social and environmental benefits to the community - by providing input for decisions that impact upon resource use, management of the environment, and the safety and wellbeing of Australians.

Our range of products includes:

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

A number of our products are now available free online or for the marginal cost of transfer as a result of the Commonwealth Government's policy to maximise the accessibility of spatial data to the community.

For more information:
PO Box 378 Canberra ACT 2601 Australia
Tel: (02) 6249 9966
Fax: (02) 6201 9982
Freecall: 1800 800 173
Email: mapsales@ga.gov.au
Website: www.ga.gov

GEOSOFT AUSTRALIA PTY LTD STAND 28 & 29

Hay Street
SUBIACO WA 6008 Australia
Tel: (08) 9214 3905
Fax: (08) 9322 8133
Email: info.au@geosoft.com
Contact Person: Levin Lee

"Geosoft is a software and services company that serves the international earth science community through a growing worldwide network of offices, distributors and strategic partners. The company is known as a global leader in developing solutions for geoscience applications, including many advanced technologies for storing, manipulating and visualizing large-volume spatial data. This proven reputation reflects a commitment to delivering consistent software value, and maintaining a high level of personalized technical expertise and support.

Geosoft addresses client needs with one-stop software and service solutions based on Oasis montajT - a powerful interface for working with spatial data.

Solutions can be tailored to deliver the products, custom development, systems integration and services that satisfy the business and technical requirements of each customer."

GNS NEW ZEALAND STAND 69

Gracefield Research Centre
41 Bell Rd South, PO Box 30368
LOWER HUTT New Zealand
Tel: 0015 64 4570 4892
Fax: 0015 64 4570 4603
Contact Person: Chris McKeown

GNS is New Zealand's primary geological science organisation, with over 260 staff. Our hydrocarbon exploration consulting group combines a long established reputation in geoscience research with industry standard software and highly experienced professionals.

We have an international reputation in providing best in class outcrop analogue studies, databases of sedimentary basins and non-exclusive reports relating to New Zealand's oil and gas prospects.

Our multi-disciplinary teams are experts in reservoir sedimentology, biostratigraphy, organic geochemistry, basin modelling, seismic processing and seismic interpretation. We provide innovative technical and software solutions for exploration and development problems throughout the Asia Pacific Region.

GPX GEOPHYSICAL EXPLORATION SERVICES STAND 97 & 98

Locked Bag 3
APPLECROSS WA 6153 Australia
Tel: (08) 9316 8033
Fax: (08) 9316 8111
Email: gpx@gpx.com.au
Contact Person: Ron Creagh

GPX Services Pty Ltd was formed in late 1997 after a management buyout of World Geoscience Ground Geophysical Division. In January 2002 GPX Airborne began operations to commercialise Newmont's Helicopter EM "Hoistem" system and provide Fixed Wing and Helicopter Magnetics and Radiometrics to the mining and environmental industries. Both companies now offer ground and airborne geophysics worldwide.

GRANT GEOPHYSICAL INC. STAND 11

4/67 Robinson Rd East
VIRGINIA QLD 4014 Australia
Tel: (07) 3285 5830
Fax: (07) 3889 2127
Email: greg.dunlop@grantgeo.com
Contact Person: Greg Dunlop

Grant Geophysical is an independent energy service company providing specialized land, shallow marine, OBC and transition zone seismic acquisition services to the petroleum and mining industries worldwide. Grant has over 70 years experience of providing quality data to our clients and has developed unique expertise operating in the most challenging environments.

Grant utilizes the latest technology available in the marketplace, tailored to exceed client's demands and supplemented with customized proprietary vessels and equipment. Grant actively researches and implements emerging technologies with conventional 2D and 3D operations as well as multi-components and 4D seismic, providing our clients with complete seismic solutions.

HAINES SURVEYS STAND 105

PO Box 196
ALDGATE SA 5156 Australia
Tel: (08) 8370 8779
Fax: (08) 8370 8758
Email: hainsurv@ozemail.com.au
Contact Person: Graeme Haines

Haines Surveys are specialists in the acquisition of high quality gravity data using the latest state-of-the-art Trimble GPS Receivers and Scintrex CG-3 Gravity Meters. They have offices in Adelaide and Perth to provide a cost effective service Australia wide. The company has been operating since 1991 and was one of the first companies to introduce high accuracy GPS surveying to the industry. Haines Surveys have completed gravity projects in all parts of Australia and several regions overseas including North America, Europe, Scandinavia, South East Asia and Africa. Their clients are provided with a highly professional, reliable and economical service through the use of experienced staff, in house developed processing software, and the latest field equipment.

HALLIBURTON ENERGY SERVICES STAND 118-120

Halliburton Landmark
Capital Centre, Level 2, 256 St Georges Tce
PERTH WA 6000 Australia
Tel: (08) 92784405
Fax: (08) 9278 4400
Email: leanne.walker@halliburton.com
Contact Person: Leanne Walker

Leading the world in Integrated Energy Services, Engineering, Construction and Maintenance.

The Energy Services Group (ESG) is the real-time, knowledge company serving upstream oil and gas industry. The Group offers the broadest array of products and services through Real Time Operations (RTO), stretching from the design and manufacturing of drill bits and a wide variety of downhole and completion tools and pressure pumping services as well as subsea engineering and project management.

ESG consists of Halliburton Energy Services, Landmark Graphics Corporation, Wellstream, Subsea 7 and Integrated Projects. Real Time Reservoir Solutions (RTRS) is the Group's most advanced form of value creation, uniting different elements of information technology to enable fast, high-quality decisions about reservoir development. Real Time Reservoir Solutions is unifying concept behind many technological developments and a new way of think about the energy services business.

Halliburton Energy Services (HES) provides products, services and integrated solutions for oil and gas exploration, development and production. The HES products and service lines including drilling services, drill bits, drilling fluids, logging and perforating, cementing tools, testing and tubing conveyed perforating, stimulation, well completions, sand control, reservoir description and integrated solutions.

Landmark Graphics Corporation. Landmark is the leading supplier of integrated E&P technical and economic software and services to support decision making about finding, drilling and producing oil and gas. Knowledge-based E&P companies now are turning to Landmark for T2B technical-to-business process integration for improving returns on their investments. Visit the Landmark Web Site at www.lgc.com.

Founded in 1919, Halliburton Company is a diversified energy services, engineering, energy equipment, construction and maintenance company. The company's World Wide Web Site can be accessed at www.halliburton.com.

HYVISTA CORPORATION STAND 103

PO Box 437
BAULKAM HILLS NSW 2131 Australia
Tel: (02) 9878 0977
Fax: (02) 9878 3615
Email: tdc@hyvista.com
Contact Person: Terry Cocks

HyVista Corporation Pty Ltd was founded in 1999 and is a privately owned Australian company with headquaters in Sydney, Australia and a branch office in Johannesburg, South Africa.

The company specializes in the supply of airborne hyperspectral remote sensing data and information products for a wide range of applications covering earth resource mapping, environmental monitoring, agriculture, urban mapping and many research development projects such as simulating future hyperspectral satellites, defense surveillance, soil degredation and species habitat mapping.

HyVista Corporation's mission is to bring an end to end service to customers requiring airborne hyperspectral surveys and to conduct such surveys on a worldwide basis.

To date the company has provided survey services in every continent around the world including 23 countries from Austria to Zimbabwe.

Hyperspectral remote sensing is a relatively new, but extremely powerful technology. The current high level of commercial interest in the remote sensing technique is a result in no small part to the activities of HyVista Corporation which has, for the first time, made high quality hyperspectral data and information products widely available on a commercial basis.

HyVista Corporation's clients enjoy the best service and data quality commercially available. This world class level of product begins with the the world's highest performance hyperspectral sensor, a HyMap™ airborne hyperspectral scanner. HyMap™ is a 126 band sensor which provides a combination of spatial resolution, spectral coverage, signal to noise ratio and image quality that is the best on the market.

HyVista Corporation is committed to an on-going development program aimed at providing an ever improving service to its customers.

INTREPID GEOPHYSICS STAND 106

Unit 2, 1 Male Street
BRIGHTON VIC 3186 Australia
Tel: (03) 9593 1077
Fax: (03) 9592 4142
Email: phil@dfa.com.au
Contact Person: Philip McInerney

Intrepid Geophysics provides specialist services in advanced processing and interpretation of magnetics, gravity and 256-ch radiometrics. The Intrepid software is a complete geophysical data processing and interpretation solution, which continues to be a leader in innovation in geophysical data analysis and management. Recent innovations include:

- Radiometrics - implementation of NASVD and MNF for advanced statistical noise reduction in 256-ch data
- Automatic Depth Methods - further improvement of Naudy depths (line data) and implementation of the Extended Euler for improved depths (grid data)
- Spectral Filtering - re-write of GridFFT, specifically to filter very large grid files
- JetStream - web data management and distribution (OPeNDAP technology).

LSI LOGIC STORAGE SYSTEMS STAND 56 & 57

20405 State HWY 249 - SUITE 450
HOUSTON TEXAS 77070 USA
Tel: 281 379 7800 / 970 206 5883
Fax: 970 206 5150
Email: energy@lsilogicstorage.com or
mike.tenhulzen@lsil.com
Contact Person: Mike Tenhulzen

LSI Logic Storage Systems develops and manufactures storage systems that make seismic and other subsurface and surface data more available to E&P asset teams. As a result, these teams utilize earth knowledge more effectively to find and exploit reservoirs. A core competency of E&P organizations is mixing data and people in ways that most quickly produce the best earth knowledge. LSI Logic Storage Systems makes a crucial difference by developing specialized storage systems focused on the performance requirements of exploration and analysis. Dig deep. Explore how solutions from LSI Logic Storage Systems can improve E&P strategies and operations while making E&P professionals more productive. Enable your organization to more effectively exploit its assets in the ground.

MINERALS AND PETROLEUM VICTORIA STAND 75

PO Box 500
EAST MELBOURNE VIC 3002 Australia
Tel: (03) 9412 5077
Fax: (03) 9412 5155
Email: paul.a.mcdonald@nre.vic.gov.au
Contact Person: Paul McDonald

Minerals and Petroleum Victoria (MPV) is responsible for promoting and regulating the Victorian oil and gas, extractive and mineral exploration and mining industries. MPV specifically facilitates the development of these industries in Victoria.

Statewide pre-competitive geoscientific products are provided from a program that combines new geological data collection with MPV maintained historical 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 provided by MPV 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.

MIRA GEOSCIENCE STAND 121

27 Hazelton Street
RIVERHILLS QLD 4074 Australia
Tel: (07) 3715 8987
Fax: (07) 3366 8030
Email: glennp@mirageoscience.com
Contact Person: Glenn Pears

Mira Geoscience Limited offers software products and services centred around "Gocad" earth modelling software. Gocad is available commercially to the global mining industry exclusively through Mira Geoscience. The Gocad software suite offers the most advanced earth modelling technology available today in the domains of general 3D geological modelling, 3D visualisation, geophysical forward modelling and inversion, geostatistics, risk modelling and uncertainty analysis. 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 based on its software products.

MUTLTIWAVE GEOPHYSICAL COMPANY - MGC STAND 83

#31-06A The Concourse 300 Beach Road
SINGAPORE 199555 SINGAPORE
Tel: +65 6396 5070
Fax: +65 6396 5069
Email: rselvam@sfe.com.sg
Contact Person: Ramoo Selvam

A Worldwide marine seismic data-acquisition and geophysical support provider offering following services:

- Towed Streamer 2D, 3D and 4D Seismic
- Seabed 4C Cables, 2D, 3D and 4D Seismic
- Seabed Electromagnetic Geo-services (SBL)

MGC is a global, specialized and client focused upstream service company. Located with its Headquarter in Bergen, Norway, MGC is at all time prepared to meet the challenges found in the E&P upstream business.

Please contact us:

Multiwave Geophysical Company ASA
Damsgårdsveien 131, N-5162 BERGEN, NORWAY
Tel: +47-55947750
Email: mgc@mgc.no
Website: www.mgc.no

NCPGG - UNIVERSITY OF ADELAIDE STAND 65

The University of Adelaide
ADELAIDE SA 5005 Australia
Tel: (08) 8303 4311
Fax: (08) 8303 4345
Email: msutton@ncpgg.adelaide.edu.au
Contact Person: Maureen Sutton

The NCPGG is Australia's only postgraduate school dedicated to petroleum geology and geophysics and is a partner in the Australian Petroleum Cooperative Research Centre. This Federal funding, together with industry project sponsorship, supports its activities. The NCPGG also receives funding from the State of South Australia in the form of a State Chair and as scholarships. Preparation of students for careers in the oil and gas industry remains the most important role for the NCPGG as well as providing leading-edge technology in Petroleum Geoscience to Industry, Government and Academia. This technology is focused through education, research, training and technical services.

NORTHERN TERRITORY GEOLOGICAL SURVEY STAND 80

Centrepoint Building Smith St Mall
DARWIN NT 0800
Tel: (08) 8999 5389
Fax: (08) 8999 6824
Email: richard.brescianini@nt.gov.au
Contact Person: Richard Brescianini

The role of the Northern Territory Geological Survey is to collect, interpret, synthesise and disseminate geoscientific data to attract and render more effective mineral and on-shore petroleum exploration, and also to provide geoscientific advice in the formulation of resource policies. It proactively undertakes regional geoscience programs, mineral resource assessments, metalliferous deposit and petroleum system studies, exploration reviews and airborne geophysical surveys.

NEW SOUTH WALES DEPARTMENT OF MINERAL RESOURCES STAND 92

PO Box 536
29-57 Christie St
ST LEONARDS NSW 2065 AUSTRALIA
Tel: (02) 9901 8342
Fax: (02) 9901 8256
Email: robsond@minerals.nsw.gov.au
Contact Person: David Robson

During 2002, the NSW Department of Mineral Resources released new geology maps and geoscience packages based on geophysical data, field mapping and past exploration, over the Goulburn, Cargelligo, Broken Hill, Southern Peel, Koonenberry, Surat Basin and Clarence-Moreton Basin. New geophysical data were released over the mineral and gemstone prospective Inverell region and over the petroleum prospective Oaklands Basin. Currently, a Falcon™ airborne gravity gradiometry survey is being acquired over the Broken Hill area, an airborne magnetic and radiometric survey is underway in the Balranald / Hay area, and a seismic survey is planned in the Wilcannia area within the petroleum prospective Darling Basin.

OMNISTAR PTY LTD STAND 59

PO Box 329
WEST PERTH WA 6872 Australia
Tel: (08) 9322 5295
Fax: (08) 9322 4164
Email: k.felsner@fugro.com.au
Contact Person: Karen Felsner

Satellite positioning and associated services represent a core business activity for the Fugro Group and OmniSTAR is currently the world's leading commerical provider of DGPS services.

OmniSTAR is a reliable DGPS positioning service for land and air applications. Characterised by the portability of its receiving equipment, suitable for vehicle mounting or "backpack" use, OmniSTAR offers superior geographical coverage compared with competing systems.

OmniSTAR operates a number of DGPS augmentation services including a High Performance service, OmniSTAR-HP, designed for mineral exploration and resource mapping.

Also new to the market is the Asset Management service, OmniSTAR-AM. OmniSTAR-AM enables businesses to position, monitor, track, and aids in recovery of both fixed and mobile assets, all in real time.

PETREL STAND 46-49

Ground Floor, 2 Brook Street
EAST PERTH WA 6005 Australia
Tel: (08) 9325 8600
Fax: (08) 9325 8655
Email: laura.dew@petrelworkflow.com
Contact Person: Brett Farquhar

Asset Teams & Integration of disciplines has been a buzzword in the oil and gas industry for more than 10 years now, but most oil and gas companies are still working as if there were different disciplines. The E&P technology used today is often based on ideas and technology from the 80ties long before anybody talked about Asset Teams and integration.

Petrel has over the last 4-5 years developed a fully integrated solution for subsurface modeling. The Petrel Workflow Solution is a well-structured way of introducing a new and tailor made workflow into your organization. Together we analyze your organization and optimize your workflow. Our structured training and implementation program will make sure that you get maximum benefits from your investment.

PETROSYS STAND 84 & 87

69 Fullarton Rd
KENT TOWN SA 5067
Tel: (08) 8431 8022
Fax: (08) 8431 8010
Email: vhjm@petrosys.com.au
Contact Person: Volker Hirsinger

Petrosys are the developers of the best open mapping framework for the petroleum exploration and production industry, now in use at over 110 sites around the World.

The Petrosys mapping and data integration system ties well, seismic, production and spatial information on a map base, providing both a high level of cartographic and presentation quality as well as a streamlined workflow targeted for effective use by professional E&P staff.

Petrosys software runs on all mainstream computing platforms and ties in to most of the more specialised tools used by the petroleum industry for geological and geophysical interpretation and for reservoir and related engineering tasks.

PGS ASIA PACIFIC STAND 96 & 99

Level 4, IBM Building
1060 Hay St
WEST PERTH WA 6005 Australia
Tel: (08) 9320 9000
Fax: (08) 9320 9010
Email: nick.david@pgs.com
Contact Person: Nick David

OUR MISSION

PGS is committed to providing the oil and gas industry with innovative technology and efficient solutions.

OUR COMPANY

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.

OUR STRENGTH

The unique combination of reservoir expertise, leading edge geophysical operations and technology, with significant production expertise and production operations, enables PGS to deliver the solutions required to efficiently find, develop and produce hydrocarbons anywhere in the world.

PHOENIX GEOPHYSICS LIMITED STAND 12

3781 Victoria Park Ave, Unit 3
SCARBOROUGH ONTARIO CANADA
Tel: +416 491 7340
Fax: +416 491 7378
Email: mail@phoenix-geophysics.com
Contact Person: Leo Fox

Phoenix Geophysics is a high-tech Canadian manufacturer of world-class geophysical instruments and an experienced geophysical survey contractor. Phoenix products have been used in more than 70 countries on six continents over the past quarter century and serve an ever-expanding international clientele of academic institutions, government agencies, consultants and resource exploration companies. Combining extensive engineering knowledge and real-world experience, Phoenix provides a complete electroprospecting and magnetotellurics exploration strategy.

Phoenix electromagnetic equipment is used for hydrocarbon, mineral, geothermal, diamond, and groundwater exploration; geological engineering; and hazardous waste delineation, dam site and geothermal monitoring, earthquake research and deep crustal geological studies.

The personnel of Phoenix Geophysics have been leaders in the application of geophysical electrical methods since shortly after World War II. Phoenix engineers and geophysicists pioneered ground and airborne electromagnetic techniques, induced polarization methods, and natural-field electromagnetic measurements.

Today, Phoenix is the world's largest instrument manufacturer for Magnetotelluric (MT), AudioMagnetotelluric (AMT) and Induced Polarization (IP) techniques. Our multifunctional equipment also includes capabilities for all-digital Controlled Source AMT (CSAMT), Time Domain Electromagnetics (TDEM), Frequency Domain Electromagnetics (FDEM), and Resistivity.

PIRSA/THE MINERAL RESOURCES GROUP STAND 20 & 21

GPO Box1671
ADELAIDE SA 5000
Tel: (08) 8463 3037
Fax: (08) 8226 3177
Email: abbott.peta@saugov.sa.gov.au
Contact Person: Peta Abbot

The Mineral Resources Group is a key group for facilitating mineral exploration and development, and is focused on increasing the prosperity of South Australians by ensuring responsible development of South Australia's mineral 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.

PITT RESEARCH PTY LTD STAND 51

PO Box 485
TORRENSVILLE SA 5031 Australia
Tel: (08) 8152 0422
Fax: (08) 8152 0433
Email: mjd@pitt.com.au
Contact Person: Mark Deuter

Pitt Research Pty Ltd has been providing leading-edge airborne geophysical data processing services to the Australian mineral and oil exploration industries for the last 22 years. The company specialises in processing airborne magnetic, radiometric, and DTM data, as well as airborne EM and ground-based gravity and IP datasets.

Pitt Research has pioneered the development of a number of data processing techniques and presentations, including micro-levelling, colour imaging, regional grid compilations, radiometric noise reduction and high-quality mapping. It is now involved in promoting several exciting new interpretative tools, including the Overburden FilterTM and Spectral Depth analysis.

With a new global focus based on high-speed transfer of data via the Internet, Pitt Research is able to provide high-quality services to exploration companies anywhere in the world.

PROFESSIONAL INVESTMENT SERVICES PTY LTD STAND 54

8 Stringtbark Drive
ASPLET QLD 4034 Australia
Tel: (07) 3263 3568
Fax: (07) 3263 9652
Email: nmoriart@bigpond.net.au
Website: www.profinvest.com.au/noll
Contact Person: Noll Moriarty

Professional Investment Services is an independently owned and one of Australia's largest financial planning groups. The management, directors and shareholders provide a wealth of experience, accumulated over many years in the accounting and financial planning areas.

Noll Moriarty, an Authorised Representative of the company, conducts an extremely thorough analysis of people's financial status, needs and objectives. A detailed Plan is based on the best analytical elements of the resource and financial industries.

He has clients throughout Australia and specialises in:

- Wealth Creation Strategies
- Superannuation & Rollovers
- Stock broking Facilities
- Tax Planning Strategies
- Personal Insurance Broker
- Retirement Planning
- Mortgage Broking & Finance
- Salary Packaging

RACKSAVER, INC. STAND 22

9449 Carroll Park Drive
SAN DIEGO CA 92121 USA
Tel: +858 874 3800
Fax: +858 874 3838
Email: jimmy@racksaver.com or sales@racksaver.com
Website: www.racksaver.com
Contact Person: Jimmy Perry

RackSaver, Inc. is a world-class provider of high-density, rack-optimized, servers and supercomputing clusters for high performance seismic data processing. RackSaver's largest customer base is in the oil and gas industry. An example of RackSaver's success has been providing Veritas DGC's Houston data center with over 6000 compute nodes used to process seismic data. Veritas DGC has the latest RackSaver high-density Linux clusters in their Houston, Singapore, Calgary, and London data processing centers. RackSaver has supplied other oil and gas customers with seismic data processing clusters including Shell, WesternGeco, ADS, Conoco, PGS, TGS Nopec, and Staag Imaging to name a few.

SANTOS LTD STAND 94 & 95

91 King William St
ADELAIDE SA 5000
Tel: (08) 8224 7952
Fax: (08) 8224 7258
Email: John.Hughes@santos.com
Contact Person: John Hughes

Santos Ltd, a major Australian energy company is pleased to be the Platinum Sponsor of the 16th ASEG Conference and Exhibition. The Company has interests in every major Australian petroleum province, and interests in South-East Asia and the United States. Geophysics is a significant contributor to the success of the petroleum exploration and production industry and Santos considers it important to support events such as these which promote the innovative use of geophysical methods.

SCHLUMBERGER WESTERNGECO STAND 114-117

Level 5, 256 St Georges Tce
PERTH WA 6000 Australia
Tel: (08) 9420 4852
Fax: (08) 08 9322 3080
Email: kmoore@perth.oilfield.slb.com
Contact Person: Katrina Moore

Schlumberger Oilfield Services, a business segment of Schlumberger Limited [NYSE:SLB], is the leading supplier of services and technology to the international petroleum industry and operates offices, service locations, amd research and development facilities around the world. WesternGeco, the world's largest seismic company, provides comprehensive worldwide reservoir imaging, monitoring, and development services, with the most extensive seismic crews and data processing centres in the industry, as well as the world's largest multiclient seismic library. Services range from 3D and time-lapse (4D) seismic surveys to multicomponent surveys for delineating prospects and reservoir management.

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828 Pacific Highway
GORDON NSW 2072 Australia
Tel: (02) 9498 0498
Fax: (02) 9418 2023
Email: megan.barrelle@sun.com
Contact Person: Megan Barrelle

Since its inception in 1982, a singular vision - The Network Is The Computer[tm] - has propelled Sun Microsystems, Inc. (Nasdaq:SUNW) to its position as a leading provider of industrial-strength hardware, software and services that make the Net work. Sun can be found in more than 170 countries and on the World Wide Web at http://www.sun.com.au.

SYSTEM DEVELOPMENT INC STAND 81

10500 Westoffice Dr. #100
HOUSTON TEXAS 77042 USA
Tel: +1 713 266 5667
Fax: +1 713 974 4911
Email: ndaly@sdicgm.com or sales@sdicgm.com
Website: www.sdicgm.com
Contact Person: Noel Daly

SDI 'Computer Graphics Metaware'

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TENIX LADS CORPORATION PTY LTD STAND 53

Second Avenue Technology Park
MAWSON LAKES SA 5095 Australia
Tel: (08) 8300 4447
Fax: (08) 8349 7588
Contact Person: Rhys Barker

The Laser Airborne Depth Sounder (LADS) is the worlds fastest and most cost-effective tool for accurate bathymetric survey in shallow, complex waters, coastal zones and reef areas. Tenix LADS Corporation provides contract survey services utilising its LADS MkII system. This unique service covers the full range of survey activities from survey planning, deployment, data collection, data processing, survey reporting and also includes comprehensive logistics and engineering support to meet specific customer requirements.

In operation since August 1998 the exclusive LADS MkII system which mounted in our de Havilland Dash 8-202 aircraft is fully owned and operated by Tenix LADS Corporation. Since August 1998 LADS MkII has executed survey contracts for several Governments, Hydrographic agencies and Oil & Gas companies.

Tenix LADS Corporation has surveyed approximately 3500km2 on the NorthWest Shelf of Western Australia. The high density and high quality bathymetry has been used to enable the safe navigation of seismic vessels in the shallow hazardous waters. LADS data in the coastal zone has also been used to assist pipeline construction.

TOTAL DEPTH PTY LTD STAND 17

21 Churchill Ave
SUBIACO WA 6008 Australia
Tel: (08) 9382 4307
Fax: (08) 9382 4308
Email: jim@td.iinet.net.au
Contact Person: Jim Dirstein

Total Depth has provided geophysical consulting services in Australia since 1993. Our objective is to help our clients find innovative solutions and suitable workflows that can be applied to their exploration and exploitation challenges. Typically, we work closely with our client to create tailored workflows that are adapted to address the problem at hand. Moreover, the application of these hybrid and/or parallel workflows helps to address some of the non-uniqueness elements of the solutions and better discriminate between potential success and failure. Total Depth clients include companies involved with Petroleum/Minerals Exploration/Production, Research and Software Development. We firmly believe that the development and continued nurturing of close relationships with these types of companies will enable us to contribute to cost-effective and innovative solutions that can help all of our businesses grow.

UTS GEOPHYSICS STAND 101 & 102

Fauntelroy Ave
PERTH AIRPORT WA 6104 Australia
Tel: (08) 9479 4232
Fax: (08) 9479 7361
Email: david_abbott@uts.com.au
Contact Person: David Abbott

UTS are world leaders in the acquisition of ultra-high detailed magnetic, radiometric and digital terrain model data through the use of specialised low level fixed-wing survey aircraft. They are also pioneers of the stinger mounted helicopter survey system - ideal for high resolution, low level acquisition in rugged and mountainous terrains.

UTS was formed in Perth, Western Australia in 1992. High quality data as well as accurate GPS positioning are achieved by combining the latest available technology with in-house acquisition systems.

Today the company boasts an enviable track record, having successfully acquired and processed more than two million line kilometres of airborne data for government bodies, exploration companies and consultants both in Australia and internationally.

VELSEIS PTY LTD STAND 90 & 91

PO Box 118
SUMNER PARK QLD 4074 Australia
Tel: (07) 3376 5544
Fax: (07) 3376 6939
Email: mreveleigh@velseis.com.au
Contact Person: Mike Reveleigh

Velseis Pty Ltd is an Australian seismic exploration company providing a fully integrated range of seismic technologies. Velseis has built a reputation as the leading Australian contractor in this field, with over 25 years of experience throughout the Asia-Pacific Region. The company provides contracting services for coal, mineral and hydrocarbon exploration utilising Dynamite, Mini-SOSIE, Vibroseis and Airgun techniques.

Services available include survey design, drilling, data acquisition (3D, 2D, and multi-component), data processing and interpretation. Velseis takes pride in its ability to configure a specialised acquisition service to suit almost any situation. The company provides conventional 3D, 2D, heli-portable, and shallow-marine recording services.

VERITAS DGC ASIA PACIFIC LTD STAND 108-113

38 Ord St
WEST PERTH WA 6005 Australia
Tel: (08) 214 6200
Fax: (08) 9214 6260
Email: Wendy_Mobley@vdgc.com.sg
Contact Person: Wendy Mobley

At Veritas, our mission is to acquire, process and sell seismic data to the oil and gas industry. Defining who we are takes much more than simply stating what we do. Supporting our corporate mission is a vision shared by Veritas employees around the globe - a vision that continues to differentiate our company from its competitors and shape our role as a leader in providing seismic services. Veritas is a process-driven organisation with a focus on you, our customer.

Veritas' headquarters is based in Houston, Texas, Veritas operates 6 marine vessels, which acquire both 2D and 3D seismic data, up to 46,000 recording channels for land/transition zone seismic data acquisition, and 14 data processing centres worldwide, all spread over six continents. The Company's library of non-exclusive seismic data - data available for license to multiple clients on a non-exclusive basis - now exceeds three million line kilometres, one of the largest in the industry.

We offer the petroleum industry 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. The 3500 people of Veritas comprise one of the most experienced teams of energy explorationists in the industry. Our people 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.

As energy companies look for new ways to lower their costs and risks associated with energy exploration, our customers are seeking strong, reliable partners capable of providing innovative solutions to meet their needs and solve challenging problems. Today, through our advanced technologies and in-depth understanding of the markets we serve, we are becoming a strategic partner with our customers by providing them with more information at faster speeds. The information we provide allows them to make more informed decisions about where to drill for oil and gas.

To facilitate these partnerships, Veritas now offers a complete range of advanced data interpretation and analysis skills designed to turn geophysical data into knowledge that our customers can use. Our team of geophysicists, geologists, petrophysicists and engineers integrate expert interpretations of seismic data, well logs and core descriptions with high-resolution reservoir descriptions and simulations to provide customers with a degree of information previously unavailable from a single source. The future holds tremendous opportunity for us to extract even more information from geophysical data to assist reservoir engineers in optimising the development and production of their reserves.

With more than 36 years of operating experience in seismic data acquisition, processing, interpretation and data sales, we have achieved a reputation for responsiveness, quality and performance. One of our fastest-growing services is data library survey, which is developed, acquired, processed and licensed to multiple clients on a non-exclusive basis. Veritas has one of the largest seismic data libraries in the industry today.

We also provide comprehensive exploration and development information services to oil and gas companies. These services include data management, positional accuracy verification, mapping services, software products, data visualisation and a GIS on line.

Veritas is a company that aggressively pursues innovative new technologies through ongoing research and development efforts, both internally and externally. As the search for hydrocarbons intensifies throughout the world, Veritas is well positioned to provide oil companies with the geophysical solutions they need for success. The continued growth of Veritas will be achieved by adhering to our core strategy of providing customers with greater value through quality products and services, based on the Company's stated promise "*to deliver and do what we say*".

ZONGE ENGINEERING & RESEARCH ORGANISING PTY LTD STAND 18 & 19

98 Frederick St
WELLAND SA 5001 Australia
Tel: (08) 8340 4308
Fax: (08) 8340 4309
Email: zonge@ozemail.com.au
Contact Person: Kelly Keates

Zonge Engineering and Research Organization is a recognised leader and innovator in the development of electromagnetic and induced polarization survey technology. We have been providing field services for mining, petroleum, and environmental investigations for 25 years worldwide. Our survey techniques can be used to characterise landfills and dumps, map plumes or perched aquifers, locate tanks and buried debris, track groundwater, track contaminants and spills for environmental clean-up. Field experience, gained worldwide, together with a skilled technical staff enables us to provide an efficient and professional service, including survey design, data collection, data processing and analysis, and interpretation for a broad spectrum of geophysical applications. We are constantly supporting our field services by developing our equipment and software to meet demand.

Preview

Section 3

ASEG 2003
GROWTH THROUGH INNOVATION

ASEG's 16th International Conference and Exhibition

Welcome to ASEG's 16th International Conference and Exhibition, particularly our overseas visitors. This meeting makes a major contribution to Australia's resource industries by providing a showcase of 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 2001/2002 for example we earned $54.7 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 orebodies and petroleum reservoirs are developed, we need more sophisticated methods to find the prizes hidden beneath the regolith or under the deep offshore areas of our continent. These are the challenges facing the exploration geophysicist.

The technical presentations at this conference, and the services and products on display at the exhibition exemplify the range and skills available in Australia. A quick look through the abstracts of the papers to be given, and the biographies of the presenters, shows the scope and depth of talent. We are indeed very fortunate to have these researchers here in Australia, and we must be vigilant to ensure that the higher educational institutions continue to be available to maintain our teaching and research facilities.

The geosciences have been given a boost in the research front with ***Developing Deep Earth Resources*** being identified as a priority goal (see Eristicus's contribution on page 40) within the Commonwealth Government's National Research Priorities. However, we all 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 will be threatened.

The conference organisers have recognized this issue, and as part of the broader promotion of geophysics the now-traditional high school student day is being complemented by a day for undergraduate students from South Australia and 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 Adelaide, 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 has any ideas, or can identify someone else who has, please let me know.

Enjoy Adelaide, and have a rewarding conference.

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

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

Contributions

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

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

References

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

Blackburn, G. J., 1981, Seismic static corrections in irregular or steeply dipping water-bottom environments: 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 the publisher, RESolutions Resource and Energy Services, (see details elsewhere in this issue) for advertising rates and information. The ASEG reserves the right to reject advertising, which is not in keeping with its publication standards.

Advertising copy deadline is the 22nd of the month prior to issue date. Therefore, the advertising copy deadline for the April 2003 issue will be 15 March 2003. A summary of the deadlines is shown below:

Preview Issue	Text & articles	Advertisements
103 Apr 2003	15 Mar 2003	22 Mar 2003
104 Jun 2003	15 May 2003	22 May 2003
105 Aug 2003	15 Jul 2003	22 Jul 2003
106 Oct 2003	15 Sep 2003	22 Sep 2003

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2003

March 31-April 11
ASEG/NGTN/VIEPS Geophysical Field Camp and Software Workshop
Hosted by: Monash University, Clayton, Victoria
Contact: Graeme Beardsmore
Tel: (03) 9905 4888
Email: gbeards@mail.earth.monash.edu.au
Website: http://www.earth.monash.edu.au/research/geophysics/courses/GWF+GSW.html

April 6-10
Symposium on the Application of Geophysics to Environmental and Engineering Problems (SAGEEP), San Antonio, Texas, US
Organised by: Environmental and Engineering Geophysical Society
Website http://www.eegs.org

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

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

June 16-18
Symposium on Extreme Petroleum Operations
Hosted by: Curtin University's Department of Petroleum Engineering, the Centre of Excellence in Petroleum Geology and the WA Petroleum Research Centre
Venue: Sheraton Hotel, Perth
Contact: Jenny Dyer: motive@vianet.net.au

August 31-September 4
EAGE/SEG Summer Research Workshop, Trieste
Theme: The role of velocity models in seismic processing and imaging
Website: www.eage.nl

September 1-4
EAGE Workshop on Fault and Top Seals: What do we know and where do we go? La Grande Motte (France)
Website: www.eage.nl

October 6-9
1st North Africa/Mediterranean Petroleum & Geosciences Conference and Exhibition, Tunis, Tunisia
Website: www.eage.nl

October 13-15
Water in Mining 2003
Theme: The role of water in a sustainable minerals industry
Venue: The Sheraton Brisbane Hotel and Towers
Sponsor: The AusIMM; Website: www.ausimm.com
Email: Conference@ausimm.com.au

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

2004

February 8-13
Geological Society of Australia
17th Australian Geological Convention, Hobart, Tasmania
Theme: Dynamic Earth: Past, Present and Future
Website: http:www.17thagc.gsa.org.au

June 7-11
66th EAGE Conference and Exhibition, Paris, France
Website: www.eage.nl

August 14-18
Australian Society of Exploration Geophysicists
17th International Conference and Exhibition
Venue: Sydney Convention Centre, Sydney NSW
Website: www.aseg.org.au

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

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& Energy Services
Tel: (08) 9446 3039
Fax: (08) 9244 3714
Email: brian@oilfield.com.au

Editor: David Denham
7 Landsborough Street, Griffith ACT 2603
Tel: (02) 6295 3014
Email: denham@atrax.net.au

Associate Editors:
Petroleum: Mick Micenko
Email: micenko@bigpond.com

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

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

Engineering, Environmental &
Groundwater: Geoff Pettifer
Email: g.pettifer@geo-eng.com.au

ASEG Head Office & Secretariat:
Glenn Loughrey
AMCO Management Pty Ltd
PO Box 42, Everton Park Qld 4053
Tel: (07) 3855 8144
Fax: (07) 3855 8177
Email: secretary@aseg.org.au
Web site: http://www.aseg.org.au

Federal Executive 2002

President: Kevin Dodds
Tel: (08) 6436 8727
Email: kevin.dodds@csiro.au

1st Vice President: Klaas Koster
Tel: (08) 9348 5762
Email: klaas.koster@woodside.com.au

2nd Vice President: Jenny Bauer
Tel: (07) 3858 0601
Email: jenny.bauer@upstream.
originenergy.com.au

Honorary Treasurer: Robert White
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Email: lisa.vella@wmc.com

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Email: tpippett@alpha-geo.com

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Email: andrew.mutton@bigpond.com

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Kim Frankcombe
Tel: (08) 9316 2074
Email: kim@sgc.com.au

Membership Committee: Koya Suto
Tel: (07) 3858 0612
Email: koya.suto@upstream.
originenergy.com.au

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Email: stewart.greenhalgh@adelaide.edu.au

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Tel: (08) 9389 8722
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Internet Committee and Web Master:
Voya Kissitch
Tel: 0419 651 737
Email: vkissitch@falconbridge.com

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

Continuing Education and ad-hoc
Committee for Constitution:
Ray Shaw
Tel: (02) 9969 3223
Email: vanibe@bigpond.com

Committee

Helen Anderson
Tel: (08) 9366 3232
Email: opa@cygnus.uwa.edu.au

Jim Dirstein
Tel: (08) 9382 4307
Email: jim@td.iinet.net.au

Howard Golden
Tel: (08) 9479 8576
Email: howard.golden@wmc.com

David Howard
Tel: (08) 9222 3331
Email: david.howard@mpr.wa.gov.au

John McDonald
Tel: (08) 9266 7194
Email: mcdonald@geophy.curtin.edu.au

Koya Suto
Tel: (07) 3858 0612
Email: koya.suto@upstream.originenergy.
com.au

Paul Wilkes
Tel: (08) 9266 2330
Email: wilkes@geophy.curtin.edu.au

ASEG Branches

ACT
President: David Robinson
Tel: (02) 6249 9156
Email: David.Robinson@ga.gov.au

Secretary: Nick Rawlinson
Tel: (02) 6125 0339
Email: nick@rses.anu.edu.au

New South Wales
President: Stephen Webster
Tel: (02) 9858 5559
Email: swebster@sneaker.net.au

Secretary: Michael Moore
Tel: (02) 9901 8398
Email: moorem@minerals.nsw.gov.au

Northern Territory
President: Gary Humphreys
Tel (08) 8999 3618
Email: gary.humphreys@nt.gov.au

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

Queensland
President: Werner Dutler
Tel: (07) 3228 6514
Email: werner.dutler@santos.com

Secretary: Kathlene Oliver
Tel: 0411 046 104
Email: ksoliver@optusnet.com.au

South Australia
President: Andrew Shearer
Tel: (08) 8463 3045
Email: shearer.andrew@saugov.sa.gov.au

Secretary: Graham Heinson
Tel: (08) 8303 5377
Email: graham.heinson@adelaide.edu.au

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

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

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President: James Cull
Tel: (03) 9905 4898
Email: jcull@earth.monash.edu.au

Secretary: Ashley Grant
Tel: (03) 9412 5099
Email: ashley.grant@nre.vic.gov.au

Western Australia
President: Kirsty Beckett
Tel: (08) 9479 4232
Email: kirsty_beckett@uts.com.au

Secretary: Guy Holmes
Tel: (08) 9321 1788
Email: guy@encom.com.au

National Research Priorities announced by the Prime Minister

Following extensive consultation, the Federal Government has selected four ***National Research Priorities*** to focus its investment on research in key areas that can deliver significant economic, social and environmental benefits to Australia.

This is the first time that the Commonwealth has set national research priorities, an exercise aimed at building on our national research strengths while seeking new opportunities in emerging areas.

The National Research Priorities, announced by the Prime Minister on December 5th 2002, are:

- ***An Environmentally Sustainable Australia;***
- ***Promoting and Maintaining Good Health;***
- ***Frontier Technologies for Building and Transforming Australian Industries; and***
- ***Safeguarding Australia.***

Each of the themes has a number of priority goals, which are given below:

An Environmentally Sustainable Australia

Transforming the way we use our land, water, mineral and energy resources through a better understanding of environmental systems and using new technologies.

1. Water - a critical resource

Ways of using less water in agriculture and other industries, providing increased protection of rivers and groundwater and the re-use of urban and industrial waste waters.

2. Transforming existing industries

New technologies for resource-based industries to deliver substantial increases in national wealth by reducing environmental impacts on land and sea.

3. Overcoming soil loss, salinity and acidity

Identifying causes and solutions to land degradation using a multidisciplinary approach (examples include incorporating hydrology, geology, biology and climatology) to restore land surfaces.

4. Reducing and capturing emissions in transport and energy generation

Alternative transport technologies and clean combustion and efficient new power generation systems and the capturing and sequestration of carbon dioxide.

5. Sustainable use of Australia's biodiversity

Managing and protecting Australia's terrestrial and marine biodiversity to develop long term use of ecosystem goods and services ranging from fisheries to ecotourism.

6. Developing deep earth resources

Smart high-technology exploration methodologies, including imaging and mapping the deep earth and ocean floors, and novel efficient ways of commodity extraction and processing (examples include minerals, oil and gas).

Promoting and Maintaining Good Health

Promoting good health and preventing disease, particularly among young and older Australians

1. A healthy start to life

Reducing the impact of genetic, social and environmental factors predisposing infants and children to ill health and reducing their life potential.

2. Ageing well, ageing productively

Developing new and better social and medical strategies to reduce mental and physical degeneration based on greater knowledge and understanding of the causes of disease and degeneration of mind and body.

3. Preventive healthcare

New evidence-based strategies to promote healthy attitudes, habits and lifestyles and to develop new health-promoting foods and nutraceuticals.

Frontier Technologies for Building and Transforming Australian Industries

Stimulating the growth of world-class Australian industries using innovative technologies developed from cutting-edge research.

1. Breakthrough science

Better understanding of the fundamental processes that will advance knowledge and develop technological innovations (examples include bio-informatics, nano-assembly, quantum computing and geo-informatics).

2. Frontier technologies

Enhanced capacity in frontier technologies to power world-class industries of the future and build on Australia's strengths in research and innovation (examples include nanotechnology, biotechnology, ICT, photonics, genomics/phenomics, and complex systems).

3. Advanced materials

Advanced materials for applications in construction, communications, transport, agriculture and medicine (examples include ceramics, organics, biomaterials, smart materials and fabrics, composites, polymers, and light metals).

4. Smart information use

Improved data management for existing and new business applications and creative applications for digital technologies (examples include e-finance, multimedia, content generation and imaging).

Safeguarding Australia

Safeguarding Australia from terrorism, crime, invasive diseases and pests, and securing our infrastructure, particularly with respect to our digital systems.

1. Critical infrastructure

Protecting Australia's critical infrastructure including our financial, energy, computing and transport systems.

2. Protecting Australia from invasive diseases and pests

Counteract the impact of invasive species through the application of new technologies and by integrating approaches across agencies and jurisdictions.

3. Protecting Australia from terrorism and crime

By promoting a healthy and diverse R&D system that supports core competencies in modern and rapid identification techniques.

4. Transformational defence technologies

Transform military operations for the defence of Australia by providing superior technologies, better information and improved ways of operation.

But are they really priorities?

Although these goals are touted as priorities, and although nobody could seriously argue that they are not all important, the question remains: how can you have a series of priorities when everybody's current research will fit under at least one of the goals?

With all the current research covered, how will the Government determine where the funds should go? In other words for this process to make a difference we really need another process to change the funding mix. At present there is no way (under these goals) for the government to decide whether money being spent on (for example) ***preventive healthcare*** has a higher priority than that spent on ***overcoming soil loss, salinity and acidity***. In other words, the real priorities are yet to be addressed.

How this challenge will be tackled depends heavily on the implementation phase. In the Prime Minister's media release he said:

All research and research funding bodies of the Commonwealth will be expected to participate in implementing the priorities to the extent that it is consistent with their mandates or missions.

Implementation of the priorities will be driven by the research community who will advise the Government on the best way to proceed. Commonwealth agencies will be developing plans outlining how they propose to implement national research priorities and will submit them to Government by May 2003.

In the end, I suspect it will be up to the effectiveness of Ministers in the Cabinet when the budget is being put together later this month.

Geosciences do well

Nevertheless, the Earth Sciences feature well in the Sustainable Australia category, and there should be no difficulties in developing attractive research proposals under the identified goals.

Government commits $478 million for 30 new CRCs

Science Minister Peter McGauran announced the 30 successful CRC grants, in December 2002.

As most members would be aware, the CRC program brings together universities, research organisations, government agencies and industry to undertake strategic and tactical research. The new round of funding will support 12 new CRCs, an additional nine to be developed from existing CRCs, and supplementary funding for another nine existing CRCs.

This will bring the total number of active CRCs to 71 from July 2003, up from the current 62 (funding for three existing CRCs will expire by then.

In the Mining and Energy sector the number of CRCs will be unchanged because the Australian CRC for Renewable Energy will be closed and a new CRC, for Sustainable Resource Processing will start.

The current state of play is given in the table below:

CRC	Grant period	Total Commonwealth funding over duration of CRC
AJ Parker CRC for Hydrometallurgy	1999-2006	$19.4M (includes $0.9M supplementary funding in 2002 round)
Australian CRC for Renewable Energy (ceases in 2003)	1997-2003	$10.4M
Australian Petroleum CRC	1997-2003	$18.3M
CRC for Geenhouse Gas Technologies (developed from Petroleum CRC)	2003-2010	$21.8M
CRC for Clean Power from Lignite	1999-2006	$14.1M
CRC for Coal in Sustainable Development	2001-2008	$14.5M
CRC for Landscape Evolution and Mineral Exploration	2001-2008	$20.2M
CRC for Mining Technology and Equipment	1997-2003	$18.6M
CRC for Mining (developed from Mining and Technology CRC)	2003-2010	$27M
CRC for Predictive Mineral Discovery	2001-2008	$18M
CRC for Sustainable Resource Processing	2003-2010	$18.8M

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46Geoscience Australia

Two new reports released at the end of 2002 by Geoscience Australia provide interesting reviews on the nation's reserves in mineral and petroleum resources.

The first, ***Australia's Identified Mineral Resources Report 2002*** shows that gold, nickel and mineral sands registered significant growth in reserves to reach record levels in economic demonstrated resources (EDR) for 2001. In the same period, the EDR of bauxite, copper, lead, magnesite, nickel, phosphate, PGM, tantalum, silver, vanadium and zinc rose, while those of black coal, diamonds, iron ore, lithium, manganese ore and uranium fell.

For gold, the EDR is now estimated to be 5156 t, which will not even last for 20 years at current production rates of close to 300 t/year. More needs to be found.

The publication also provides an overview of exploration activity in 2001. It is an important annual nation-wide assessment of Australia's ore reserves and mineral resources and can be downloaded from: http://www.ga.gov.au/pdf/RR0112.pdf.

The second report is the ***Oil and Gas Resources of Australia 2001***. This shows that Australia's commercial and non-commercial gas and condensate reserves have continued to increase as a result of further discoveries and revision of gas and condensate reserves.

Current gas reserves increased in 2001 to 141 trillion cubic feet, 23 per cent over 2000 reserves.

Reserves of crude oil and condensate currently amount to 4084 million barrels – an increase of 6.7 per cent from 2000 despite sustained levels of production and a decline of five per cent in crude oil reserves. This is due to increases in reserves of condensate in gas fields.

As the Minister for Resources, Warren Entsch stated: "These significant increases in our commercial and non-commercial gas reserves are attributable to continuing large gas discoveries and revisions to the reserves of existing fields particularly off north west Australia in the Carnarvon and Browse Basins.

In addition, further gas discoveries made in 2001 and the first nine months of this year will also significantly add to our gas reserves and provide further security for Australia's gas supplies and for further LNG exports."

However, "While there have been some large gas discoveries made, recent discoveries of crude oil are insufficient to maintain production in the medium term," he said.

"A reduction of nearly 37 per cent in crude oil and condensate production is expected by 2005 and possibly 55 per cent by 2015, however, this shortfall situation could change in the near future if we were to discover a significant new oil province."

The Oil and Gas Resources of Australia 2001 contains a record of oil and gas expenditure, exploration, reserves, undiscovered resources, development, production and supporting information and statistics. It also includes a forecast of Australia's crude oil and condensate production from 2002 to 2015, an estimate of undiscovered oil and gas potential, and sustainability indicators for petroleum resources.

The report can be downloaded from http://www.ga.gov.au/pdf/OC0035.pdf

Geological Survey of Victoria

New Department Name

The former Department of Natural Resources & Environment has been split into two new Departments – the Department of Sustainability and Environment, and the Department of Primary Industries. The Minerals and Petroleum Division, which includes the Geological Survey of Victoria, will form part of the new Department of Primary Industries under the Hon Theo Theophanus, Minister for Energy Industries and Resources. The Department of Primary Industries will have a particular emphasis on innovation and industry development in the key areas of agriculture, fisheries, commercial forestry and minerals and petroleum.

Tenement Exemption over Walhalla-Woods Point Area

An exemption on the granting of new Exploration or Mining Licences in the Walhalla-Woods Point area, Gippsland has been effective since 5 September 2002. The exemption will apply until 31 December 2006. The exemption allows for granted licences still to be effective with existing conditions. New Mining Licence applications will only be accepted within Exploration Licences that the company already holds.

Cont'd from page 41

The CRC for Greenhouse Gas Technologies is of interest. It aims to develop innovative and cost effective ways to capture carbon dioxide and then store it in the subsurface. The plan is to capture CO_2 ; identify geological sites suitable for injecting CO_2 into the subsurface; carry out a demonstration project to store up to 1M tonnes of CO_2; develop ways of using carbon dioxide to improve petroleum production or to produce useful minerals; and undertake a regional initiative to examine how a range of industries can work together using geological sequestration to jointly decrease their emissions.

The Australian CRC for Renewable Energy missed out on any extension to its seven-year program. This was a surprise given that ***An Environmentally Sustainable Australia*** is one of the key national priorities announced by the Government.

Eristicus
January 2003

The exemption has been placed over the area that will be subject to regional mapping and mineral deposit studies by the GSV. It will ensure that as much land as possible is available to mineral explorers when the GSV produce the geological maps and insights into the regional controls and style of mineralisation in the Walhalla-Woods Point Goldfields and surrounding areas.

New Regolith Program

A pilot regolith study over the Ballarat East - Creswick area during 2001-2002 established a new regolith database structure, regolith map production techniques and procedures for geochemical characterisation of regolith landform units. As a result of the success of this pilot study the GSV commenced a new program of regolith mapping in central and western Victoria in early 2003. Key features of the Regolith Mapping Program are:

- Mineral explorers are the major client group that the program aims to service, although regolith map production scale will be 1:100 000 to service both mineral explorers and other land management clients.
- The regolith program comprises two main elements - regional regolith mapping and detailed case studies.
- Regional regolith mapping over the next few years will focus on 1:100 000 tile coverage of central and western Victorian goldfield areas, working sequentially from areas of outcrop/shallow cover to areas of deeper cover.
- Detailed studies over the next few years will follow on from regional mapping in key goldfield areas and their extensions under cover.
- The regolith mapping will commence with the Bendigo 1:100 000 regolith map and report.

Free Geoscientific Data Packages

Geoscientific data packages of Victoria containing geographic information systems (GIS) themes (or layers) and geoscientific databases are available free-of-charge on CD-ROM. The geoscientific GIS themes include:

- Detailed new generation 1:50 000 scale geology and regional 1:1 000 000 to 1:250 000 coverage;
- Registered geophysical images (magnetics, radiometrics, digital terrain, gravity);
- Geological interpretation of geophysics;
- Regolith geology;
- Mineral occurrence and production data; and
- Exploration geochemical data.

These themes are provided in both MapInfo and ArcView format and are supplemented by important baseline map data that includes:

- Land status (National Parks, restricted and unrestricted crown land);
- Exploration and Mining title boundaries (both past and present); and
- Road, town and map sheet information.

Geoscientific databases provided are:

- Boreholes (new mineral exploration and historic groundwater data);
- Surface geochemistry (soil and stream sediment samples);
- Mineral occurrence (location and production data); and
- Mineral exploration licence summaries (linked to the historic exploration licence GIS theme).

Data are provided on a 1:250 000 map tile area as well as a statewide Victoria Data Package that provides seamless geoscientific data for the whole of the state. In addition, software specific workspaces and projects have been compiled covering key aspects of each CD. For users without GIS software, links to free viewing software are provided to view the data. The packages are freely available from the GSV and can be ordered at www.nre.vic.gov.au/minpet.

Honeysuckle Creek TEMPEST Survey

During July-August 2002 a drilling and petrophysical logging (conductivity, gamma, and mag susceptibility) program of 13 holes throughout the 2001 Honeysuckle Creek TEMPEST survey area was completed. TEMPEST data having at least one of these drill holes within the system footprint were extracted from the complete dataset. Using quantitative and qualitative measures of fit, conductivity logging data were used in conjunction with the extracted data subset to derive "ground calibrated" EMFLOW processing parameters. Results substantially improved shallow depth slice (0-5 m) mapping of known surface salinity expressions and suggested several areas for shallow follow up investigations. Additionally, "ground calibrated" processing resulted in significant revision of depth to bedrock and possible salt store volume estimates.

Tenement Reports on CD

Digital versions of open file tenement reports on CD will be launched at the next VIMP data release. These will include scanned images of the report text as well as digital files of tabulated drilling and geochemistry data submitted by exploration and mining companies. Reports dating back to the early 1990s will initially be available, with the aim to eventually have all open file reports available digitally. Explorers will find the data far more accessible and useable in this format than on the current microfiche copies of the report held in the Minerals and Petroleum library.

New Magnetic Stitch of Victoria

In 1994 the acquisition of detailed (down to 200 m line spacing) airborne magnetics and radiometrics commenced as part of the Victorian Initiative for Minerals and Petroleum (VIMP). The airborne geophysical program was

Fig. 1a. Contractor supplied TMI grid with 'residual 1' filter applied; note minimum curvature gridding artefacts.

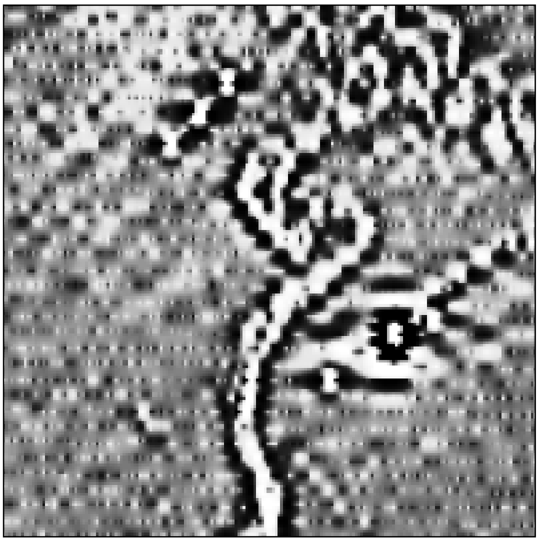

Fig. 1b. GSV TMI grid with 'residual 1' filter applied.

completed in 2001, with the grids and located data being made freely available. Changing acquisition and processing capabilities over this time led to data being provided in varying formats and quality.

To overcome these variations, the located data of the VIMP, company and Geoscience Australia surveys were converted to ASEG-GDF format, and then improved grids of the TMI data produced to a uniform standard. The cell size and origin of each TMI grid were chosen to avoid re-sampling when the individual surveys were merged together. In addition, each TMI grid was further processed to produce a first vertical derivative (1vd) TMI grid, reduced to the pole (rtp) TMI grid and a 1vd rtp grid. The TMI data has now been merged and stitched together to form a seamless coherent TMI grid for the whole of Victoria. The new survey grids and the stitch of the magnetic data of Victoria show significantly less gridding and processing artefacts when compared to the original survey data.

Otway Basin Interpretation

An integrated study of magnetic, gravimetric, bathymetric and deep seismic datasets has outlined the way that pre-existing basement fractures controlled much of the later Otway Basin-evolution, the structural style and the distribution of hydrocarbon bearing structures. Although the potential field data do not directly delineate hydrocarbon accumulations, when integrated with other data they provide powerful tools for exploration. For instance, it is possible to map the distribution of Paleocene channels that overlie the basement and represent likely reservoir facies, while data integration with palaeoenvironmental interpretations can highlight areas in which source rock facies developed.

The Otway Basin formed by the profound interaction between crustal fabric in the Proterozoic and Palaeozoic basement and the extensional stresses during Gondwana break-up. Regionally, the way the rifts have formed with respect to the basement fabric suggests that the dominant extension direction in the basin was N to NNW. Integrating the interpretation with regional studies in the western Tasmanian region supports the proposition that the western part of the south Tasman Rise was once the lower plate below the deep-water parts of the Otway Basin SW of Cape Otway.

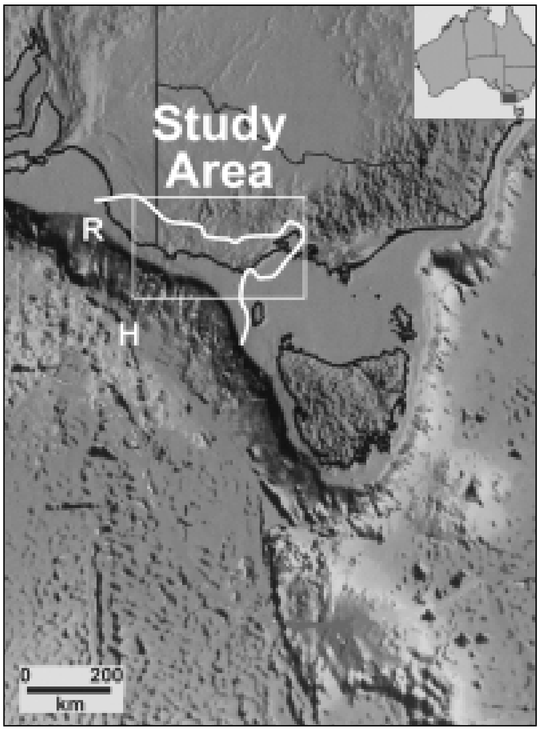

Fig. 2. Topography-bathymetry image from Geoscience Australia showing the Otway Basin study area, basin extents and the position of the Hunter Sub-basin (H) and Robe Trough (R).

The results of the Otway Basin Study have been published as Victorian Initiative for Minerals and Petroleum (VIMP) Report 78.

Bendigo Goldfield Detailed Gravity Traverse

The GSV collected gravity data along an 8 km traverse through Bendigo with station spacings varying from 50 to 200 m to determine if structural and density information could be mapped using gravity. The gravity data were collected using a Scintrex CG3 gravity meter and DGPS positional data using Sercel NR101 GPS receivers. The resultant gravity data have an accuracy of ±1.5mm/s2.

Bendigo is Victoria's largest goldfield, with gold-quartz mineralisation occurring as narrow vein style deposits. The siting and geometry of veins is strongly controlled by bedding, folds and faults. The bedrock of Bendigo consists of a Lower Ordovician turbidite sequence, which is subdivided into biostratigraphic units based on excellent graptolite fauna.

Preliminary results from the traverse are promising. Using Nettleton's method for estimating density from elevation and Bouguer anomaly the rocks appear to have densities ranging from 2.4 to 3.3 t/m3. The densities tend to increase from west to east approaching the major fault zones, possibly due to deeper crustal levels being exposed at the faults. Voids in the subsurface caused by mining activities have also been determined from the gravity data.

Geological Maps on the Web

The GSV has added the 75dpi and 125dpi images of the geological Quarter Sheets and 1:63 360, 1:250 000, 1:100 000 and 1:50 000 scale geological maps to the Minerals & Petroleum theme on the Department website (www.nre.vic.gov.au/minpet). The site contains tenement status and maps, which are refreshed weekly, and an extensive product catalogue that includes a range of geological report abstracts and maps that are viewable on-line. A geophysical survey index with detailed airborne survey acquisition parameters is available for download and free Victorian digital geophysical data can be ordered. Other new information includes overviews of Victorian geology, mineralisation and prospectivity and a summary of the Victorian Initiative for Minerals and Petroleum (VIMP) program.

2003 Data and Products Release

The next data release is planned for May 2003. Data and products to be released include:

- Ballarat, Bendigo and Ararat 1:100 000 regolith maps and reports;
- Castlemaine and Bendigo1:100 000 geological maps and reports;
- Updated GIS based Geoscientific Data CDs;
- The revised statewide magnetic intensity grids and images;
- First of the scanned Exploration Licences CDs;
- Honeysuckle Creek TEMPEST ground calibrated CDI products; and
- GIS based mineral exploration and geology themes on the Web.

For further information on any of the above products contact Kim Ricketts at the Minerals and Petroleum Business Centre (+61 (0) 3 9412 5103 or email mbc.info@nre.vic.gov.au) or Alan Willocks on +61 (0) 3 9412 5131 (Email: Alan.Willocks@nre.vic.gov.au).

Tasmania

Mineral Resources Tasmania has now released all the digital data from the airborne geophysical surveys flown under the Western Tasmanian Regional Minerals Program. The surveys included the acquisition of about 15 500 line-km of frequency domain helicopter electromagnetic data over the Mt Read Volcanic Belt and in areas with shallow granite and potential host rocks for replacement-style base- and precious-metal deposits. This is the first large-scale government sponsored airborne electromagnetic survey over a mineral province in Australia. In addition to the located data and grids supplied by the contractor the available data include conductivity-depth transformations (from both EMFlow and Sengpiel transformations).

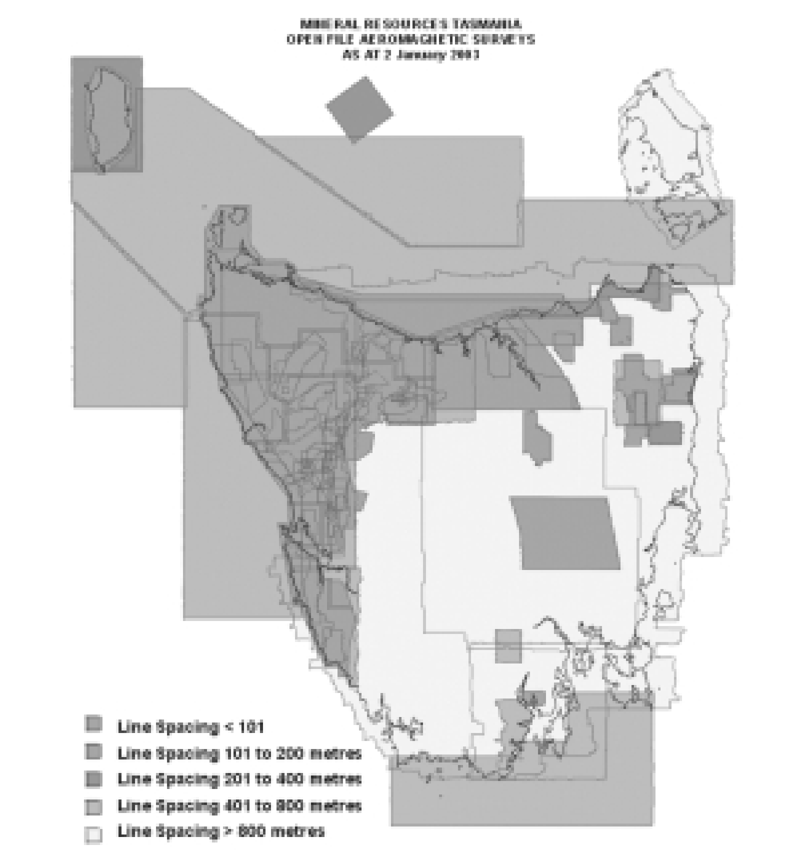

Fig. 1. Coverage of Open File aeromagnetic surveys available from the MRT

In combination, the electromagnetic data and the 116 000 line km of helicopter and fixed wing aeromagnetic and radiometric data acquired over King Island and western and northwestern Tasmania provide an unprecedented insight into the geology of the area.

In addition, MRT is providing other value-added products, including qualitative and quantitative interpretations of the aeromagnetic and radiometric data, reports on ground-truthing and new interpretations of the Mount Read Volcanics and the Devonian granite aureoles, based largely on the new data.

This package of products represents a significant opportunity for explorers, with new areas of potential recognised and a number of new tenements already issued. There will be several related presentations at the ASEG 2003 conference.

For further details contact Bob Richardson (ph 03 6233 8324) or visit the MRT website (www.mrt.tas.gov.au).

Geophysical Signatures of South Australia Mineral Deposits: ASEG Special Publication 12

Geophysical Signatures of Western Australia Mineral Deposits (ASEG Special Publication 7, Centre for Strategic Mineral Deposits (University of WA) Publication 26) was published in 1994 and sold close to a 1000 copies, with orders received from all over the world. An equivalent volume on the mineral deposits of South Australia will be launched at the ASEG Conference in Adelaide in February 2003. This volume is also the result of collaboration between the University of WA (now Centre for Global Metallogeny) and the ASEG, together with Primary Industries and Resources South Australia (PIRSA).

The organisation and production of Geophysical Signatures of South Australian Mineral Deposits was different from its predecessor. Firstly, like all recent ASEG publications, the book is being produced in WA by RESolutions Resource & Energy Services. Digital publication allows total control over the format of the publication, facilitating quality control of figures and allowing a coherency of style unattainable with the earlier publication on Western Australia.

Secondly, from necessity, the project was undertaken in a very different fashion. South Australia was chosen as the follow up to the WA volume largely through the efforts of Terry Crabb, then Chief Geophysicist at Mines and Energy South Australia (now PIRSA). In the case of Western Australia, the volume was produced during a period of intense exploration activity, and numerous industry-authored case study papers were fairly easy to find. This meant comparatively little data had to be located in the WA Mines Department archives. The 'gap-filler' material written by the editors comprised only a small part of the total content, and in fact was largely a summary of published material.

When the SA project began, the level of exploration activity in SA was very low. However, this was at the time when the State Government began to encourage exploration with the South Australian Exploration Initiative (SAEI), and later the Targetted Exploration Initiative South Australia (TEISA), and in association with other Governments, the Broken Hill Exploration Initiative (BHEI). The resulting extensive public-domain regional aeromagnetic datasets became a crucial aspect of the project and images of these data were specially created by Cowan Geodata Services. These provide excellent illustrations of the structural and stratigraphic settings of the deposits.

As the project progressed, the increased exploration activity following the SAEI etc. meant industry-authored papers became available. Nevertheless, the volume still contains a significant amount of material from the PIRSA archives, and the proportion of material written by the editor is far larger than for the WA volume. However, to ensure an industry perspective, as far as possible, the geophysicists who directed the original exploration were asked to collaborate and co-author these papers. The final volume contains 20 papers, of which 14 have industry authors. There are a further 6 papers which are based on reviews of archival material. An additional paper contains a geological overview of South Australian geology and mineral deposits.

The papers comprising Geophysical Signatures of South Australian Mineral Deposits are summarised below. The geophysical responses of all the important deposits and styles of mineralisation are described. In additional to the world-class Olympic Dam copper-uranium-gold-silver-REE deposit, there is comprehensive coverage of the Proterozoic iron oxide copper-gold mineralisation in the State (Portia/North Portia, White Dam, Kalkaroo, Moonta-Wallaroo, Dome Rock). Also of interest is a description of the geophysical characteristics of the mineralisation recently discovered at Prominent Hill, in the eastern Gawler Craton. The volume also contains the first comprehensive descriptions of the geophysical characteristics of several important types of deposits. For example, the high grade and large tonnage 'zinc-oxide' deposits, such as Beltana, Aroona, and the recent Reliance discovery. Another important class of deposit, which has been neglected in geophysical publications, is sediment-hosted stratiform copper-sulphide mineralisation. The volume contains a comprehensive description of those in South Australia, combining regional to prospect-scale surveys. Other notable deposits described include the heavy mineral sand accumulations at Mindarie in the Murray Basin, the Uley graphite deposit on the Eyre Pensinsula, the recently discovered Archaean gold mineralisation at Challenger in the Gawler Craton, sandstone-type uranium deposits in the Frome Embayment and the well known iron-ore deposits in the Middleback Ranges.

Geophysical Signatures of South Australian Mineral Deposits, which costs A$99 including GST, is available from RESolutions Ltd (resres@oilfield.com.au). Production will be limited to 500 copies.

Sky Has Been The Limit For Geophysics Pioneer

Pat Cunneen has had a varied career in the mining and petroleum game, starting out with Western Mining 41 years ago, when he painstakingly mapped a large portion of South Australia's Yorke Peninsula in the early 1960s as part of an induced polarisation crew. He worked with some of the pioneers of the geophysics profession and later was instrumental in setting up two world-renowned aerial geophysical survey companies, starting with an initial investment of $500 over lunch at a Kings Park restaurant with three colleagues, 26 years ago.

[1]This article is based on an interview by Brian Wickins, after Pat Cuneen received his SEG Enterprise Award last year.

Pat Cunneen got to see more of the Yorke Peninsula then he would probably care to remember. It was on the peninsula that 20-year-old Cunneen got his first taste of the science that was to take him on an extraordinary adventure, with the sky the limit, literally, in pursuit of his quest to help unravel the secrets of the Earth.

Cunneen was working as a treatment plant operator at the Great Boulder gold mines before he joined a Western Mining induced polarisation crew in 1962 as a geophysical technician under the direction of Anton Triglavcanin. Induced polarisation was a new technique at the time and Western Mining was using it as a reconnaissance tool to map the peninsula. "We would typically do 20-mile lines, cross over 1000 feet, and do 20-mile lines back again, and we would do that for years", he said.

After two years with Western Mining, ending up as a party chief, Cunneen got a job with McPhar Geophysics, which was set up by Phil Halloff, as a geophysical party chief doing 2D induced polarisation work. Cunneen left McPhar Geophysics two years later and started working for John Newman at Australian Mining and Engineering Geophysics Pty Ltd's (AMEG) airborne operations division, as a data compiler, in 1967. It was here that he got his first introduction into the world of airborne geophysics.

Cunneen's work at AMEG included doing aerial surveys for several companies during the Kambalda nickel boom before he took a break from the industry in 1969, setting up an air-conditioning and refrigeration business in Port Hedland. He then joined Scintrex, in 1971, where he spent the next six years doing airborne data processing work before being retrenched in 1976.

All this job hopping was starting to get to Cunneen, so in 1977 he decided it was time to 'create a job for himself' in the fledgling airborne geophysics industry. So with Mike Macauley, John Stewart and Louis Coremans, he took the plunge and went into business, starting a company called Aerodata. The deal was done over lunch at a restaurant at Kings Park, Perth when the partners contributed $500 each for the company's working capital.

"This created a few challenges and it was a lot of fun", he said. "We did a lot of borrowing and a lot of exciting things. We fired along and bought our first plane, a brand new Cessna 206 in 1979." Aerodata was airborne and the company was doing well domestically, capturing about 70% of the Australian market in four years.

Aerodata Holdings Limited became a listed company in 1985, but getting into the international airborne geophysics market was a whole new ball game. "After early attempts and only partial success in our orthodox marketing attempts to get business from Malaysia, Thailand and Indonesia, we changed our game plan and decided to set up a whole new company and a new business", Cunneen said. This resolve was the beginning of World Geoscience Corporation Limited in 1987.

Pat Cunneen stands in front of a Briton Norman Trislander configured for airborne electro magnetics during the mid 1990s.

"We acquired key technologies, such as INPUT, hired exploration geologists and took an enhanced service to the international market. We also diversified into making electric motors by acquiring Western Electric Pty Ltd. The rationale for this move was to add a stabilizing factor to the combined business- the more predictable revenue stream of Western Electric modifying the volatility of airborne geophysics", he said.

World Geoscience had a conditional underwriting of $13M from Melbourne brokers, May and Mellor, to obtain state-of-the-art equipment. "We went around the world and bought what we thought were the best technologies. This included a Canadian company called Questor Limited, which was named Selection Trust when it developed the INPUT, time domain electromagnetic technology in 1986", he said. World Geoscience acquired the technology but the $13M didn't eventuate due to the 1987 stock market crash.

"So we had a big bill and no money and that created another set of challenges," Cunneen said. But the company survived and went on to become a world leader in airborne geophysics, with a squadron of 21 aeroplanes, 200 staff members, sales of $45 million and offices in Toronto, London and Santiago. "At one stage we were flying aeroplanes in 13 counties all on the same day", he said.

Environmentalist, David Bellamy chats with Pat Cuneen.

Times were good. While the company's target market was the mining industry, it was also getting into the oil market through the application of its high-resolution magnetometers, revealing intra sedimentary structures that had never seen before. "Our strategy was to hire seismic interpreters and then to induct them into the magnetic area, so they could integrate the magnetics and the seismic" Cunneen said.

"We took the approach of looking at geophysics from the geologist's perspective. We'd hire geologists at exploration manager level and then induct them into the interpretation techniques so that, first of all, they drove the techniques in a way which was useful and, secondly, they could communicate at the exploration manager level with the people who had exploration problems."

> “World Geoscience became a world leader in airborne geophysics, with a squadron of 21 aeroplanes, 200 staff members, sales of $45 million and offices in Toronto, London and Santiago. At one stage it was flying aeroplanes in 13 counties all on the same day.”

Meanwhile, back in Australia Western Electrical Australia Pty Ltd wasn't doing too badly either. It was manufacturing and selling a range of electric motors to local and South East Asian markets with sales of $20M before it was sold in 1995.

After 18 years with Aerodata Holdings, Cunneen started to think of trying some new things and having a bit of a rest. In 1997, aged 54, he thought retirement from day-to-day management sounded like a good idea. But it didn't last. "My golf didn't improve and my wife told me to get out of the house between 9 and 5 because she was used to that." So he came up with the idea of getting into the television production game as he had always fancied himself as a bit of a Steven Spielberg.

His plan was to help lift the image and the profile of the mining industry in Australia. "The industry was almost interested enough to support it, but not quite", he said. "We did a couple of pilots for the mining program and I think they were pretty good. I think the industry should have its own TV program but the industry's organising bodies are too many and too diverse.

"There is a plethora of them and this results in the mining industry having no real voice, which is a bit of a disaster for the country's leading industry but that is a fact. The industry should give itself a smack and get its act together." He also had a bit of fun putting a motor sports program together for Channel 7 and although it was "pretty good"; it wasn't a major money earner.

Retirement didn't last long when in 2000, Cunneen was asked to join a new company called GPX Airborne with several of his former employees from Aerodata Holdings who had bought the World Geoscience ground geophysics division and had plans to get back into the airborne business. "We've got an exclusive licence agreement with Newmont to commercialise their electromagnetic system called HOISTEM, which is a very good system indeed, and is giving excellent results", Cunneen said. One of those results has been unexpected, with the technology being a good locater of fresh water.

With former World Geoscience employee, Bob Pavlik, GPX Airborne has collaborated in the development of a new magnetometer and a new gamma ray spectrometer. "The resolution and the accuracy of both systems is beyond our expectations", he said. The technology is currently employed in a survey for the Namibian government. "We are achieving accuracies of 1.5 picotesla with the magnetics, at 1.4 Hz bandwidth, and the spectrometer is successfully delineating the Pb 214 gamma peak at 352 Kev making possible a more robust elimination of Radon contamination", Cunneen said. "The new sensitivity of the magnetics should reveal another layer of structures in sedimentary basins and the spectrometer will enable soil mapping for precision farming applications."

The industry has undergone mammoth technological changes during Cunneen's career and a vital driver of change has been the support of the Government of Ontario, Canada. "The development of instrumentation was largely driven by the Government of Ontario who were wise enough to offer dollar for dollar in development over a long time and it has encouraged lots of small operators to do lots of small innovative things", he said.

"If they succeeded and did something well, they became big, and if they didn't, they usually went back to their garage and tried again or joined a bigger company. The Government created in Toronto something which still exists, that is a culture of instrumentation." He said that similar assistance from the Australian Government has led to Australia becoming a world leader in the development of airborne electromagnetics after originally importing the generic technology, like INPUT, from Canada.

Cunneen tried to create a market-leading company whilst with World Geoscience. He approached Geoterrex several times in an attempt to affect a merger. "But it didn't happen until I had moved on", he said. "It did eventually happen though, through Fugro, and I think this was a very healthy development. With Fugro achieving sufficient size to assume the mantle of a market leader, they are enabled to set sustainable prices and also to chart the destiny of the airborne geophysical industry."

"This makes it a lot easier for other people such as ourselves to come in and do innovative things." He said specialist sectors need a market leader. "An industry without a

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Integrated Exploration in a Changing World: Sydney 2004

The 17th ASEG Conference and Exhibition will be held in Sydney from the 14th to 18th of August 2004. This conference will be held at the Sydney Convention Centre at Darling Harbour and will be co-hosted by PESA (NSW).

The theme of the conference is "*Integrated Exploration in a Changing World*".

The conference will feature integrated exploration techniques for both petroleum and minerals in a setting that is evolving professionally, academically and commercially.

The committee is up and running under the co-chairmanship of Barry Smith and Timothy Pippett.

The conference secretariat is:

Conference Action Pty. Limited
Suite 104, 308 Pacific Highway
Crows Nest, NSW, 2065.

Tel: 02 9437 9333
Email: confact@conferenceaction.com.au

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market leader is not a healthy industry", he said. "Domination is no good, but one company can never dominate for too long. They are, in reality, providing an umbrella to keep the rain off the smaller players." Cunneen rejected suggestions that the idea of competition within a sector was to 'bury' the smaller players. "That may be the idea, but it doesn't work, it does the opposite, it encourages the smaller players", he said. "You don't get all the small players cutting themselves to pieces so that they can keep the cashflow going."

The development of equipment in the airborne geophysics industry has led to spinoffs applicable to other areas, like the use of laser-induced flurosensing to monitor oil dumping and combining with global positioning systems (GPS) technologies for agricultural applications.

Cunneen said the development of laser-induced fluroscence could lead to a clampdown on illegal oil dumping, particularly in the Arabian Gulf. The application detects distinctive aromatic compounds in oils and can be traced back to individual tankers. "The authorities in the Gulf have huge problems because the captains of oil tankers always flush their tanks before they get out into the Indian Ocean and it is a cat and mouse game", he said. "At the moment the captains always win, but it would be a reasonably simple technological problem to analyse all those oils and track them right back to individual tankers."

"GPS technology now allows farmers to map their paddocks, you can get a map of productivity and look for relationships with various geophysical parameters", he said. "I'm quite sure that in the next few years we will be able to supply projections of productivity in the wheatbelt. The farmer will be able to relate his projected return with his economic application of fertilizer, and things like that."

Cunneen, on behalf of his World Geoscience colleagues, has picked up a swag of awards over his career, including a SEG Enterprise Award in Salt Lake City last year, a WA Company of the Year Award in 1993, WA Exporter of the Year (services) 1994, Australian Exporter of the Year (services) also 1994, Australian Landcare Research Award 1995 and a Diggers and Dealers technical services award in 1996.

Pat Cunneen receives his SEG Enterprise Award from former SEG President, Walt Lynn.

Cunneen maintains his interest in television production, as well as his hobbies of environmental science, poetry, geology, geophysics, instrument engineering, business philosophy, ancient history and scuba diving. And on top of all that, he is still finding time to work on his golf swing and keep out of the house during working hours.

New Members

We welcome the following new members to the ASEG. Membership was approved by the Federal Executive at its meeting on 27 November 2002.

Name	Organisation	State/Country
Yvonne Cheryl Fraser	Placer Granny Smith	WA
Karen Jennifer Pittard	De Beers Australia	WA
Ana Virginia Brana	North Atlantic Natural Resources	Sweden
William Robert Lodwick	Essential Petroleum	Vic
Louise Pellerin	Consultant	USA
Margarita Louise Norvill	Curtin University	WA
Thomas Robert Klopf	Santos	SA
Petros Karmis	Inst. of Geology & Mineral Exploration	Greece

Australian Capital Territory – by David Robinson

Nick Direen resigned as President of the ACT Branch of the ASEG in September. Nick has moved to Adelaide where he has accepted a lecturing position at the University of Adelaide. Nick has served the local Geophysics community for a number of years and will be greatly missed. The ACT Branch wish Nick and his family the best of luck in Adelaide and hope that Nick finds his way to the Adelaide Branch of the ASEG where we know he will be very welcome. Nick's final role as President of the local branch was to oversee the election of an interim executive that will serve until the AGM early next year. The interim executive is as follows:

President: David Robinson
Vice President: Eva Papp
Treasurer: Trevor Dhu
Secretary: Nick Rawlinson
Committee: Alice Murray, Jacques Sayers, Prame Chopra and Peter Milligan

On the 27 November Malcolm Sambridge (Research School of Earth Sciences, ANU) presented a talk at Geoscience Australia entitled: *Fully non-linear inversion with ensemble inference – Monte Carlo or bust*. Malcolm's talk traced the beginnings of Monte Carlo inversion techniques from the earliest applications, in the days when computers had valves and a Macintosh is what you wore in the rain, to modern ensemble inference techniques. A particular emphasis was given to a recent approach (developed by Malcolm himself) known as neighbourhood sampling. The basic ideas were outlined with the aid of three blind mice that were seeking the best cheese. The talk concluded with a number of applications for the neighbourhood sampling technique and was followed by a local wine tasting.

South Australia – by Andrew Shearer

As preparations for the 16th ASEG Conference and Exhibition in Adelaide gathered pace throughout the second half of the year the local branch maintained a high level of activity. This was achieved despite a large number of the local committee members being also heavily involved in the organisation of the Conference. Branch activities and presentations for the last six months of 2002 were:

July: *Pore-Fluid and Lithology Predictions: Can we forecast any new advances?* presented by Fred Hilterman (Geophysical Development Corporation), co hosted with PESA and sponsored by Roberston Research

August: *Quantifying AVO attributes and their effectiveness*, presented by Martin Brewer (Hampson-Russell) and sponsored by Hampson-Russell.

September: *Native Title: Implications for Mineral and Petroleum Exploration in South Australia*, presented by Kate Bickford (Finlaysons) and sponsored by PIRSA.

October: Annual Industry Night, with speakers from:
Stuart Petroleum (John Iredale)
Global Geoscience Services Inc (Doug Mason)
School of Petroleum Engineering and Management, University of Adelaide (Peter Behrenbruch)
Newmont Australia Ltd. (Mike Sexton)

November: ASEG Melbourne Cup Lunch, sponsored by Beach Petroleum.
Annual Student Night (sponsored by the University of Adelaide and NCPGG), with the following speakers:
Emma Nelson (NCPGG)
David Mitchell (University of SA)
Tania Dhu (CRC LEME, University of Adelaide)
Philip Heath (CRC LEME, University of Adelaide).

Emma Nelson was awarded Best Paper, and Tania Dhu gave the Best Presentation.

December: Christmas Function

The SA Branch also organised the annual ASEG wine offer, after careful and controlled tastings of a large number of South Australia's finest.

All events throughout the year were well attended by a broad cross section of the geoscientific community and it was encouraging to see large numbers of students attending the technical meetings. A special thank you is made to the sponsors that made it possible to hold all the functions throughout the year.

Western Australia - by Kirsty Beckett

Technical Meetings

At the final technical evening for 2002 we looked at the latest in airborne gravity with *The Falcon™ Airborne Gravity Gradiometer*, presented by Dave Isles.

The system has proved itself to be a highly effective gravity system, with applications for both the minerals and petroleum industries. But how do you get hold of the system if you want to use it? Gravity Capital Limited is the "distributor" of the Falcon™ system in Australia. It has an agreement with BHP Billiton to gain priority air-time use of the aircraft for Australian projects. Acting as a sort of screening mechanism for BHP Billiton, Gravity Capital can help finance a potential project and aid with technical expertise in the interpretation of the data in a joint venture style of operation. Then BHP Billiton has the rights to buy Gravity Capital out of the company if the project target suits there needs. A win-win situation for BHP Billiton, the developers of the system, as they can ensure the data are interpreted correctly through the knowledge store of experience at Gravity Capital and farm into highly profitable projects discovered by their system. And a win smaller exploration companies who think they are on a winner, but need financial backing to help them through.

2002 ASEG WA Student Night

The ASEG WA annual Student Nights were held last month, show-casing the talent of new geophysics graduates from across Western Australian campuses.

Cross pollination of the previously estranged disciplines of seismic (oil) and minerals exploration saw Reece Foster take out the Best Minerals Presentation award for his presentation on *The effectiveness of spectral analysis of surface waves for mapping regolith*, a technique with great future application.

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Placer Dome completes takeover of AurionGold

On 2 January 2003 Canadian -based Placer Dome Inc announced that its wholly owned subsidiary, Placer Dome Asia Pacific Limited (PDAP), has completed the compulsory acquisition process and as of December 31, 2002, now owns 100% of AurionGold Limited.

PDAP's bid for the Australian gold producer was launched on May 26, 2002, and by mid-October Placer Dome had gained a controlling interest.

The AurionGold acquisition increases Placer Dome's interest in the Granny Smith mine in Australia from 60% to 100%, and increases the company's interest in the Porgera mine in Papua New Guinea from 50% to 75%. It also adds three new mines in the Kalgoorlie region of Western Australia and a fourth in Tasmania. Asia Pacific is now Placer Dome's largest region and is expected to contribute 56 tonnes, or about half of the company's total production, in 2003.

Placer Dome is the world's fifth largest gold mining company, with interests in 18 mines in six countries employing 12,000 people. Placer Dome was listed on the ASX in October 2002 and currently is the 18th largest company listed with a market capital of $7.5 billion.

AurionGold of course, which had a market capital in November 2002 of $1.4 billion, is no more and overseas interests have acquired another major Australian gold resource company.

Both mineral and petroleum exploration activity rise in September quarter 2002

In the October 2002 Preview we commented that exploration investment in Australia may be about to rise, even though the June 2002 quarter figures indicated a fall from previous quarters. Well, for the first time in over two years both the mineral and petroleum numbers moved upwards during the September 2002 quarter.

Minerals

Figures released in December 2002 by the Australian Bureau of Statistics showed a significant turn around in the September quarter. The trend estimate for total mineral exploration expenditure increased by 4.6% to $171.7M and is 4.9% higher than September quarter 2001. The actual mineral exploration expenditure increased by $14.8M (8.8%) in the September quarter 2002 (up 15.5% in seasonally adjusted terms). Expenditure on production leases increased by $5.9M (16.3%) and expenditure on all other areas increased by $8.9M (6.7%).

The largest increases occurred in Western Australia ($4.3M or 4.5%) and New South Wales ($1.4M or 10.9%). All

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Ben Hansen's polished presentation on *Evaluating the impact of fracture-induced anisotropy on reservoir rock property estimates made from seismic data* and ease of fielding questions demonstrated his comprehensive knowledge of his dissertation topic and saw him awarded the Best Petroleum Presentation.

The standard of presentation over the two nights was once again remarkable (this is the first professional presentation for most of these students). We wish all the presenters the best in their careers.

WA Annual General Meeting

The WA Branch Annual General Meeting was held on Wednesday 18th December at the Celtic Club in West Perth. We'd like to give a big thank you to out going committee members John Watt (Treasurer) and Guy Holmes (Secretary) and welcome Kim Cook (Treasurer) and Megan Evans (Secretary) to the WA Executive.

2002 was a great success for the Western Australian Branch. WA held 10 technical evenings, 2 student nights, 1 conference, 2 professional development courses and 3 social events. However, none of these events would have been possible without this assistance of this year's committee. Thank you to:
Guy Holmes, John Watt, Kevin Dodds, David Howard, Don Sherlock, Anton Kepic, Satyavan Reymond, Megan Evans, Kim Cook, Liz Clydsdale, John McDonald, Graham Jenke, Troy Herbert, Katherine McKenna, Louisa McCall, Rachel Masters, Howard Golden, Levin Lee, Greg Street, Andrew Foley, Brian Evans, Jayson Meyers, Peter Wolfgram, Klaas Koster and Mark Russell.

WA Monthly Email Newsletter

Each month the ASEG WA Branch sends an email newsletter to all of its known members (and many non-members) in WA. However, email addresses tend to be transient, and one misplaced letter means that you don't receive a copy! If you have not been receiving the monthly ASEG WA Newsletter and would like to receive a copy, please email Kirsty Beckett at ASEG_WA@hotmail.com and we'll update your email details and add you to the mailing list.

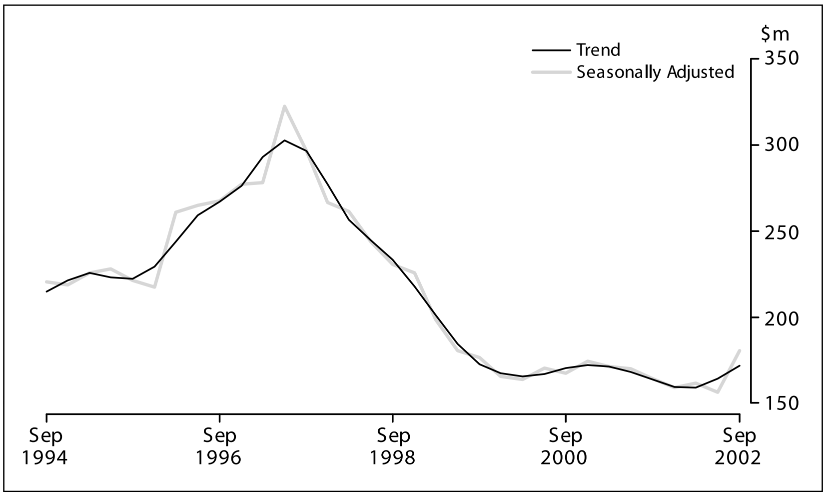

Fig. 1. Trend and seasonally adjusted quarterly mineral exploration expenditure from September 1994 to September 2002 (provided by the Australian Bureau of Statistics).

Fig.2. (Below) Quarterly gold price in US$/oz from 1986 to 2003, not adjusted for CPI.

Fig. 3. (Below right) Onshore and offshore quarterly petroleum exploration expenditure from 1986 to 2002.

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remaining states recorded slight increases except the Northern Territory, which recorded a slight decrease.

Gold exploration was the main driver, with an increase of $10.7M (18%) for this commodity alone in Western Australia. The increase in drilling activity from 1211 km drilled in the June quarter to 1468 km in the September quarter is indicative of the increased activity.

However, given the substantial increase in the price of Gold from about US$270/oz in mid-2001 to close to US$350/oz at the time of writing, the increase in interest in this metal is not really surprising.

Figure 1 shows the mineral exploration trends form the ABS data and Figure 2 shows the price of gold from 1986 to the time of writing.

Petroleum

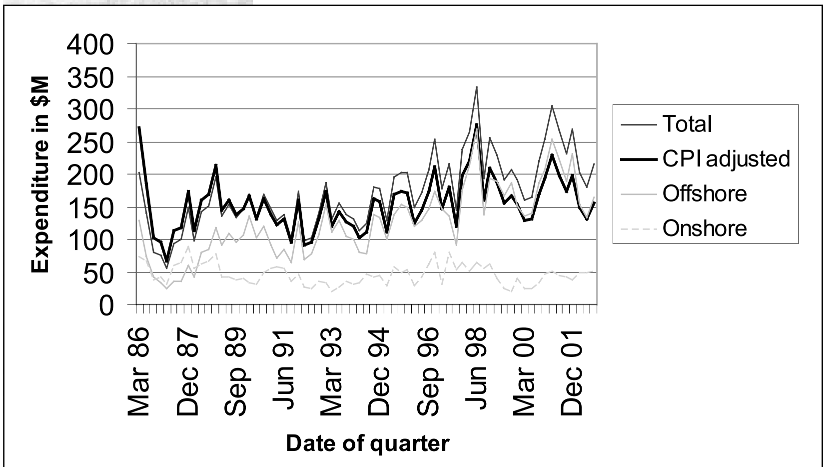
In the September quarter 2002, expenditure on petroleum exploration increased by $34.8M (19.3%) from the previous quarter to $215.3M.

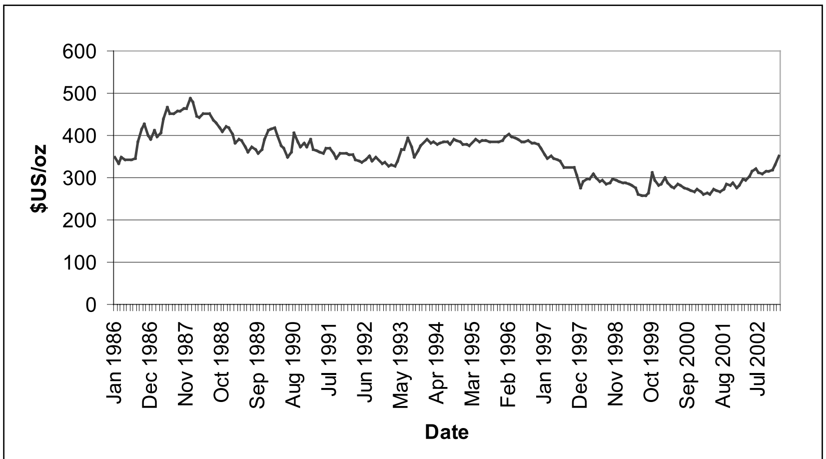
This was mainly due to a $32.5M increase in offshore exploration. The other good news was that most of that increase ($25M) took place outside areas covered by production leases; in other words, in new areas where exploration is still at the immature stage.

Victoria was the main contributor to the increase in petroleum exploration expenditure with an increase of $40.2M to $54M, mostly on offshore drilling.

The bad news for geophysicists is that the non-drilling offshore expenditure fell from $59.8M to $42.9M in the September Quarter. This is the lowest level since March 2000.

Figure 3 shows the trends on both onshore and offshore expenditure for the last 25 years.





Data Metallogenica to go to AMIRA

With the closure of the Australian Mineral Foundation last year, many in the geoscience community expressed concerns about the future of the *Data Metallogenica* collection. This was housed at the AMF, and consequently subject to the Receiver's deliberations with respect to disposing of the AMF's assets to meet it's creditors outstanding claims. It has now been agreed that AMIRA will be responsible for the collection, at least for the next two years.

AMIRA International's original *Data Metallogenica* project was launched in 1999 to assist in the preservation of an irreplaceable collection of samples and supporting data from over 4000 mineral deposits from around the world, assembled over a lifetime by Professor Peter Laznicka and his wife Sarka while he was based at the University of Manitoba in Canada.

The collection was acquired by AMIRA on behalf of the minerals industry with the support of over 70 companies, institutions (including the Geological Society of Australia, the Australasian Institute of Mining & Metallurgy, Society of Economic Geology, Geoscience Australia and CSIRO) and the South Australian Government, and is housed in its own centre (formally the AMF) in Adelaide, South Australia.

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Annual Geoscience Exploration Seminar
Alice Springs 25-26 March 2003

CONTACTS

Richard Brescianini
Acting Director
Richard.Brescianini@nt.gov.au
+61 8 8999 5377

Ian Scrimgeour
Assistant Director Regional Geosc
Ian.Scrimgeour@nt.gov.au
+61 8 8999 5214

Masood Ahmad
Assistant Director Mineral Reso
Masood.Ahmad@nt.gov.au
+61 8 8999 5276

Richard Brescianini
Chief Geophysicist
Richard.Brescianini@nt.gov.au
+61 8 8999 5389

Tracey Rogers
Manager Geoscience Informa
Tracey.Rogers@nt.gov.au
+61 8 8999 5279

Greg Ambrose
Senior Petroleum Geologis
Greg.Ambrose@nt.gov.au
+61 8 8999 5342

Gary Andrews
Manager Cartographic Se
Gary.Andrews@nt.gov.au
+61 8 8999 5326

Chris Edgoose
Senior Geologist Alice S
Christine.Edgoose@nt
+61 8 8951 5302

Geoscience Inform
Geoscience.Info@nt.
+61 8 8999 5281

NTGS
www.dbird.nt.gov

Titles Informatio
www.dbird.nt.go

Darwin Office
3rd Floor Centrep
Smith Street Mall
GPO Box 3000
Darwin NT 080
+61 8 8999 531
+61 8 8999 682

Alice Springs
Minerals House
58 Hartley Street
PO Box 2655
Alice Springs NT 0871 Australia
+61 8 8951 5658
+61 8 8952 7762 fax

Northern Territory Government
Department of Business, Industry & Resource Development

NT GEOLOGICAL SURVEY
GPO Box 3000
Darwin NT 0801
Australia

Telephone: +61 8 8999-5313
Facsimile: +61 8 8999-6824
www.dbird.nt.gov.au/ntgs

Dear Explorer

I invite you to attend the Northern Territory Geological Survey's next Annual Geoscience Exploration Seminar (AGES), to be held at Rydges Plaza Resort Alice Springs on 25-26 March 2003.

Under the NT Government's Exploration Initiative, almost everything we do is designed to encourage and sustain mineral and on-shore petroleum exploration. AGES is an opportunity for us to report to you on work programs that have been completed over the last year, to preview future programs and to give ideas on new exploration opportunities.

The relevance of our multidisciplinary geological province studies, our strong client focus via free and rapid distribution of data, and the capacity for explorers to access land, now considered the best in Australia, help give the NT a competitive edge on the national and global scene.

AGES 2003 will include presentations on the following topics, some in collaboration with Geoscience Australia under the North Australia NGA Project:

Tanami 3D modelling
Western Arunta synthesis
Arunta regional framework
Eastern Arunta base metal styles
Resource potential of Southern Georgina Basin
Uranium in the Pine Creek Orogen
Regional geochemical datasets, including diamond indicators
Geophysical programs
Land access and titles developments.

AGES 2003 will, for the first time, include presentations from explorers currently active in the NT. This new initiative has been enthusiastically embraced by the following presenters: De Beers, Tanami Gold, Rio Tinto, Compass Resources, Newmont, Arafura Resources, Cameco, Elkedra Diamonds, AngloGold and GeoDiscovery Group.

You can register for AGES 2003, either online at www.dbird.nt.gov.au/ntgs or by contacting Diane Cook on (08) 8999-5313 or diane.cook@nt.gov.au. Registration with lunch is only $80 (including GST) per delegate.

Yours sincerely

RICHARD BRESCIANINI
ACTING DIRECTOR NT GEOLOGICAL SURVEY

6 January 2003

AGES

Northern Territory Geological Survey

Preview Classified Advertising

ASEG understands that with the mineral exploration industry experiencing tough times, members continue to seek new and cost effective ways of delivering a focused message to their potential customers.

Preview Classified Advertising has been designed with this in mind and, at just A$55 (including GST)** provides an economical medium through which companies can advertise their services and contact details.

Conditions apply when advertising in Preview Classified Advertising so, for more information, contact Will Butun on +61 8 9446 3039 or email will@oilfield.com.au.

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The 3-year P554 development project added missing deposits, digitally imaged the collection, contributed critical support data, and created a web site with extensive public domain and subscriber sections in July 2002. The web database is restricted to Foundation Sponsors until July 2003, when it will become open for public subscription.

Further development work under AMIRA extension project P554A will continue for a further two years. An initial focus on geological aspects of ore deposits will later extend to data on mining and mineral processing. Current support funding is generated by both web subscription fees and by sponsorship of the new P554A project.

The web database currently offers the following features:

- High resolution digital images of 3000 rock sets and 1200 individual samples from 4000 mineral deposits in 100 countries: over 65 000 samples of ores, host rocks, alteration and regolith;
- Over 5500 interpreted (PIMA) mineral reflectance spectra of notably epithermal and porphyry settings;
- Supporting "Legends", and growing numbers of deposit descriptions and summaries, and district overviews;
- Advanced data compression transmission of images; and
- Fast searching on deposits, provinces, countries, regions, commodities, deposit types.

The new two-year project, P554A, will add significant breadth and depth to existing mineral deposit information:

- Progressive electronic access to deposit descriptions, typical cross-sections, geological maps, geological photo-libraries, petrographic photographs, technical bibliographies and other information for each deposit;
- Development of supporting mineral province data through collaboration with government geological surveys and key research groups; and
- Cooperative linkages will be established to other quality data providers resulting in the development of a vital information network for the mineral industry and educators.

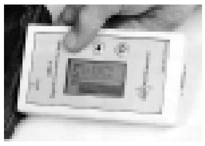
Data Metallogenica has to be self-funding but will be based on not-for-profit principles. Web subscription fees will vary proportionally according to the size of each organisation, with a minimum level of A$200 per annum (plus GST) for unlimited access for bona-fide individuals (i.e. non-employees of a company or organisation). Because of the early important support by the Geological Society of Australia, AusIMM and SEG, members of those organisations will be eligible for a 50% discount (A$100 per annum) once DM becomes public during 2003.

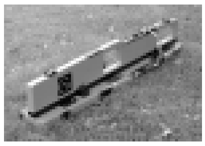
Data Metallogenica is already a unique global reference system for ore deposit information for industry and is predicted to rapidly grow as a critical repository of all kinds of data in the future.

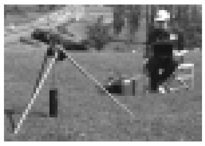
It should also be invaluable as a teaching resource for universities throughout the world – as an example, where else could you ask students to compare the ores, alteration mineralogy and textures, and host rocks of hundreds of porphyry copper deposits, such as Escondida, Bingham Canyon and Batu Hijau, as well as downloading photos for report writing? Universities will have unlimited access for all staff and students for A$1000 per year beginning in mid-2003.

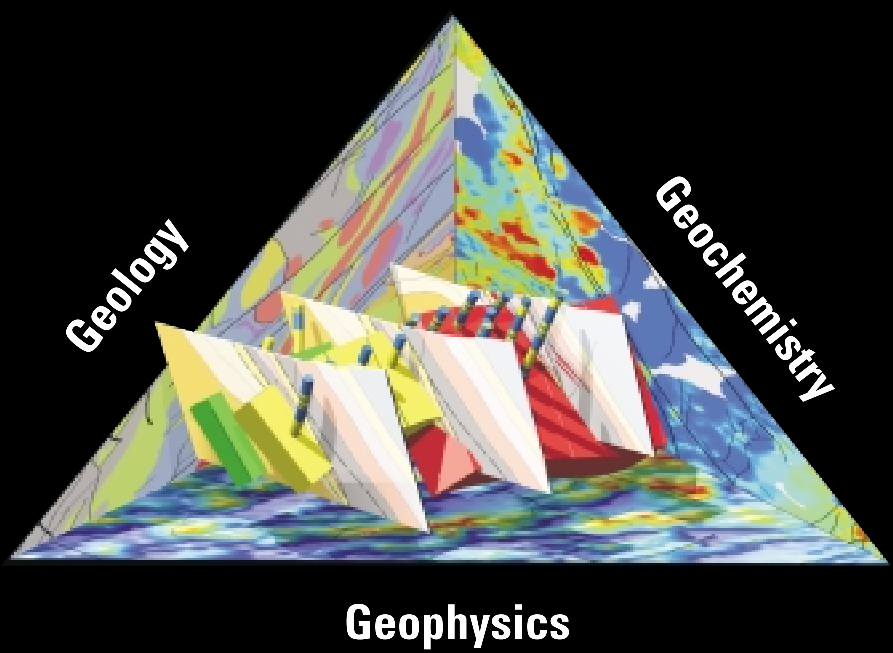
Further information, including sample data and imagery, is available either on the DM website, www.datametallogenica.com or through the AMIRA website, www.amira.com.au

The highest quality images (based on 20Mb master files) are provided in seconds on broadband via a unique compression technology, MrSID, available as a free download on the DM website. Contact Alan Goode at AMIRA for details of the project, sponsorship and web subscription at alan.goode@amira.com.au









Geology
Geochemistry
Geophysics

Abstracts

Section A

ASEG 2003

GROWTH THROUGH INNOVATION

MONDAY FEBRUARY 17 - SESSION 1

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Keynote / Seismic Technical Forum 1: Seismic Amplitudes

SOME KEY GEOPHYSICAL CHALLENGES FACING SANTOS IN AUSTRALIA

Dennis Cooke
dennis.cooke@santos.com.au

This presentation covers some of the key geophysical technical challenges facing Santos in the Cooper and Otway Basins, and NW Shelf of Australia.

In the Cooper Basin, Santos' immediate need is to develop exploration tools for new play trends, with the highest potential new play being Permian stratigraphic traps. AVO and inversion are critical to the Permian strat play. Successful AVO and inversion require improvements to our data quality; with the biggest data quality problem being aliased ground roll on the inner source-receiver offsets. Some examples are presented where this ground roll is successfully removed pre-stack, which gives significant improvements in the stack as well as the ability to do AVO and inversion on the near offset traces.

In the Australian southern margins, Santos has solved some traditional exploration problems by using 3D in the onshore Otway Basin, but the average field size there is small. We are going offshore in that area to find bigger structures, but are challenged by multiples and extracting far offset reflections (for AVO) that are masked by direct arrivals. We think we have solved these processing problems, as shown by recent drilling successes.

For the NW Shelf of Australia, the key challenges facing Santos are multiple suppression and time-depth conversion. For time-depth conversion, PSTM and PSDM appear to be helping, but the imaging velocity may not be the depth conversion velocity, probably because of anisotropy. The multiple problem in the NW Shelf is one of the most difficult challenges we face. Some help has come from tau-p decon and radon transforms, but this problem is not solved.

INCORPORATING UNCERTAINTY IN THE QUANTITATIVE INTERPRETATION WORKFLOW

Klaas Koster
klaas.koster@woodside.com.au

QI: geophysicists are often asked questions like:

1) Is this feature on the seismic data a direct-hydrocarbon-indicator (DHI), and how much does this increase the probability of a successful well?

2) Is this fault block with anomalous amplitudes filled with oil or gas?

3) What is the total oil-volume in place (STOIIP) for the reservoir?

The temptation (and pressure!) is there to give 'straight' answers to these questions. However, application of Bayes' rule is very appropriate in these situations. Bayes' formulated a well-known mathematical approach for updating our perceptions when additional information becomes available. It combines this new information with existing knowledge and also takes into account the uncertainty in using the new information.

The use of Bayes' rule in the above mentioned QI problems could look like this:

1) The prior probability of finding gas in a specific prospect with a dubious trap is 8%. The suspected DHI has a reliability score of 61% and a measurement uncertainty of 20%. Given these DHI scores and the prior probability, the posterior probability of finding gas given the observed DHI is 20%. The updated probability achieves a good compromise between having a likely DHI but a low chance for the trap sealing.

2) A Monte Carlo technique is used to model a large number of reservoir models. These models have varying thickness, net/gross and porosity in the reservoir. Furthermore, the acoustic properties of the sandstones and shales are allowed to vary. Close cooperation with the geophysicist, the geologist and the petrophysicist is required to put realistic bounds on the degree of variation for each parameter. Synthetic seismic attributes are calculated from the reservoir models. The observed attribute map is calibrated to the model in an area where the fluid phase is known. Bayes' rule is subsequently used to calculate fluid phase probability maps over the fault block.

3) Reservoir models, which are realistic from a geological point of view, but result in a large range of possible STOIIP, can be constrained using inversion of seismic data while taking into account the uncertainty in geological, geophysical, and petrophysical information. In this case, the results are a suite of reservoir models, which are consistent with all the data. Typically, this process reduces the uncertainty in STOIIP.

EM / Res Case Studies

AEM BATHYMETRY NEAR BUSSELTON, WESTERN AUSTRALIA - COMPARISON OF 25 HZ AND 12.5 HZ GEOTEM IN AREAS OF HIGH CONDUCTANCE

Julian Vrbancich, Peter Wolfgram and Daniel Sattel
julian.vrbancich@dsto.defence.gov.au

Airborne electromagnetic (AEM) data were collected offshore Busselton, Western Australia, using GEOTEM™ operating at both 12.5 Hz and 25 Hz over the same survey area. The survey covered a region in shallow water up to 35 m depth, and two overlapping tie lines skirting Cape Naturaliste extending into deeper water. The objectives were to compare 12.5 Hz (8 ms pulse) and 25 Hz (4 ms pulse) AEM data in an area of high conductance using conductivity depth sections to map water depth and seafloor resistivity, and to compare B-field and dB/dt responses.

CDI processing of the data with *EMFlow* software showed that for this dataset, CDIs based on the B-field are better suited for high-conductance targets than CDIs based on the dB/dt data. Water depth was best resolved using 25 Hz B-field data. Sub-sea material and deeper water depths below 45 m was best resolved with 12.5 Hz Bz field data. The 25 Hz dBz/dt data gave the poorest results, due to changes in the bird position not being accounted for in the CDI algorithm.

APPLICATION OF ELECTRICAL RESISTIVITY PROSPECTING FOR GEO-ENVIRONMENTAL INVESTIGATION

Mikyung Park, Mutsuo Takeuchi and Hiroomi Nakazato
mikyung@affrc.go.jp

Among geophysical exploration techniques, the application of the electrical resistivity method has recently increased for geo-environmental investigation such as in the detection of soil and groundwater contamination. The electrical resistivity method is used to identify permeable soil layers that are possible channels of contaminant transport. Geo-environmental investigation deals with important social issues and is a growing field of innovation.

This paper describes the present state of soil and groundwater contamination in Japan and the application of the electrical resistivity method to the identification of permeability structures that are possible channels of pollutants. Two field studies were carried out: an analysis of the infiltration of saline water and a measurement of the movement of saline water masses by resistivity monitoring.

The results are summarized as follows: (1) determination of the state of saline water infiltration by resistivity is effective in preventing contamination by saline water and in determining appropriate sites to bore wells where fresh groundwater is available, and (2) combination with the indirect method of resistivity monitoring, which roughly estimates the positions of saline water masses, sharply improves the efficiency of the salt tracer method. Therefore, the two methods should be combined to understand accurately the flow mechanisms of groundwater in contaminated districts.

NEW DEVELOPMENTS IN HIGH RESOLUTION AIRBORNE TEM INSTRUMENTATION

K. I. Sørensen and E. Auken
kurt.sorensen@geo.au.dk

During the last decade, approximately 40 000 ground-based, single-site TEM soundings have been carried out for groundwater investigations in Denmark (an areas of 42 000 km²). In future the investigations will be even more intensified, and therefore the use of airborne TEM measurements has been proposed.

Detailed groundwater investigation in Denmark calls for high-resolution, continuous TEM measurements in the decay time interval from approximately 10 µs 10 ms. In order to meet these requirements, a new airborne TEM system, HETEM, has been developed.

The transmitter coil, together with the Rx coil, is mounted on a 10 x 10 m frame carried by a helicopter at an altitude of 30 m above ground and a speed of 20 km/hr.

The transmitter pattern is segmented, and the highest moment is 16 000 Am². The waveform, together with other controlling parameters, is measured "on the fly" to ensure high data quality. Off-time decay signals are measured in the time interval of 15 microseconds to 10 ms. The data quality from the system is comparable to the data quality obtained by conventional ground-based systems.

Potential Fields - Acquisition

AIRBORNE GRAVIMETRY - A NEW GRAVIMETER SYSTEM AND TEST RESULTS

E. John Joseph, J. Segawa, S. Kusumoto, T. Ishihara, M. Komazawa and E. Nakayama
john@ni.aist.go.jp

Success of airborne gravity surveys mainly depends on determining the three-dimensional (3-D) position of the moving platform. Recent advances in technology, especially in Global Positioning System (GPS) have made it possible to determine the velocity and position of the moving platform with greater accuracy. Taking the advantage of these advancements in GPS technology and using a newly developed system, helicopter-borne gravity measurements were successfully carried out over the Kanto and Tokai districts of Japan. This new gravimeter system is composed of servo accelerometer sensors, stabilized platform, optical-fibre gyroscope to control the stabilized platform, GPS receivers and a data processor.

The 3-D position of the helicopter at every second was accurately determined by interferometric GPS method. These GPS data were also used to compute various correction factors which are applied on the measured gravity acceleration. Real-time differential GPS positioning was also conducted using a separate receiver mounted on the helicopter. These real-time positioning data were used for controlling the optical-fibre gyroscope. The gravity acceleration data were processed and necessary corrections were applied. Numerical filtering was carried out to remove high frequency noises present in the data. The observed free-air gravity anomalies were then compared with upward continuation of the ground truth. We also made an attempt to compile airborne gravity anomaly map.

AIRBORNE VECTOR MAGNETICS MAPPING OF REMANENTLY MAGNETISED BANDED IRON-FORMATIONS AT ROCKLEA, WESTERN AUSTRALIA

Mark Dransfield, Asbjorn Christensen and Guimin Liu
mark.h.dransfield@bhpbilliton.com

Strongly remanent magnetic sources such as those found in the banded iron-formations (BIFs) of the Hamersley Basin impair the interpretation of standard total magnetic intensity survey data. The use of aircraft attitude information, provided by the FALCON™ airborne gravity gradiometer (AGG) system, makes it possible to reference geographically the vector magnetic information collected by the fluxgate triad on board the aircraft. A full aircraft compensation processing method, allowing for permanent, induced and eddy current effects, provides usable vector magnetic data. These data supply valuable extra information for the interpretation of strongly remanent BIFs.

An example using data from a FALCON™ survey near the Rocklea Dome in the Hamersley Basin demonstrates improved mapping of the BIFs by the use of the vector-residual magnetic intensity data.

DRAPE RELATED PROBLEMS IN AEROMAGNETIC SURVEYS: THE NEED FOR TIGHT-DRAPE SURVEYS

D. R. Cowan and G. R. J. Cooper
cowangeo@compuserve.com

The trend towards higher flight height and loose-drape fixed wing surveys has important implications for high-resolution aeromagnetic surveys for mineral exploration, especially for targets such as kimberlites. The IAGSA specifications, implemented by leading airborne geophysical contractors and some governments, make it virtually impossible to acquire adequate data in areas of even moderate relief using conventional aircraft.

Variations in survey elevation give rise to changes in magnetic relief and magnetic texture that are not related to magnetic sources but are simply artifacts produced by varying depth-to-source. Important high frequency and low amplitude magnetic signals are absent in areas of high survey elevation and cannot be recovered by drape corrections, which involve intrinsically unstable downward continuation.

Geophysicists are well aware of the loss of horizontal spatial resolution as survey elevation increases but the loss of subtle information on depth extent is even more serious in exploration for pipe-like bodies such as kimberlites. Aeromagnetic data are relatively insensitive to depth extent because of the rapid decay of the kernel function with depth. At shallow depths there is a clear difference in anomaly shape between a pipe source and a thin sheet but as depth-to-source increases these differences become much less obvious.

For cost-effective high-resolution aeromagnetic surveys for kimberlites we need to fly tight-drape surveys at low level, using aircraft designed to fly at low level such as the Pacific Aerospace Cresco and Fletcher FU-24. The terrain following ability of these aircraft is impressive.

Comparison of loose-drape and tight-drape data shows a dramatic improvement in high frequency content for tight-drape surveys with both magnetic relief and magnetic texture of small local anomalies being preserved. The loose-drape examples show significant variations in magnetic texture due entirely to variations in survey elevation.

MAGNETIC SIGNALS GENERATED BY OCEAN SWELLS

TINA PEDERSEN, TED LILLEY* AND ADRIAN HITCHMAN
Tina_Pedersen@wanadoo.dk

Ocean waves and swells generate magnetic signals, which may be spurious for aircraft carrying out magnetic surveys over ocean areas, and particularly over continental shelves. To check the character of such signals at the sea surface, a magnetometer has been set free from a ship to float unrestricted on the ocean surface for periods of several days. The path of the magnetometer was tracked by satellite; this procedure enabled also the eventual recovery of the magnetometer by the ship.

Superimposed upon a background of slow change of magnetic field, as the magnetometer drifted across different patterns of crustal magnetisation, are high-frequency signals generated by the strong ocean swell present at the time. These wave-generated signals are typically 5 nT trough-to-peak, consistent with theory for their generation by ocean swells several metre trough-to-peak in size.

The magnetic signals reflect the oceanographic effects of wave dispersion, and changing sea-state. In particular, the power spectra for the observed magnetic field exhibit a strong (-7) power fall-off with increasing frequency above the peak of 13 s. This strong fall-off is consistent with oceanographic observations of the spectra of surface swell, and suggests higher-frequency disturbances in such situations will generally be negligibly weak in aeromagnetic data.

INDUCED POLARISATION

COLE-COLE INVERSION OF TELLURIC CANCELLED IP DATA

PETER ROWSTON STEPHEN BUSUTTIL* AND GERARD MCNEILL
parowsto@mim.com.au

Induced Polarisation, like all geophysical methods, suffers from the presence of noise. Of the many sources of noise, tellurics can often be one of the most problematic to remove.

An effective method of removing telluric noise has been trialled on dipole-dipole data acquired by MIM Exploration's proprietary MIMDAS system, during routine surveying in NE South Australia. The method utilises impedances determined from previously acquired MT data to estimate the natural field component of the measured signal.

This paper presents results obtained thus far, displaying significant improvement in data quality when compared to the uncorrected data. The benefits of increased signal to noise and higher confidence in Cole-Cole parameter estimation are outlined.

INTRINSIC NEGATIVE CHARGEABILITY OF SOFT CLAYS

IAN BRANDES AND R IAN ACWORTH
i.brandes@wrl.unsw.edu.au

Lithologies with high clay contents can have negative chargeability. This response is usually attributed to geometric effects in induced polarization and electromagnetic surveys. Negative chargeability has also been noted in laboratory studies, but has remained unexplained.

Traditional membrane polarisation models are of a series of membrane constrictions within a solid substrate, but this model produces only positive chargeability responses. Alternate soft clay polarisation model are considered, involving bulk sample ionic fluxes. These fluxes have been previously studied in electrokinetic dewatering and decontamination studies, but over longer time periods. Of particular note are the large pH gradients that form under an applied electric field. Relaxation of these gradients at the sample's surface produces a potential in the opposite sign to the applied potential, and so produces negative chargeability.

Laboratory electrical impedance spectroscopy data is presented. The experimental data covers a variety of clay types at a variety of water contents. For pure clay samples, a relationship exists between negative chargeability and water content (as a percentage of liquid limit). This trend is not apparent in natural clays.

Field measurements of negative chargeability are presented. Logging data through a soft clay lithology is shown to discriminate between clay and sand layers.

REDUCTION OF NOISE IN INDUCED POLARIZATION DATA USING FULL TIME-SERIES DATA

JOHN PAINE AND ALEX COPELAND
john.paine@onaustralia.com.au

There are a variety of noise sources which affect the accuracy of Induced Polarization data, such as cultural noise, varying self-potential, lightning strikes, telluric currents, EM coupling etc. In this paper we describe a new IP data collection system, which collects full time series data rather than just a single averaged windowed decay. The recording of the full time series allows for greater flexibility in analysing the data to allow noise to be rejected or removed.

This paper will outline the process used to collect the time series data, illustrate the many types of noise observed in the field and demonstrate the superiority of the resulting IP data.

BENEFITS OF LARGE CHANNEL CAPACITY SYSTEMS IN ELECTRICAL GEOPHYSICS

JOHN KINGMAN AND STEPHEN GARNER
jeekingman@cs.com

The merits and value of large channel capacity electrical geophysical systems reach further than simply collecting more responses per interpretation, which in itself is generally sufficient to justify the technology. In addition to that aspect are benefits related to productivity, SNR, and control or weighting of inversion and imaging data feed. No assessment of the cost/benefits analysis of pursuing large channel capacity technologies would have meaning without considering these many other side benefits.

This paper contends that data collected with high resolution, highly synchronous, distributed acquisition systems are ideally suited for advanced data manipulation based on superposition principles.

MINE/COAL GEOPHYSICS

SURFACE ROUGHNESS AND BOREHOLE RADAR IMAGING IN THREE-DIMENSIONS

NAOMI OSMAN, CARINA SIMMAT, JONATHAN HARGREAVES AND IAIN MASON
naomi@es.usyd.edu.au

Broadband VHF borehole radars (BHR) can be used as a tactical tools to map orebodies, faults and other marker horizons; to identify hazards in advance of mining and to stop unnecessary mine development. Ground penetrating radar (GPR) operations in boreholes have a number of advantages over those conducted in mine galleries. Boreholes give freedom from gallery reverberation and offer access to the third dimension. Mine boreholes are often drilled in fans, and can be used to reconstruct targets in 3D.

Significant progress has been made in recent years in using synthetic aperture radar interferometry (InSAR) to reconstruct 3D images from sparse arrays. SAR systems work with backscatter echoes and specular/nadir reflections from smooth surfaces are deliberately avoided. Hard-rock boreholes are thin requiring slimline BHR systems. The fact that slimline BHR systems are not directional makes it difficult to avoid recording nadir data.

Automatic methods of projecting data into 3D image space such as migration and InSAR make stringent demands upon rock homogeneity, translucence and the accuracy of borehole trajectories. These demands can be relaxed by kinematic mapping using geologically plausible 3D primitives such as cylinders, planes and hollows. Field data quality and object illumination constraints set the point of balance between object identification in image space and interactive interpretation in observation space. The balance sought must be able to take advantage of specular reflections, as BHR time sections are frequently dominated by nadir glare.

HIGH-RESOLUTION 3D SEISMIC REFLECTION ACQUISITION APPLIED TO COAL MINING

Gary Fallon, Mike Reveleigh, Troy Peters and Tony Kenny
gnfallon@mim.com.au

In recent years significant improvements in survey design, acquisition and processing technologies have advanced high-resolution 3D seismic reflection imaging. However, shallow coal applications require high-resolution imagery that is more costly than conventional petroleum-scale reflection.

The 3D seismic grid design fundamentally controls the effective spatial sampling and signal-to-noise ratio of the final seismic volume. Whilst orthogonal, brick and slant-line shot-receiver geometries have all been employed, the latter has been found to produce fewer imaging artefacts, at a lower shot density and line-kilometre preparation cost. For targets at depths typical of underground coal-mining operations (70 to 700 m), a CMP bin size of approximately 50 m^2 provides an optimal trade-off between spatial resolution and acquisition cost. If the bin size is increased beyond this point, the definition of subtle structural features in the target coal seam is compromised.

In typical coal imaging situations, dynamite charge sizes are in the range of 150-400 g, which are small enough to provide necessary bandwidth, whilst still generating acceptable signal levels. Practical experience has determined that optimum source coupling is achieved by locating the charge at least 2 m below base of weathering, and at least 12 m below surface. To minimise the reduction in high-frequency fidelity, geophones with a natural frequency of at least 30 Hz are best.

SMART SOLUTION TO A STICKY PROBLEM: IN-MINE CLAY MAPPING USING HIGH-RESOLUTION GEOPHYSICS

G. F. Burnham and P. J. Hawke
glen.burnham@robe.riotinto.com

Within the Mesa J pisolite iron ore mine, clay is distributed unevenly and often forms pods and channels less than 10 m in width. The mine resource model, based on 50 m x 50 m spaced drilling, has been unable to accurately delineate the clay for scheduling and mining purposes. Therefore, alternative methods for mapping the clay-contaminated ore were sought.

Predictive clay mapping will significantly reduce production costs at Mesa J through improved selective mining practices, more accurate scheduling, reduced wear on mining equipment and minimising the need for maintenance of haul roads and ramps.

High lateral resolution electromagnetic (EM) surveying using the Geonics EM31 tool can quickly delineate the extent and orientation of the clays. A block model based on the interpretation of the EM data accurately predicts the volume and tonnage of ore and waste material. While rip-line mapping, infill drilling, ground penetrating radar and gravity can delineate clay to varying degrees of success, none were as efficient as EM31.

Seismic Attributes

APPLICATION OF THE RADIAL BASIS FUNCTION NEURAL NETWORK TO THE PREDICTION OF LOG PROPERTIES FROM SEISMIC ATTRIBUTES

Brian Russell, Dan Hampson, and Larry Lines
brian@hampson-russell.com

The use of the radial basis function neural network (RBFN) for the seismic-guided estimation of log properties was first discussed by Ronen *et al.*, (1994). They applied the RBFN to averaged intervals from log data and the corresponding averaged intervals from the 3D seismic data volumes which were tied by these logs. In more recent work (Hampson *et al.*, 2000), neural networks were used to predict log properties from the complete 3D seismic volume, using each log sample over the zone of interest in the training phase. In this latter approach, the generalized regression neural network (GRNN) was used for the prediction of log properties. In this paper, we extend the RBFN method to the computation of log properties from the full 3D seismic volume, and show the relationship between the RBFN and GRNN methods. Although both methods are based on the application of Gaussian weighting functions to distances measured in multiple seismic attribute space, they are quite distinct and can produce different results if care is not taken in the training procedure. We compare the methods using both model and real seismic datasets and discuss the strengths and weaknesses of each approach. We also discuss the relationship between these two distance-based methods and the better-known multi-layer perceptron neural network (MLPN).

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FLUID AND LITHOLOGY PREDICTION WITHIN A COAL SEQUENCE USING SEISMIC ATTRIBUTE MODELLING AND ANALYSIS (GIPPSLAND BASIN)

Martin Kim, Jarrod Dunne and Boris Gurevich
martin.kim@woodside.com.au

In the Latrobe Group of the Gippsland Basin (Australia) the seismic response of the reservoir is masked by the presence of coal seams. These coal seams possess a large contrast in their acoustic properties (density and P-wave velocity) to those of the surrounding rocks (sands and shales). This causes strong sidelobe interference and coherent noise that overprints the more subtle sand/shale and porefill responses that we aim to detect. This has prevented reliable delineation of existing fields and the possible discovery of new fields in the area.

To study the effect of coal seams on seismic attributes we modelled the seismic response of sand-shale-coal sequences. Synthetic seismograms of a 'coaly sequence' were built from simple models consisting of three to four layers and also from blocked well log data. The synthetic seismograms were computed for these models using convolutional modelling as well as the reflectivity method, which takes into account multiple reflections and mode conversions. Input models created by randomly shuffling the blocked logs were used to analyse the sensitivity and robustness of AVO attributes to variations in rock and fluid properties.

Fluid effects were detectable on the far-offset amplitudes for coal sequences with no more than fifteen to twenty percent coal content. For larger amounts of coal, fluid detection becomes ambiguous regardless of the distribution of coal layers in the sequence. A useful attribute for predicting coal content is the near-offset average absolute amplitude. A better attribute for detecting fluid effects can be formed as a linear combination of the far-offset event amplitude and the near-offset average amplitude.

These attributes were applied to a 3D prestack depth migrated dataset to characterise the 'coaly sequence' and calibrate it to nearby wells. The combined fluid attribute predicted the porefill in all five wells and indicated possible hydrocarbon extents in the known fields.

RESERVOIR MONITORING WITH CONTINUOUS ACOUSTIC MEASUREMENTS

*D. M. Leslie and B. M. Hartley**

This paper describes a technique for detecting changes in the subsurface, possibly caused by extraction of oil and gas from reservoirs, by using phase conjugation of continuous acoustic signals. This technique can equally be applied as an alternative to conventional seismic surveying methods.

The method is based on measurements of the response of the subsurface to continuous acoustic signals at a number of fixed frequencies. Changes in the subsurface will result in changes in amplitude and phase of the returned signal. These changes are all that are required to identify alterations in the subsurface. Without knowledge of the subsurface velocity field, temporal images of the changes can be produced from the superposition of reconstructed continuous signals. If the velocity field is estimated from conventional processing flows, the changes can be imaged in depth by back propagating the changed signals through the subsurface velocity model. Alternatively, if the changes in the subsurface can be predicted or modelled, the changes in the returned signal can be used to improve the velocity model of the subsurface. Back propagating the changed response as a continuous signal produces high amplitude intensity in the areas where changes have taken place.

The methodology exploits on lock-in amplifier concepts that detect amplitude and phase of fixed frequency signals against a reference signal. Lock-in amplifier operation can be simulated from digitised data provided that the reference signal phase is also recorded. Lock-in amplifiers can easily reject interfering signals that are 1 million times (120 dB) larger than the signal being measured without using prefilters. Integration of signal can be made over extended periods and monitoring of the signal can be continuous. All this means that the source signal does not have to be of high power, so that it may be compact and fixed in position.

Seismic Acquisiton 1

3D STRIKE VS DIP STREAMER SHOOTING DIRECTION COMPARISON

Andrew S. Long and Jurgen Hoffmann
andrew.long@pgs.com

A decision to pursue 3D streamer acquisition in a certain shooting direction requires a consideration of seismic phenomena including subsurface illumination, spatial sampling, wave propagation, and the idiosyncrasies of seismic imaging technology. We provide both theoretical and synthetic modeling examples to provide a framework for objective discussion.

The important aspect is that the 2D dip-shooting requirement becomes irrelevant in 3D surveys. In any 3D survey location, a series of arguments will arise that support each possible shooting direction. The key issue is that both the subsurface model and the surface acquisition geometry are intimately linked, and each must be given specific consideration during processing. Consideration is also given to new streamer acquisition technologies that are helping to blur the distinctions between dip and strike shooting results.

THE EFFECT OF SEA SWELL ON SEISMIC DATA

Alex Shepherd and John McDonald
shephera@geophy.curtin.edu.au

Marine seismic surveys are often run in rough sea conditions. While this issue is not necessarily regarded as significant for single surveys, it is more important to quantify these effects for use in time-lapse differencing for monitoring of hydrocarbon reservoirs. Sea swell causes the vertical displacement of both the seismic source and the receivers (mainly the receivers). There is also the consideration of the ghost signals that reflect off the water surface above the source and the receivers that can be displaced relative to the primary signal. These displacements can affect the seismic signals so that there is a significant mismatch in the data from different surveys.

A synthetic survey was made on a physical modelling system over a horizontal acrylic block immersed in water in a tank. A shot record was collected using piezoelectric transducers as the source and receiver containing 36 channels. From this, 144 shot gathers were generated to form a 2-D line with two planar seismic horizons. Using this as the master dataset many sub samples were generated, each of which had varying degrees of swell statics introduced. Each sub set was differenced with the master 2-D line to generate difference 2-D sections showing the effects of swell. The statistics analysed for each sub set were the maximum positive, negative and root mean square (RMS) trace amplitude values.

Results indicate that there is a significant effect on the data with a swell of over 2-3 metres. The maximum effects of sea swell appear toward the sea wave amplitude consistent with approximately half the seismic wavelength of 100 Hz showing evidence of "notching" at this frequency. Thus a moderate swell can have a significant effect on data to be differenced in time-lapse studies.

IN PURSUIT OF THE IDEAL 3D STREAMER SYMMETRIC SAMPLING CRITERIA

Andrew S. Long, Charles R. T. Ramsden and Jurgen Hoffmann
andrew.long@pgs.com

Artifact-free seismic imaging explicitly depends upon uniform surface and subsurface sampling of the 5D seismic wavefield. This is never achieved in practice, as compromises must be made in the name of cost. We use the principles of *3D symmetric sampling* and *minimal data sets* to build a foundation for evaluating the optimal *single vessel* 3D acquisition methodology.

We demonstrate through synthetic and real data examples a number of innovative acquisition scenarios that might provide significant advances in subsurface illumination density, noise attenuation, and improved seismic data quality.

Our conclusion is that High Density 3D streamer acquisition + 100% sail line overlap + anti-parallel sail lines + strike shooting offers the best available solution, as constrained by operational considerations.

Anisotropy / Seismic wave inversion

FREQUENCY DEPENDENT ANISOTROPY OF POROUS ROCKS WITH ALIGNED FRACTURES

Miroslav Brajanovski and Boris Gurevich
miro@geophy.curtin.edu.au

One of the main issues in the characterization of any reservoir is the ability to predict the effect of fluid properties on seismic characteristics. This effect is studied by modelling fractures as very thin and highly porous layers in a porous background. Elastic moduli of a porous rock permeated by a system of such fractures distributed periodically are obtained using the result of Norris for elastic properties of layered poroelastic media.

When both pores and fractures are dry, such material is equivalent to a transversely isotropic elastic porous material with linear-slip interfaces. When saturated with a liquid this material exhibits significant attenuation and velocity dispersion due to wave induced fluid flow between 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 the attenuation and dispersion depends on the background permeability, fluid viscosity, as well as fracture density and spacing.

APPLICATION OF AMPLITUDES IN SHALLOW SEISMIC REFRACTION INVERSION

Derecke Palmer
d.palmer@unsw.edu.au

I generate three starting models for the inversion of a set shallow seismic refraction data using wavepath eikonal traveltime tomography. Two models are generated with the generalized reciprocal method (GRM), which uses a multi-layer model with discrete velocity changes while the other is generated with a one dimensional (1D) inversion algorithm similar to the tau-p method, which uses a model with vertical velocity gradients. There is little correlation between the results in either the absolute depths, the relative depths or the refractor velocities.

I attribute the differences in the absolute depths to the occurrence of a velocity reversal in the overburden, the existence of which is indicated by the concave-upwards shape of the traveltime graphs and by the extremely rapid decrease in amplitudes. I attribute the differences in the relative depths and seismic velocities to the poor starting model generated by the 1D tau-p inversion algorithm, which is unable to resolve the fundamental ambiguity between seismic velocity and structure on refracting interfaces. The GRM-derived refractor velocities are compatible with the head coefficients determined with amplitude products.

The existence of velocity gradients is suggested by the convergence of the traveltime graphs with increasing shot-to-detector distance. I attribute this convergence in part to the large variations in signal-to-noise ratios, which affect the accuracy of the traveltime data.

The shot amplitudes decrease rather than increase with distance, which supports the occurrence of distinct interfaces with velocity gradients over relatively small depths. Therefore, while velocity gradients are likely to occur, the results generated with 1D tau-p tomography are probably not representative of the subsurface conditions.

The considerable differences between the results generated with the GRM and those obtained with 1D tau-p tomography are compelling demonstrations of the non-uniqueness of model-based inversion and of the importance of the selection of the initial model. Accordingly, all methods of model-based inversion of shallow refraction data could usefully include starting models generated with the GRM or the refraction convolution section.

SHALLOW SURFACE WAVE INVERSION - RESEARCH AND APPLICATIONS IN WESTERN AUSTRALIA

Adam O'Neill, Mike Dentith and Ron List
aoneill@geol.uwa.edu.au

Existing surface wave modelling methods fail to correctly interpret some critical engineering scenarios, for example Earth models comprising 'soft' under 'hard' layers. Numerical and experimental repeatability analyses and the use of synthetic seismograms to reproduce the field data exactly, accounting for all superposed modes, leads to a better understanding of resolution and accuracy of the inversion results.

An inversion scheme based on the observation of an 'effective mode' phase velocity, whilst employing realistic error envelopes, has proved more successful than conventional methods, and demonstrated the need for array length at least 2.5 times the depth of investigation.

Keynote: Environmental

MAPPING SALINITY AND GROUNDWATER SYSTEMS- A MULTI-DISCIPLINARY APPROACH INTEGRATING GEOPHYSICS AND REGOLITH GEOSCIENCE

Ken Lawrie, Dave Gibson, John Wilford, K. P. Tan, Colin Pain and Tim Munday
ken.lawrie@ga.gov.au

In Australia, regolith (the soils, sediments, weathered bedrock and sediment, that lie between fresh air and fresh bedrock) is the major salt store in the landscape. Groundwaters move through these regolith materials, mobilising the salt which salinises our groundwaters, waterways and land. Yet today there is little more than surficial knowledge of regolith landscapes and materials, little appreciation of the distribution of salt or saline groundwaters buried in the landscape, and even less information on the dynamics of water-rock-salt interactions in these environments. This paucity of information restricts management options.

CRC LEME's approach integrates new bedrock and regolith science knowledge, in a flexible, multi-disciplinary approach that utilises a variety of remote sensing (e.g. Landsat, ASTER) and geophysical technologies (eg high resolution DEMs, electromagnetics, magnetics and radiometric data) appropriate to particular landscapes and problems. Airborne and ground geophysical data are typically acquired at sub-catchment scales in key study areas considered representative of the catchment and problem to be addressed. When validated by surface and drilling data, these data can provide 2D and 3D maps of key elements of salinity and groundwater systems.

Importantly, interpretation of these geophysical data is assisted by an understanding of regolith geoscience. Multi-disciplinary studies that include landscape evolution, geomorphology, sedimentology, sequence stratigraphy and weathering history provide a knowledge framework for resolving the distribution of materials in the sub-surface. This is particularly useful in mapping and predicting the connectivity of aquifers and aquicludes, and in identifying and mapping units of similar hydraulic conductivity and potential groundwater flow paths in the sub-surface. These data in turn provide information that constrains models of groundwater flow and salt mobilisation. This approach builds on existing groundwater flow system and catchment characterisation frameworks, and provides a basis for assessing the risk of salinity within catchments at a range of scales and in a variety of landscapes.

GEOPHYSICAL INVESTIGATION OF RIVER MURRAY SALINITY: A CASE STUDY USING FAST-SAMPLING TEM

Michael A. Hatch, Ben Hopkins, and Geoffrey White*
zonge@ozemail.com.au

Australian Water Environments (AWE) has been engaged by the Bookpurnong - Lock 4 Environmental Association (BL4EA) to investigate the interception of saline groundwater along the River Murray downstream of Berri, South Australia. Groundwater discharge contributes approximately 70 tonnes per day of salt to this reach of the river. Salt loads are predicted to rise to more than 200 tonnes per day over the next 30 years. The proposed Environmental Enhancement Scheme (EES) comprises a series of shallow pumping wells constructed primarily on the floodplain to intercept saline groundwater before it reaches the river. Intercepted groundwater will be pumped to the Noora Disposal Basin located some 25 km inland. A detailed understanding of the hydrogeological environment is essential to the design and effective operation of the EES and similar groundwater interception schemes.

In March 2001, Zonge Engineering conducted a fast-sampling TEM (time-domain EM) traverse to investigate changes in sub-surface resistivity across the highland area adjacent the River Murray and the floodplain within the riverine trench. The highland is planted with citrus and has been irrigated since the 1960's. The shallow depth to saline groundwater within the Monoman Formation aquifer has seriously degraded the health of native vegetation health across the floodplain.

In May 2002, twelve shallow wells were constructed along a narrow stretch of floodplain located approximately one kilometre downstream of the first traverse. Accurate formation samples were collected and logged. Zonge Engineering conducted a second fast-sampling TEM survey in June 2002 along a line parallel to the trial borefield to investigate the correlation between TEM data and variations in hydrogeology identified during drilling.

This paper reports the results of the two land-based geophysical surveys and comments on the utility of fast-sampling TEM as a tool for mapping subsurface hydrogeology across the highland and floodplain at Bookpurnong.

GROUND-BASED GEOPHYSICAL MEASUREMENTS IN SALINITY-AFFECTED AREAS PRIOR TO AEM SURVEYS

G. Buselli, D. Hunter, T. Munday and K. Wilkinson
jock.buselli@csiro.au

Ground-based electromagnetic and electrical surveys were conducted in areas of southeast Queensland in March 2001 to establish representative ground conductivity values down to depths of greater than 50 m for use in designing suitable airborne electromagnetic (AEM) surveys to be flown in those areas later that year. Once AEM data were available, a comparison between the results of the ground-based and AEM surveys was made.

High-resolution definition of near-surface conductive structures was achieved with the combined use of DC resistivity and frequency-domain EM31 measurements, while transient electromagnetic (TEM) soundings provided reliable values of deeper conductivity.

A comparison of the results of ground-based and corresponding AEM data shows that there is broad agreement between the behaviour of the conductivity of the conductive layer detected by AEM and corresponding conductivity values derived from ground-based data. However, the models obtained from the two sets of data do not agree in detail, probably because the AEM inversions were constrained to have a resistive basement, whereas ground-based and down-hole results show that the basement is generally relatively conductive.

Mineral Case Histories: SA/NT/BH Session 1

CHALLENGES IN MINERAL GEOPHYSICS: EXPLORATION FOR UNCONFORMITY URANIUM IN ARNHEM LAND (NT)

Geoff Beckitt and Andrew Bisset
Geoff_Beckitt@cameco.com.au

Since the late nineties Cameco Australia Pty. Ltd. and Cogema Corporation Pty. Ltd have been involved in exploration for unconformity related uranium deposits in Arnhem Land Australia. During this time the exploration model has evolved from the initial Canadian-Athabasca based model. Physical property measurements and field tests have led to the current integrated exploration strategy that incorporates the disciplines of geology, geochemistry and geophysics.

Airborne radiometrics continues to be the primary tool for identifying surface uranium anomalies. However, other geophysical techniques are utilised in order to map basement lithologies, alteration and the depth of sandstone cover, which are also key exploration objectives. With these aims in mind airborne hyperspectral, magnetic and electromagnetic geophysical techniques have been extensively utilised as efficient methods for quickly evaluating large areas where rugged topography prevents effective use of ground techniques. The usefulness of these techniques is discussed utilising examples from Cameco's King River project, located in northern Arnhem Land.

It is shown that 0.5 s sampling is viable for detailed airborne radiometrics, TEMPEST can be used to estimate the unconformity depth and Hyperspectral airborne surveys can be used instead of ground PIMA measurements for detecting alteration within sandstone.

In both Arnhem Land and the Athabasca, exploration is now focusing on identifying uranium below thick sandstone cover sequences. The Australian challenge is to undertake this exploration without the strong graphitic conductors, which are closely related to the Athabasca unconformity uranium deposits.

GEOPHYSICAL RESPONSES OF THE PROMINENT HILL FE-CU-AU-U DEPOSIT

John Hart and Hamish Freeman
jhart@minotaurexploration.com.au

In November 2001, Minotaur Resources announced the results of discovery drillhole URN001. The drillhole intersected 107 m averaging 1.94% copper and 0.66 g/t Au from 200 m depth and a further 152 m averaging 1.20% Copper and 0.61 g/t Au from 429 m, hosted in a hematite breccia. URN001 was targeted at a gravity anomaly, located to the south of an intense magnetic anomaly. Targeting of the gravity anomaly utilised 3D smooth model inversion.

Following the announcement of the assay results from URN001, potential field and electrical surveys were completed over the prospect area. Downhole induced polarisation logging of URN001, showed that the high-grade copper mineralisation was associated with chargeability and resistivity anomalies.

In an attempt to highlight zones of high-grade copper mineralisation, a dipole-dipole induced polarisation (IP) survey was performed. A strong phase anomaly, coincident with a gravity anomaly was highlighted by this survey.

Drill testing of this anomalous source resulted in the intersection of massive hematite, containing little to no copper mineralisation. Downhole IP logging, and petrophysical work has confirmed that the hematite is chargeable and has a low resistivity. The electrical properties of the "barren hematite" are comparable to the high-grade copper mineralisation. The barren hematite is also a significant contributor to the gravity anomaly seen at Prominent Hill. As a consequence it is difficult to distinguish between mineralised and unmineralised breccias by geophysical methods.

Keynote / Seismic Technical Forum 2: The Drive For Better Bandwidth

THE DRIVE FOR BETTER BANDWIDTH

Mark S. Egan
egan9@gatwick.westerngeco.slb.com

As the saying goes, you can never be too rich, too thin,... or have too much bandwidth. Consequently the desire for better bandwidth has been never ending.

Actually, the term "bandwidth" is sometimes used a little loosely. For instance, "bandwidth" and "resolution" are often used interchangeably, but actually there is a fine distinction. Bandwidth relates to the range of frequencies in the spectrum, and thereby refers both to Fmin and Fmax.

This is an attribute relevant for discussions in inversion. Resolution refers to the ability to delineate things like thin beds and pinchouts in wiggle trace displays. Although opinions vary, from a pragmatic and empirical perspective, many geoscientists feel this is tied chiefly to Fmax. That is, the specific value of Fmin is not particularly relevant to resolution - as long as at least two octaves of "bandwidth" are present.

Causes that limit recoverable bandwidth and resolution are many. They include ghosts, multiples, noise and arrays. The industry has had some success at addressing these causes by changing how the wavefield is sampled. For instance in seabed surveys, sampling both the pressure and particle velocity components of the wavefield allows signal to be acquired more continuously from Fmin to Fmax - thereby improving bandwidth. This is because the corresponding ghost notches are staggered.

On the other hand, by sampling just one component of the wavefield, but doing so more finely in a spatial sense, noise trains can be suppressed better. This is because the noise trains are no longer aliased and can therefore be easily attacked by various FK or adaptive filters. This is the strategy in single sensor surveys. In the case of ground roll in onshore surveys, this can have benefits at both ends of the temporal spectrum. For instance, direct-travelling ground roll is often strongest at low frequencies; so removing it from a data set can allow the low frequency content in the underlying signal to be seen - thereby effectively lowering the Fmin value. However, if scattering is prevalent, the contamination of the spectrum at high frequencies can be significant too. This is because the amplitudes of scattered waves are proportional to the square of the temporal frequency. Hence, in such cases, being able to remove scattered ground roll from a data set can allow us to see the high temporal frequencies in the signal - thereby increasing the effective Fmax.

Analogously in the marine case, by sampling the swell noise more finely along the streamer, we are able to remove it more successfully than in the past. This allows us to tolerate the acquisition of more noise in the raw data. Therefore, the streamers can be raised to shallower (noisier) depths. By doing this, the receiver ghost notch in the signal is shifted to a higher temporal frequency often permitting dramatic improvements in resolution.

Finally, improvements in data processing and interpretation have also permitted improvements in the drive for better bandwidth. One case in point is the full waveform prestack inversion as enabled by formulations that exploit the genetic algorithm. This method simultaneously finds the correct NMO velocity and the correct amplitude variation with angle. Consequently both low- and high-frequency model components are derived by the inversion.

RECENT SEISMIC ACQUISITION TRIALS IN THE COOPER BASIN

J. R. Hughes and S. R. Brew
john.hughes@santos.com.au

During the last two decades, whilst acquiring approximately 102 000 km of 2D data and 9 100 km^2 of 3D data in the Cooper/Eromanga Basins, extensive testing has been conducted to optimise the quality and productivity of the seismic coverage. The most significant results of trials carried out up to the mid-90s have previously been published in papers dated 1989 and 1995 (Hughes & Fitzgerald).

As a result of tests carried out in recent years, it has become apparent that we have gone as far as we can in gaining improvements in quality and productivity with the state-of-the-art acquisition systems currently available. Innovative acquisition technologies will be required if we are to make further advances in data quality whilst improving productivity to balance the inevitable higher cost of such systems.

This paper summarises the trials carried out in the Cooper Basin utilising both prototype technology and the partial simulation of technology becoming available in other parts of the world. The prototype technology consisted of a 36 tonne tracked vibrator being compared to the existing 27 tonne non-tracked vibrators. In addition, the impact of utilising densely sampled receiver spreads, consisting of 1.67 m and 5 m group intervals compared to our production group interval of 40 m, in sampling and subsequent attenuation in processing of the various noise trains is reviewed.

These trials provide some insights into the potential nature of future acquisition systems needed in the Cooper Basin if we are to increase the bandwidth to achieve our interpretive objectives.

EM: Noise Reduction

100% DUTY CYCLE TEM: FASTER ACQUISITION AND LESS NOISE

Anton Kepic and Brett Adams
kepic@geophy.curtin.edu.au

In a typical impulse TEM system, such as SIROTEM, the loop current is periodically switched between on and off with the direction of current flow alternating after every off period. Measurements are performed in the off period; thus, measurements are conducted in the absence of any primary field. In Australia almost all TEM systems are operated at 50% duty cycle, that is for half of the transmitter cycle the transmitter is not connected to the loop. With the introduction of relatively high-voltage, battery powered transmitters, such as the Zonge ZT-30 and full waveform recording, clean data from 100% duty cycle TEM is a matter of pushing a button. With current swing now doubled and changing at twice the normal rate we can expect an improvement in signal-to-noise by almost a factor of three. However, is it TEM as we know it?

The principal difference between 100% and 50% duty cycle is that during measurement the transmitter loop is connected to a high voltage, low impedance source rather than being left open circuit. This has two very important ramifications:

A) The loop time constant is superimposed on the data, and

B) High voltage gradients across the loop during measurement can contaminate the TEM measurement.

Simultaneous measurement of the current waveform and post-processing can remove the effect of the loop time constant. Problem B precludes the use of single loop (for obvious reasons) and separated loop configurations. Both are saturated with coupling to the high voltages the transmitter uses to push current through the loop. In the separated loop configuration capacitive coupling between wires completely dominates for 20 ms or more. The use of a small loop or sensor that is electrically isolated (with a Faraday Cage), such as a RVR or downhole probe, counteracts this problem.

CHARACTERISATION OF CULTURAL NOISE IN THE AMT BAND

Louise Pellerin, David Alumbaugh and Nestor Cuevas
pellerin01@aol.com

As part of a project to investigate long-term exposure of low-level earth currents on dairy cows, an unusual multiple-site, remote-reference audio magnetotelluric (AMT) data set was acquired on four Wisconsin dairy farms and two remote sites in the summer of 2001. At each dairy, several five-component sites were recorded along with a remote located in a wildlife refuge, at a distance of roughly 50 km from the farms. EMI MT24 systems were deployed under power line transformers, above and below three-phase transmission lines, in close proximity to machinery such as compressors, pumps, electric fences, and large fans. Data were recorded at the dairies with 20 m dipoles to capture the natural signal while not overloading the instrument electronics with high cultural signals. Sampling frequencies of 48, 9.6 and 2 kHz were employed.

To accurately determine the characteristics of the earth's fields, including the magnitude of the very narrow band-nature of 60 Hz signal and its harmonics, normal impedance estimation techniques using relatively short segments of the time series were found inadequate. Thus, the data were processed with a Fast Fourier Transform of length 524 288 applied to each of the 500 000 data point segments. Electrical resistivity data were acquired with Wenner array spacings of 1 to 10 m. Earth current densities were estimated from the 1 m resistivity values and the electric field data from the MT24.

Short recording times were used to determine earth currents under different conditions, not to estimate the impedance. Hence, we present characteristics of various cultural noise sources to improve the knowledge base of what practitioners must deal with in noisy environments. We are not evaluating processing technique, but have applied some robust processing to observe if it is possible to attain impedance estimates in the presence of coherent noise and low signal strength.

ESTIMATING NOISE LEVELS IN AEM DATA

ANDY GREEN AND RICHARD LANE
greenaa@ozemail.com.au

This paper reports the results of analysing AEM data where the same flight line has been flown repeatedly to monitor system performance.

When these data are corrected for the effects of variable survey altitude they provide a good measure of the reproducibility of AEM data. The analysis has been conducted for both frequency and time domain systems and shows that, where the area is even moderately conductive, multiplicative errors will provide the dominant source of noise for AEM surveys. Errors typically have standard deviations of 2 % and can easily induce fluctuations of 10%. Moreover, because of their geometric origins, these errors are highly correlated between channels. Frequency domain HEM and Z component time domain systems produce errors that are largely unrelated to time/frequency/conductivity. This is not the case for X component data from asymmetric systems.

OPTIMISING AEM TECHNOLOGY FOR SALINITY APPLICATIONS

ANDY GREEN
greenaa@ozemail.com.au

In seeking to apply AEM data to salinity problems it is important to understand that the requirements are substantially different from that of mineral exploration. Given its exploration history, it's perhaps not surprising that currently available technology could be considerably improved for salinity applications. This paper suggests how we could change the way we acquire, process and interpret AEM data to improve its usefulness in a number of key areas.

Improved conductivity discrimination in the top 10 m
This will only be obtained by improving the high frequency fidelity, reducing survey altitude, and increasing the geometric stability of our existing systems. There is much that can be done in this area and some systems are getting close to the required specifications.

More accurate, constrained inversion strategies to estimate the true the regolith conductivity profile
We need new inversion strategies that can take advantage of the improved quality data and make use of constraints that are available from other data sets and models of groundwater processes.

New ways of using AEM that will reduce the total cost
When AEM is acquired in the same way as mineral exploration surveys it is just too expensive to find wide application for salinity applications. On the other hand many salinity applications do not require this very high sampling density. We need new ways of designing surveys that only acquire AEM data where it is needed to complement other information and to establish the conductivity structure in critical areas. This may mean flying widely spaced lines or even single flight lines to establish the conductivity profile in critical areas.

The paper will review these challenges and recommend strategies for improving our performance.

ENVIRONMENTAL SALINITY

GROUNDWATER EXPLORATION WITH AEM IN THE BOTETI AREA, BOTSWANA

DANIEL SATTEL AND LESEGO KGOTLHANG
dsattel@fugroairborne.com.au

As part of a project by the Department of Water Affairs, Botswana to evaluate groundwater resources in the Boteti Area in Botswana airborne EM data were acquired with the TEMPEST system. The project area is characterised by a palaeolake system bordered by elevated terrain to the south. Lower-lying areas are covered by a thick layer of Kalahari Beds with saline groundwater generally situated less than 20 m below surface. The elevated areas have Karoo Sediments, consisting of sandstones and mudstones, at shallow depths.

For the palaeolake terrain, the target aquifers are fresh water zones associated with recharge pans above the saline water table. The correlation of AEM-derived conductivity-depth profiles with drillhole records show that the conductivity of Kalahari Beds is primarily a function of clay content, water saturation and water salinity. The shallow conductivity structure outlines several resistive zones located within Boteti River alluvium beneath the present and past river channels. These prospective zones are interpreted to have a low clay content and to be saturated with fresh water.

In the elevated terrain the target aquifers are sandstones sandwiched in-between dry alluvium and mudstone. The comparison of AEM results with drillhole data indicates that sand- and mudstones have low and high conductivities, respectively. Favourable locations for freshwater exploitation include palaeochannels incised into the mudstone and shallow fractured sandstone units.

LARGE-SCALE TEM INVESTIGATION FOR GROUNDWATER

ESBEN AUKEN AND KURT I. SØRENSEN
ESBEN.AUKEN@GEO.AU.DK

The TEM method has proven to be a strong tool for the delineation of water bearing sand and gravel layers. We discuss newly developed TEM systems (PATEM and HiTEM) along with developments in data interpretation. Finally the TEM part of the Aarhus Survey is presented. This survey covers an area of more than 100 km^2 and about 6000 TEM soundings have been measured.

A GEOPHYSICAL INVESTIGATION OF DRYLAND SALINITY AT CRESSY, TASMANIA

G. D. PETERS AND J. E. REID
geoffp@elkedra.com.au

Geophysical methods have been used at Panshanger Estate near Cressy, Tasmania to map the distribution of salt affected areas, and the underlying catchment structure.

Frequency domain electromagnetic (FEM) techniques were used to detect near surface salt affected zones on the basis of their high conductivity. Areas visibly affected by salt were found to coincide with areas displaying the highest conductivities. Other areas displaying moderate to high conductivity did not appear to be salt affected but may represent areas of future salt risk. Magnetic, gravity and time domain electromagnetic (TEM) techniques, in conjunction with drill logs from holes near the field area, indicate that the western half of the field area is underlain by shallow Jurassic dolerite, while to the east and north east, the dolerite is covered by a thicker layer of sediment. In the western part of the survey area, high conductivities occur close to the edges of bedrock highs, indicating that bedrock topography may be controlling groundwater movement. These bedrock highs generally correlate with surface topographic highs, and the elevated conductivities, indicative of high salt storage, are measured over depressions and creeks.

A sinuous conductivity anomaly in the north east of the field area occurs on slightly elevated ground, in an area where Tertiary cover is thick. There was no visible evidence of salinity at the surface over this feature, and it was interpreted as a shallow palaeo-channel on the basis of EM measurements. An investigation borehole intercepted an upwardly fining sandy clay sequence, representative of a meandering fluvial system. EC 1:5 analysis of the sediment core and water analysis indicates that the palaeo-channel may act as a mechanism of salt transport and storage.

Mineral Case Histories: SA/NT/BH Session 2

THE IP RESPONSE OF SEDIMENTARY COPPER DEPOSITS AT KAPUNDA, SOUTH AUSTRALIA

Robert Stuart and Mike Dentith
rstuart@geol.uwa.edu.au

The Adelaide Geosyncline is host to sedimentary copper deposits that led to the formation of a copper mining industry in Australia in the mid 1800's. During the 1960's, historic workings at Kapunda were revisited in the search for possible extensions to mineralisation. Due to poor outcrop, geophysics played a significant role in this program. In particular the induced polarization method was used to look for primary sulphide mineralization of the Kapunda ore. The interpretation of these data relied largely on the calculation of a metal factor. A re-interpretation of these data using inversion of the PFE has revealed further information regarding the structure of the mineralised zones, and led to the identification of several targets for copper mineralisation.

MAGNETIC MODELLING AND PETROPHYSICAL DATA FROM THE MUSGRAVE RANGES, SA

N. Shearer, and J. Gum
shearer.andrew@saugov.sa.gov.au

Following acquisition of detailed aeromagnetic data by Primary Industries and Resources South Australia (PIRSA) within the Musgrave Block of South Australia a program of reconnaissance drilling was planned. The drilling program was designed to provide geological, geophysical and geochemical information in an area that has not been actively explored on a large scale for almost forty years.

Initial location of the drill holes was based on interpretation of the regional aeromagnetics. The aim of the drilling program was to define occurrences of the highly prospective ultramafic/mafic Giles Complex and the Birksgate Gneiss. Drill holes were also planned to test structures observed on the regional aeromagnetics. To further define the drill hole locations a series of detailed ground magnetic profiles were acquired. Due to time constraints and a lack of petrophysical data, modelling of the ground magnetic profiles was initially limited to qualitative methods rather than forward modelling. Results of the drilling program allowed more complex geophysical models to be generated. The results of these models could be used for a future drilling program. Density and magnetic susceptibility values were subsequently measured for both the target lithologies and country rock. These petrophysical properties along with the geological and geochemical data obtained will be invaluable in planning future programs in the area.

MAPPING MINERALOGICAL AND STRUCTURAL RELATIONSHIPS WITH SATELLITE-BORNE ASTER AND AIRBORNE GEOPHYSICS AT BROKEN HILL

R. D. Hewson, A. Mah, M. Dunne and T. J. Cudahy
rob.hewson@csiro.au

The recent availability of 14 band multi-spectral and 15 m DEM data from the satellite borne ASTER (Advanced Spaceborne Thermal Emission Reflection Radiometer) instrument has introduced new possibilities for geological mapping and integration with traditional geophysical data sets. Calibrated radiance at the sensor data and atmospheric corrected ASTER products, such as surface reflectance and emissivity imagery, have been made available by NASA/USGS and the Japanese agency, ERSDAC. ASTER radiance data measures five bands at 30 m resolution, within the short-wave infrared 2.1 to 2.5 μm wavelength region, and also five bands at 90 m resolution within the 8 to 12 μm thermal infrared region. This compares with only one band as measured by Landsat TM for each of these regions. An investigation into the capabilities of ASTER and strategies for its integration with geophysical data (using ER Mapper) was undertaken at Broken Hill, given its high spatial geological control and extensive airborne geophysical data sets. Mineral (group) maps derived from multi-scene ASTER data, collected over the Broken Hill Block, proved useful for discriminating stratigraphic units, regolith and areas of alteration. In particular ASTER imagery highlighted several sericite-rich as well as quartz-rich colluvial regolith. Variations in ASTER's derived AlOH mineral spectral signatures correlated with higher potassium radiometric responses and indicated a change in the muscovite chemistry, possibly due to retrograde metamorphic alteration. However, structural features associated with retrograde shear zones were identified most clearly using aeromagnetics. Overall ASTER data products provided complementary mineralogical information to the structural interpretation afforded by geophysical data sets.

Seismic Attributes 2

QUANTIFICATION OF FLUID PHASE PROBABILITY IN PROSPECT EVALUATION USING A BAYESIAN APPROACH

Torill Andersen, Paul Martin and Klaas Koster
torill.andersen@woodside.com .au

This paper discusses a method to quantify fluid phase probabilities by integrating rock property trend models with seismic attribute maps.

Rock property trend models for the reservoir sandstone and surrounding shales, with quantified uncertainties, were used to model the near and far angle seismic response.

Forward modelling of many realistic reservoir models was done in close cooperation with the petrophysicist and geologist. Brine, oil and gas filled reservoir sandstones were modelled. A statistical method was used to calculate fluid phase probability maps from calibrated fluid factor or near/far angle attribute maps. These probability maps may be used to rank undrilled prospects, and as a part of risking the fluid phase for each prospect in the area under investigation.

USING VSP DATA TO EVALUATE THE RESPONSE OF SEISMIC ATTRIBUTES FOR RESERVOIR CHARACTERISATION

Milovan Urosevic and André Gerhardt
milo@ geophy.curtin.edu.au

Seismic trace and sequence attributes are commonly utilised for interpretation of seismic data. The meaning and use of these attributes are well documented in the literature. However, an "optimum set" of attributes for characterisation of a particular reservoir is usually not known a priori. Finding the optimum attributes can be a lengthy process. We propose an alternative approach where optimum attributes are

selected based on VSP data analysis. VSP data allows us to investigate the response of seismic attributes with respect to variation of a specific property of interest such as porosity, fracture density, fluid type, etc., with depth.

The approach we propose can be summarised as follows:

- Analysis of down-going VSP waves and computation of various seismic attributes;
- Correlation between attributes computed from up and down-going energies;
- Selection of optimum attributes;
- Correlation of VSP-derived attributes with attributes computed on 3-D seismic data;
- Map attributes to characterise the variation of a specific property across the reservoir.

Particular attention was devoted to the analysis of instantaneous frequency (IF). IF computation relies on the Hilbert transform which is, most of the times, obtained via the Fourier transform, therefore it is unable to properly handle the non-linear and non-stationary nature of seismic data. IF is also well known for being very sensitive to noise. We propose to use the Empirical Mode Decomposition (EMD) method, an adaptive wavelet-type spline decomposition based on the local characteristic time scale of the data, to obtain the fundamental oscillating modes and them compute the IF on the wavelet space.

The proposed VSP-based attribute analysis approach, aimed at an improved reservoir characterisation, is tested on several three-component VSP data sets acquired offshore North-West Shelf and correlated with surface seismic.

SURFACE SEISMIC IMAGING WITH MULTI-FREQUENCY FULL-WAVEFORM AMPLITUDE INVERSION

Stewart Greenhalgh and Bing Zhou
stewart.greenhalgh@adelaide.edu.au

Numerical experiments have been performed to test three inversion schemes for the imaging of surface seismic data. Three shallow subsurface models were considered: buried karst topography, dipping blocks, and isolated waste ponds. The synthetic experiments involved only a limited number of 'surveys' with just 8, 3, or 1 shots into variable length geophone arrays. In all cases, conventional seismic data processing hardly recovers the structure.

The inversion algorithm works in the frequency domain and relies on a finite element method to do the 2D/2.5D acoustic wave modelling. Our original inversion scheme used the known source signature (KSS), whereas the other two schemes either estimate it from the various shot gathers (ESI), or perform a normalised data inversion (NDI). The spectral inversions typically worked over 50-400 Hz and involved about 3500 data points. The features in the models typically have dimension of 5-20 m, which can be compared with the geophone spread length of 40 m (8 shots) to 100 m (3 or 1 shots).

The 8 shot inversion performed best for all the models. In fact, it was not possible to recover the karst structure with just 1 or 3 shots, but the other models were recovered, albeit with less accuracy, using such a small number of shots. ESI and NDI perform remarkably well on the dipping block and waste pond models. KSS yielded superior results to the other two schemes. The estimated source spectra were close to but did not exactly match the known wavelets.

Seismic Processing 1

DETAILED REFRACTION STATICS WITH THE GRM AND THE RCS

Derecke Palmer and Leonie Jones
d.palmer@unsw.edu.au

We derive refraction statics for seismic data recorded in a hard rock terrain, in which the statics corrections range from less than 10 ms to in excess of 70 ms, over distances as short as 12 receiver intervals or 480 m. We compare statics values computed with a simple model of the weathering using the generalized reciprocal method (GRM) and the refraction convolution section (RCS) with those computed with a more complex model of the weathering using least-mean-square inversion with the conjugate gradient algorithm (Taner et al, 1998). The differences between the GRM model and that of Taner et al (1998) systematically vary from an average of 2 ms to 4 ms over a distance of 8.8 km. The differences between these two refraction models and the final statics model, which includes the automatic residual values, are generally less than 5 ms. The residuals for the GRM model are frequently less than those for the model of Taner et al (1998). The RCS statics are picked approximately 10 ms later, but their relative accuracy is comparable to that of the GRM statics.

The residual statics values show a general correlation with the refraction statics values, and they can be reduced in magnitude by using a lower average seismic velocity in the weathering. These results suggest that inaccurate average seismic velocities in the weathered layer may often be a source of short wavelength statics, rather than any shortcomings with the inversion algorithms in determining averaged delay times from the traveltimes.

The significance of these results is that the RCS achieves improved accuracy through stacking to improve signal-to-noise ratios prior to the measurement of any traveltimes. Therefore, the RCS offers a new approach to determining more accurate statics with second arrivals such as shear waves, for which signal-to-noise ratios on shot records can be much less than those of the first arrival compressional waves.

HIGH-RESOLUTION COHERENT NOISE REMOVAL

Neil Hargreaves and Peter Whiting
peter_whiting@veritasdgc.com

In shallow hard water-bottom areas seismic data can be contaminated with linear refracted noise that may totally obscure signal amplitudes at medium and far offsets. Such noise is often highly aliased and resistant to removal via conventional approaches such as FK filtering or linear slant-stack. These can fail to remove the noise sufficiently for an accurate interpretation of amplitudes at far offsets, and have a tendency to smear signal amplitudes at all offsets.

In this paper we present results from an alternative approach, a high-resolution linear Radon technique that uses data-derived constraints to improve the focusing and positioning of energy in the transform. This produces a more complete noise removal and better preservation of signal than is possible with conventional techniques.

We construct constraints from a simple iterative adaption of a standard slant stack, and use these to drive a constrained least-squares inversion. This method has stability in the presence of noise that can be absent in other, frequency bootstrapping, approaches to the high-resolution Radon transform.

We have found the technique to be particularly effective for noise removal in shallow water (about 100 ms two-way time) and over simple sedimentary sequences of layers. Data examples show that it can surgically remove steeply dipping coherent noise without altering less steeply dipping data. Although FK filtering may reduce the noise, after FK filtering the far offsets may still need muting because of the residual noise. With the high-resolution Radon transform, the noise can often be removed with little if any residual noise remaining. Primary amplitudes can then be viewed and interpreted out to the furthest offsets.

MODEL-BASED DECONVOLUTION FOR DOMINANT, THIN-BED SEISMIC REFLECTIONS

STEVE HEARN AND DARYN VOSS
steveh@velseis.com.au

Predictive deconvolution is widely treated as a universally applicable tool for multiple removal and wavelet compression. The fundamental assumption of random reflectivity is seriously compromised in geological situations where the reflection sequence comprises a small number of dominant horizons. This situation is not uncommon in coal environments.

Where the primary seismic objective is high quality imaging of particular target horizons, an improved result can be achieved if the deconvolution is designed according to assumptions more relevant to the geological situation. We outline a simple example of this approach, aimed at imaging a production coal seam, of thickness 5-10 m, at a mine in the Bowen Basin, Australia.

Using horizon time picks from a preliminary volume, the full reflection package associated with the seam is extracted and deterministically filtered to obtain an estimate of the intrinsic wavelet. A Wiener spiking filter, designed on the extracted wavelet, is then used to deconvolve the seam package.

In comparison to the predictive deconvolution approach, this model-based procedure provides improved resolution of the top and base coal interfaces. In addition, derived amplitude and frequency attributes are more robust in terms of known geology. Variants of this simple model-based procedure should have relevance in a range of dominant-horizon situations where predictive deconvolution is invalid.

SIGNATURE AFTER PREDICTIVE DECONVOLUTION

JOHN F. PARRISH
john@periseis.com

Conventional predictive deconvolution is very good for suppressing normal incidence water bottom reverberations. Classic papers, some published in Geophysics, have provided rules of thumb for conventional seismic deconvolution processing. These rules have been invaluable in shortening field wavelets enough to allow structural interpretation of the subsurface. However, concepts of seismic deconvolution processing have evolved. Merely shortening the interpretation wavelet is no longer enough. In order to interpret rock properties, it is necessary to know the interpretation wavelet shape and to maintain its amplitude and phase spectrum throughout a seismic volume.

By utilizing an example seismogram synthesized with a finite impulse response (FIR) wavelet kernel, these rules can be exemplified and refined:

1. Predictive deconvolution can suppress reverberations as long as the lag is less than or equal to the minimum time of the water bottom reverberation sequence.
2. An isolated reflection's signature is not distorted by predictive deconvolution, as long as the lag is larger than the length of the wavelet kernel.
3. The dereverberation filter changes shape whenever the lagged interval includes a significant portion of the wavelet kernel's autocorrelation.
4. Placing the lag at the second zero crossing is a reasonable compromise but the reflection's signature will be distorted and it can extend beyond the lag.

The output signature can vary significantly with the value selected for the prediction distance (lag). Relative entropy deconvolution concepts can provide consistent dereverberation filters for lags shorter than the length of the wavelet kernel. Actual field signatures can be compensated to any convenient wavelet shape, including those with infinite impulse responses, before applying a relative entropy predictive deconvolution.

PROSPECT/BASIN EVALUATION

THE ORIGIN OF OVERPRESSURE IN THE COOPER BASIN, AUSTRALIA

PETER VAN RUTH, RICHARD HILLIS, RICHARD SWARBRICK, PETER TINGATE AND SCOTT MIDREN
pvanruth@ncpgg.adelaide.edu.au

The most commonly cited mechanisms of overpressure generation are burial-driven disequilibrium compaction and hydrocarbon generation. However, it is unlikely that these mechanisms generated the overpressure in the Cooper Basin. The last significant burial event in the Cooper Basin was the Cretaceous deposition of the Winton Formation (~90 Ma). Maximum temperature was attained in the Cretaceous, with cooling beginning prior to 75 Ma. Hence, overpressure related to rapid burial or paleo-maximum temperatures (e.g. hydrocarbon generation) must be at least 75 million years old. To hold overpressure in sedimentary basins over this time scale requires average pressure seal permeabilities at or below the lowest published shale permeability measurements. Moreover, the Cooper succession has cooled since the Late Cretaceous, and cooling is an underpressure generating mechanism. Therefore, it is unlikely that burial or temperature driven processes generated the overpressure witnessed in the Cooper Basin. The Cooper Basin has been subjected to an increase in horizontal compressive stress during the Tertiary, and thus an increase in mean stress. The presence of polygonal faulting the Late Cretaceous Eromanga sequence enabled the paleo-stress to be estimated. Layer bound polygonal faulting occurs in a normal fault regime with low differential stress ($\sigma v > \sigma H = \sigma h$). The contemporary stress regime in the Cooper Basin, measured using the density log, well tests and wellbore deformation modelling, is on the boundary between reverse and strike-slip ($\sigma H > \sigma h = \sigma v$). The largest measured overpressure in the Cooper Basin is approximately 14.5 MPa in excess of hydrostatic pressure at 3780 m in the Kirby 1 borehole. Mean stress has increased by 46 MPa at 3780 m in the Cooper Basin since the Late Cretaceous. The maximum increase in pressure that can be generated via disequilibrium compaction is equal to the increase in applied stress. Therefore, the increase in mean stress in the Cooper Basin is sufficient to explain the magnitude of the observed overpressure. Additionally, velocity/effective stress analyses on 9 wells indicate that the overpressure was generated by disequilibrium compaction related to increases in mean stress.

INTEGRATED EVALUATION IN THE MAURITANIAN FRONTIER

K. LAWSON, P. BOSS, T. ENMAN, G. FREER, C. LAVIN AND K. REIMANN
kate.lawson@woodside.com.au

In 1997, Woodside farmed into 40 000 km^2 of West African exploration permits in the outer continental shelf and slope of Mauritania in a strategic bid to widen its exploration portfolio to acreage outside Australia. This presentation documents the integrated approach used to evaluate this large green-field area in an accelerated timeframe, with a focus on the key geophysical workflows, which proved successful in identifying hydrocarbons and evaluating future potential.

10 000 km of 2D seismic was shot in 1998, from which major leads were identified and regional fairway mapping was conducted. This pre-empted a more focused 3D acquisition of 3400 km^2 in 1999/2000. Fast-track processing was a key factor for successful evaluation of this large 3D in little more than 6 months. Initial fast-track 3D volumes were delivered in July 2000, while the final prestack time migrations were available early November. Three months later agreement was reached on locations for the initial drilling campaign and the first of 2 wells, spudded in April 2001.

The first well, Chinguetti-1 discovered oil and now appraisal is planned for later this year. Chinguetti targeted Pliocene/Miocene objectives at the crest of a salt dome. These had DHI support in the form of 2-step amplitude functions with depth and flatspots identified with optical stacking. The workflow that led to the successful identification and quantification of DHIs in the complex channelised system of the Miocene is described.

The second well Courbine-1 targeted one of the largest closures at Maastrichtian level. Despite the lack of DHIs it was decided to drill as the Cretaceous plays had the largest upside for the permit. Courbine came in dry, but accurate seismic velocities and their use in predicting overpressures proved invaluable in the safe drilling of this well.

MODELS FOR CONTINENTAL BREAKUP AND DEEP-WATER BASIN FORMATION: INSIGHTS FROM INTEGRATION OF POTENTIAL FIELD MODELLING AND DEEP SEISMIC DATA ON CONJUGATE CONTINENTAL PASSIVE MARGINS

N. G. Direen, P. A. Symonds, J. Sayers, H. M. J. Stagg and J. B. Colwell
nick.direen@adelaide.edu.au

Recently acquired deep seismic reflection and refraction datasets, with coincident shipborne gravity and towed magnetometer data from the Great Australian Bight and its Antarctic conjugate margin basins, provide significant new constraints on conceptual models for continental breakup and subsequent deep-water basin formation.

Joint forward modelling of gravity and magnetic fields constrained by densities derived from refraction data, and by geometries from seismic reflection interpretation provide important new information on the structure and identity of middle and lower crustal elements that deformed in early rifting stages leading to continental breakup. The disposition of these elements is often found to significantly influence the position, depth and style of subsequent post-rift depocentres. Additional information from magnetic forward modelling constrains the whereabouts of limited products of breakup volcanism, as well as providing refined information about the location of initiation of seafloor spreading.

New results from the Great Australian Bight and conjugate margins include identification of:

- Large areas of mantle structuring and thinning by low-angle detachment and normal faults, with implications for mantle rheology and isostatic responses;
- Areas where lower or middle crust has been completely removed, with implications for crustal rheological response;
- Widespread presence of ultra-slow spreading seafloor crust disrupted by brittle extensional structuring;
- Areas of mantle uplift and inferred decompression volcanism and underplating; and
- Some depocentres resting directly on the brittle upper mantle.

Interpretation and synthesis of these new data has significant implications for the mechanical and thermal evolution of deep-water basins, as well as providing empirical evidence to test various theoretical models for continental breakup and non-volcanic passive margin formation.

Keynote / Electrical Inversion

CRUSTAL SCALE CONTROLS ON GOLD ORE FLUID MOVEMENT AND DEPOSITION AS REVEALED FROM ELECTRICAL RESISTIVITY STRUCTURE: EXAMPLES FROM COMPRESSIONAL AND EXTENSIONAL REGIMES

Philip E. Wannamaker, William M. Doerner, T. Grant Caldwell, George R. Jiracek and John A. Stodt
pewanna@egi.utah.edu

Structurally-controlled, meso- and epithermal gold deposition in both compressional and extensional settings is a function of local and regional stresses, rheological contrasts, and thermochemical gradients. The influence of these factors can be illustrated through their effects on electrical geophysical structure, as this structure reflects fluid composition, porosity, interconnection and pathways. In the compressional, amagmatic New Zealand South Island, magnetotelluric (MT) data imply a concave-upward ("U"-shaped), middle to lower crustal conductive zone beneath the west-central portion of the island. The deep crustal conductor suggests a volume of fluids arising from prograde metamorphism and radiogenesis within a thickening crust of paleo deep-water clastic rocks. Change of the conductor to near-vertical orientation at middle-upper crustal depths is interpreted to occur as fluids cross the brittle-ductile transition during uplift, and approach the surface through induced hydrofractures. Near the brittle-ductile pressure breakthrough are deposited modern hydrothermal veining, gold mineralization, and graphite of deep crustal provenance, subsequently exposed by erosion. In Nevada, Carlin Trend deposits appear to overlie central intrusives of late Eocene age which occupy the transition from conductive paleo-abyssal pelitic sediments (potential gold source rocks) eastward to more resistive shelf carbonate/quartzite sequences along an ancient continental margin normal fault. The intrusive is flanked by conductive, apparent accommodation fault zones, which may possess higher porosity as well as possible graphite flushed from sediments near the high-T system core and redeposited in the periphery. Exposed deposits are modelled to form at fluid pressure breakthroughs across permeability barriers such as organic shales or thrust planes, producing strong and favourable gradients in temperature, pressure and fluid oxidation.

A COMPARISON OF 2D AND 3D IP FROM COPPER HILL NSW

Derek Webb, Peter Rowston and Gerard McNeill
dlwebb@mim.com.au

This paper compares the results from 2D inversion of 2D data, 3D inversion of 2D data and 3D inversion of 3D data from a 3D pole-dipole MIMDAS IP survey conducted near Copper Hill NSW.

Six 1.5 km lines were laid out over the area of interest at 200 m spacings. Data were collected using 'pole-dipole' geometry with 100 m dipoles. All receiver stations on all lines were read simultaneously for each transmitter station.

Data were processed using standard (proprietary) MIMDAS processing. 2D data were inverted using UBC's dcip2d software while 2D and 3D data were inverted using UBC's dcip3d code ported to an NEC SX-5 supercomputer. For the 3D models, resistivities were determined by inversion of primary voltages while secondary voltages, after Time Domain Cole-Cole Inversion, were inverted for the IP model. All errors were based linearly upon observational errors.

Results highlight the differences between inversion models for the two datasets. In particular, the models demonstrate the greater resolution of the 3D survey and the restricted ability of 2D surveys to define boundaries subparallel to the survey lines is emphasized.

RESISTIVITY AND IP ARRAYS, OPTIMISED FOR DATA COLLECTION AND INVERSION

R. M. S. White, S. Collins and M. H. Loke
rwhite@tooronga.com

The advent of 3D inversion packages for Resistivity and Induced Polarisation has meant that geophysicists are no longer constrained by survey arrays designed to produce manually plottable data to be interpreted by eye. 3D inversion processing means that there is no longer a need to place receiver and transmitter electrodes in a co-linear array. Electrode arrays can now be designed to optimise target definition and data collection efficiency.

The double offset pole-dipole array offers a way to collect large amounts of data efficiently and has superior inversion sensitivity and depth of investigation to standard arrays.

CASE HISTORIES IN THE USE OF THREE-DIMENSIONAL INVERSION OF INDUCED POLARISATION AND RESISTIVITY SURVEYS

Steve Collins and Robert M. S. White
scollins@arctan.com.au

With the advent of fast three dimensional inversion software for IP and resistivity data, attempts have been made to optimise survey techniques to maximise the quality and quantity of 3D field data for a given survey cost. The result has been the development of the Offset Pole-dipole array. This survey geometry has now been used on many mineral exploration projects and a considerable degree of expertise in the execution of these surveys has been gained and some of the pitfalls associated with the technique have been discovered.

Three short case histories, which involve this technique, are presented to demonstrate the effectiveness of the technique and some of the problems encountered in its execution.

The Pegmont and Maronan prospects lie in the Eastern Succession of the Mount Isa Inlier in Northwest Queensland. The Mineral Hill Mine is in Central NSW.

The Pegmont Prospect is presented as this was the first prospect surveyed with the technique. The Maronan and Mineral Hill surveys illustrate both the relative efficiency of the Offset Pole-dipole survey technique and some of its more serious limitations.

Non-Petroleum Seismic

TAU-P VELOCITY IMAGING OF REGOLITH STRUCTURE

Penny J. Barton and Leonie E. A. Jones
barton@esc.cam.ac.uk

The tau-p velocity imaging method, first developed for obtaining the velocity field from marine multichannel seismic data, has been applied to refracted waves from the regolith in regional seismic reflection surveys on land. The technique converts travel time picks from the refracted wavefield into two-dimensional velocity models, by transforming from time-offset into the tau-p domain. Each arrival is mapped individually, and the 'true' velocity and position of the ray turning point is obtained by considering reversed raypaths. Thus the data are transformed directly into a depth or two-way time image of the subsurface displayed in seismic velocity. The method is extremely fast and involves no interpretive steps or iteration. Ideal datasets contain the refracted wavefield sampled densely and equally in the shot and receiver domains. It was therefore decided to test the application of the method for mapping the velocity structure of a portion of regolith and to compare the results with those obtained using more conventional methods.

The area chosen for study was part of a regional seismic reflection line across the Lachlan River palaeo-valley in central NSW. The data set consisted of the first break picks for 240 channels with receivers spaced every 40 m and vibration points every 40 m. The velocity images were produced as both time and depth sections and compared with one and two layer refractor models from a refraction tomographic approach. A low velocity region on the image corresponds to the deepest part of the refractor model, interpreted as the thickest part of the palaeo-valley. Bedrock velocity variations are also mapped and agree with the changes along the (lowest) refractor velocity profile. While further tuning may be required for land work, the technique has the advantage that velocities can be directly imaged and potentially related to regolith physical properties.

A GEOPHYSICAL SURVEY OF THE DERWENT ESTUARY

Michael Roach and David Gibbons
michael.roach@utas.edu.au

The Derwent Estuary is a drowned river valley system that lies within a complex NNW trending structural zone called the Derwent Graben. The graben preserves a poorly understood record of sedimentation and volcanism that extends from at least the early Tertiary to the Holocene. High-resolution marine geophysical data were acquired throughout the estuary to investigate the structural and sedimentary history of the graben.

Magnetic data clearly delineate the geometry of Jurassic dolerite basement units, basement controls on the development of the Graben and the distribution of previously unrecognised Tertiary basaltic centres. Modelling suggests that in excess of 800 m of Cainozoic sediments may be present in the centre of the graben adjacent to the Cascades Fault in the lower portion of the estuary.

High-resolution (boomer) seismic data have for the first time provided an insight into Tertiary, Pleistocene and Holocene sedimentation in the basin. Highly reflective Tertiary sediments are extensively disrupted by normal faulting and are overlain by a complex package of Quaternary sediments. The Pleistocene portion of the section is marked by numerous internal unconformities with deep channels cut during periods of fluvial erosion during sea level lowstands and filled by marine deposition during highstands.

An important outcome of the seismic survey was recognition of extensive zones of acoustic turbidity that correlate closely with the inferred late Pleistocene course of the Derwent River. These zones result from high concentrations of biogenic methane in the shallow marine sediments and are indicative of organic-rich anaerobic conditions. The presence of natural anaerobic zones significantly complicates interpretation of recent anthropogenic effects on the estuary.

SEISMIC IMAGING OF STEEP DIPS WITH LOW FOLD DATA: CASE STUDIES FOR BROKEN HILL AND THE LACHLAN FOLD BELT

Leonie E. A. Jones, Tanya Fomin and Barry J. Drummond
leonie.jones@ga.gov.au

In hard rock regions, a large range of stacking velocities is required to correctly stack reflectors of different dips. Typically, horizontal reflectors stack at 6000 m/s, whereas reflectors with dips of 60° stack at 12 000 m/s. For high fold (vibrator) data, correct stack of conflicting dips can be achieved by dip moveout (DMO) correction. However, for lower fold (dynamite) data, the sparse offset distribution complicates application of DMO. An alternative technique involves producing stacks with different stacking velocities and stacking these stacks. This technique was applied to two seismic reflection data sets, low fold dynamite data from Broken Hill and high fold vibrator data from the Lachlan Fold Belt. The Lachlan data set was used as both full 60/120 fold and reduced 10/20 fold. Velocity analysis, both analytical and empirical, was carried out to determine the range of stacking velocities. Stacking velocity increases with dip angle (cos-1q), but the velocity range across which an event stacks coherently increases more rapidly (approximately cos-3q for velocities typical of hard rock). The most critical area for analysis is the first two seconds of data, due to greater sensitivity of NMO to stacking velocity. The optimum number of stacks is an important consideration, based on the number of stacks in which an event contributes coherently to the sum. The Broken Hill stack data showed simultaneous imaging of horizontal and dipping events. For the Lachlan reduced fold data set, horizontal and moderate to steeply dipping events were stacked successfully, although not as well as the post-DMO stack of the full fold data. The technique has some problems at the shallowest levels, where the stack can be degraded due to time shifts of events in the individual stacks, but is a useful tool for low fold seismic data typical of older regional profiles.

A 3D 3C SHALLOW SEISMIC REFRACTION SURVEY ACROSS A SHEAR ZONE AT BUNGENDORE

Derecke Palmer
d.palmer@unsw.edu.au.

A three dimensional (3D) three component (3C) shallow seismic refraction survey was recorded across an extension of the Lake George fault in the butcher's paddock at Bungendore. The ANSIR equipment employed 348 channels in a static spread set out as 4 lines of 29 stations with 3 component geophones. The seismic energy source was a IVI Minivib, T15000. P- and S-wave sweeps were employed. Shear zones are an important concern in most geotechnical investigations. However, they can be especially difficult to separate from artifacts of inversion algorithms, because the travel-time anomalies are relatively small. Saline groundwater in major bedrock fractures, appears to be the source of dryland salinity in the Dubbo area. In other areas of dryland salinity, e.g. Wagga, the source is wind blown salt. Identifying the source of the salinisation is important in selecting the correct remediation strategy.

The head wave amplitudes are not satisfactorily described with the ratio of the specific acoustic impedances. Not only is there a decrease in amplitudes associated with the lower velocities of the shear zone, but there is also an increase in amplitudes with increases in velocities. Appealing to strong attenuation in the shear zone does not account for the other discrepancies. It is possible that the geological structure is complex, as is suggested by marked change in character the refraction convolution section (RCS) across the shear zone. For this June 30 deadline, only the P-wave data have been examined. However, it is a fascinating case history, which should be ready to go for the deadline in extended abstracts in October, if accepted for presentation.

Keynote / Seismic Technical Forum 3: Global Geophysical Trends

ENERGY GLOBALISATION AND THE EMERGING TECHNOLOGY RENAISSANCE

Yoram Shoham

The international Energy Resources industry has been present all over the world for more than a century. However, global presence does not equate with Globalisation. This concept will be examined in the context of Liberalization, Deregulation, Diversity and Balanced Responsibilities to Shareholders, Society and the Environment.

The world of energy resources has been highly volatile and hyper-competitive. Consequently it has gone through fundamental changes during the last years and decades. While many have enhanced the benefits of Globalisation, some have created impediments or even suffered setbacks. Only the Super-effective can survive and even prosper in such a market. The need to succeed will result in an emerging technology renaissance. Finally, an optimistic future view of the role of present and novel Exploration and Production technologies will be offered.

GLOBAL GEOPHYSICAL TRENDS

Michael Bahorich
mike.bahorich@usa.apachecorp.com

Forces internal and external to the petroleum industry have shaped the direction of the science of geophysics. New ideas and algorithms continue to have an impact, while lower computing costs enable processes that were not economic in the past.

The cost of storage, speed and bandwidth has been falling about on order of magnitude every five years. This technology disruption has provided significant benefits for the petroleum industry.

Computer gaming and medical imaging innovations have lowered the cost and improved the performance of visualization hardware and software. Parallel computing, faster networks and cheaper storage have led to advances in reservoir geophysics, seismic imaging, seismic acquisition and data management. Organizations that understand these trends and capitalise on them will be better prepared to compete in the future.

A DESERT SEISMIC CREW OF THE FUTURE

John R. Hughes
john.hughes@santos.com.au

"I have a dream!" In the immortal words of Martin Luther King, I also have a dream, albeit on a much lower level. This is that desert seismic crews of the future will be very different as a result of utilising deployment technology that is arguably available in other industries today.

My dream is based on the premise that, if agriculturalists can automatically plant and pick potatoes (and other agricultural products), then there appears to be no reason why geophysicists should not be able to plant geophones and pick geophones automatically.

We have been deploying receivers in essentially the same way since we commenced seismic surveys early last century. Thus, while we've seen massive advances in such industries as aviation, computer hardware and medical equipment, I would argue that our onshore deployment methodology has essentially stood still. This creates significant HSE impacts at a time when we are desperately trying to reduce them.

This paper explores the concept of reducing the current Australian state-of-the-art 3D crew from the 75 person, 95 vehicle/trailer accumulation that it is now to something closer to an efficient 10 person, 15 vehicle/trailer unit. With the availability of tracked technology and GPS navigation, it is argued that we could be a long way towards achieving this vision. However, the key issues of data transmission (cable laying technology or non-cable?) and sensor coupling will certainly need some research and development. Some thoughts on the technical challenges and potential solutions are presented in the hope of inspiring some research into these issues.

Potential Fields: Analysis

ON THE USE OF MAGNETICS AND GRAVITY TO DISCRIMINATE BETWEEN GABBRO AND IRON-RICH ORE FORMING SYSTEMS

James E. Hanneson
jim.hanneson@ bigpond.com

If the major rock forming minerals are divided into three categories, and, if the density, magnetic susceptibility, and the proportions of each category are known, then the density and susceptibility of a mixture of the three categories can be determined. Conversely, if the physical properties of a mixture are known along with the physical properties of each of the three components, then the proportions of each component can be calculated. This reasoning can be used to superimpose category percentage contours onto a density-susceptibility scatter diagram. Such a diagram can be used to relate petrophysical measurements on a rock specimen to its mineral category content, the veracity of which can be appraised by a geologist with a hand lens. Several hundred qualitative tests suggest that the approach is valid. The analysis is independent of scale, and can be applied to the bodies of a density-susceptibility model developed to simulate exploration data. Gabbro with magnetite plots along a specific locus on the combined phase/scatter diagram and can often be distinguished from denser accumulations of hematite and/or sulfides. Case histories for a number of economic and non-economic density-susceptibility anomalies give support for the usefulness of the method.

SPATIAL AND DIRECTIONAL ANALYSIS OF POTENTIAL FIELD GRADIENTS - NEW METHODS TO HELP SOLVE AND DISPLAY THREE-DIMENSIONAL CRUSTAL ARCHITECTURE

PETER R. MILLIGAN, PATRICK LYONS AND NICHOLAS G. DIREEN
peter.milligan@ga.gov.au

Edge detection and automatic trend analysis using potential field gradients are methods for producing unbiased estimates of sharp lateral changes in physical properties of rock packages. Where the points lying on the maximum horizontal gradients of potential field data show a lateral continuity, they can be mapped as "strings". These strings may be generated for many different levels of upward continuation.

When analysed in three dimensions, the strings provide information about the strength of the gradients, the locality of source-body edges, and possibly their dip directions and depth. For automatic analysis, sets of string-points may be converted into poly-lines, or curves, for each level of continuation. The best-fitting straight lines for curves with high linearity can be plotted as circular histograms (rose diagrams), or balloon diagrams, to provide a statistical representation of their orientations. Discrete areas can be windowed separately to show how dominant trend directions change in different geological settings. Balloon diagrams calculated for many levels of upward continuation may show how interpreted fracture sets evolve vertically.

Examples of analyses are shown for two areas of Australia, using gravity data. The first is from the Olympic Cu-Au province of the eastern Gawler Craton, mapping NW- and NE-trending structures, and the second maps the broad domains of an area of northern Australia.

THE APPLICATION OF FRACTIONAL CALCULUS TO POTENTIAL FIELD DATA

G. R. J. COOPER AND D. R. COWAN
006grc@cosmos.wits.ac.za

Gradients of magnetic and gravity data are used routinely to sharpen the edges of anomalies, or as input to interpretation techniques such as analytic signal analysis or Euler deconvolution. The most commonly used gradients are of 1st and 2nd order, higher orders being used less frequently due to noise problems. This paper discusses the benefits of a generalised approach using fractional gradients, demonstrating their usefulness as an aid to interpretation. Fractional horizontal gradients are suggested as a means of avoiding the instability problems present when magnetic data from low latitudes is reduced to the pole. They also allow the use of an improved sunshading algorithm that is less affected by noise than the standard method. Fractional vertical gradients may be used to generate both enhanced analytic signal data and enhanced Euler deconvolution solutions.

ANALYTIC SIGNAL VS. REDUCTION-TO-POLE: SOLUTIONS FOR LOW MAGNETIC LATITUDES

SHANTI RAJAGOPALAN
shanti@earthbytes.com

Australian explorers are accustomed to using aeromagnetic maps starting from the area-selection phase down to the drilling phase. As exploration activity shifts to regions at low magnetic latitudes, they find their skills harder to apply; thus leading to under-utilisation of expensively-collected magnetic survey data and disadvantaging exploration efforts.

Changes in anomaly shapes, reduction in overall amplitude and changes in map textures make the ready interpretation of geology from magnetic data at low magnetic latitudes difficult. At these latitudes, magnetic anomalies appear typically as lows, and their amplitude and form change significantly with strike. These problems are worst for inclinations within 20° of the magnetic equator.

Reduction to the Pole (RTP) is the best theoretical solution because it removes the effect of induced magnetisation and strike on the shape of magnetic anomalies while preserving dip information. Practically, at very low latitudes, the standard RTP transform usually produces poor-quality maps dominated by declination-parallel artefacts. Additionally, the RTP transform cannot completely reconstruct NS-trending anomalies at low latitudes.

The 3D Analytic Signal is a function of magnetic gradients and is easy to compute. It is almost but not entirely independent of magnetisation direction. It can be computed easily and accurately for any ambient and source magnetisation. However, it lacks the resolution that derivative maps provide and lacks the dip and textural information that total magnetic intensity and RTP maps contain.

In this paper, I discuss the pros and cons of these two methods, the limitations of each method, and ways to overcome some of these limitations.

MINERAL CASE STUDIES: GOLD

DIRECT DETECTION OF GOLD BEARING STRUCTURES AT ST IVES, WA, - DHEM VS DHMMR.

EDWARD M. G. STOLZ
edward.stolz@gfaus.com.au

The St Ives terrane is covered by a thick regolith that is saturated with hyper-saline groundwater. The regolith forms a major barrier for electrical and EM surveys designed to detect gold bearing structures in bedrock

The DHMMR method was trialed at St Ives, and did not detect recognisable responses from known structures. DHMMR does not detect anomalies because the structures have small cross sectional areas for channelling current, and the resistive bedrock does not support large current densities for channelling into targets.

DHEM surveys were trialed at St Ives and detected a strong well-defined anomaly at the Junction gold mine. The anomaly was modelled as a plate in layered earth, and the plate corresponded to a major gold bearing shear. Petrophysical tests suggest that the shear is conductive because of brine-saturated porosity.

DHEM surveys did not detect strong anomalies from a gold bearing shear at the Argo gold mine, despite the shear having low measured resistivity relative to host rock. The absence of DHEM response may be because the shear is not conductive enough to support an anomalous current system, or because the conductivity is not connected on a large scale.

GEOPHYSICAL CHARACTERISATION OF THE TRIDENT GOLD DEPOSIT, WESTERN AUSTRALIA

BEN HALL AND BARRY BOURNE
benhall@rockwater.com.au

The Trident gold deposit is contained in the Plutonic Well Greenstone Belt, about 900 km northeast of Perth, Western Australia. The deposit is hosted in a highly sheared ultramafic unit overthrusted by granite. This project examined the physical properties of the important rock units to determine whether they contrast sufficiently to allow mapping of mineralisation, geology and structure. It investigated the possible occurrence at Trident of the most important mineralised lithological unit in the district, the 'mine mafic'. The project also investigated the nature of the thrusted contact between granites and greenstones, one of the most important structures in the district.

Drill core samples representing the major lithologies at Trident underwent a range of petrophysical testing. Gravity profiles were collected over the deposit and these were analysed along with high-resolution airborne magnetic and radiometric data. The magnetic and radiometric data were

assessed qualitatively with comparisons to maps of geology, regolith and known mineralisation. Gravity and magnetic data were computer modelled using drilling information and petrophysical data. The host ultramafic unit was readily mapped and modelled to depth using magnetic data. Mineralisation itself was expressed as a relative low within the magnetic ultramafic unit. The down dip extension of the mineralised ultramafic presents a good drill target. The gravity profiles are not long enough to allow accurate interpretation, but modeling shows that it is unlikely that the mine mafic is present at Trident. Radiometric data mapped broad geology and regolith trends but did not show an anomaly related to mineralisation. The results from IP and resistivity tests on core samples indicated that these techniques were not well suited for targeting this style of mineralisation.

GEOPHYSICAL EXPLORATION OF THE PAJINGO EPITHERMAL SYSTEM

Terry Hoschke and Jennifer Parks
terry.hoschke@newmont.com.au

The Pajingo epithermal system is an area of low sulfidation epithermal veining and alteration about 15 km in diameter at the northern margin of the Drummond Basin. Tertiary and younger conductive sediments cover about 80% of the area. The gold mineralisation is within thin quartz veins and most of the ore bodies discovered to date are along the NW trending Vera-Nancy structure.

The host intermediate volcanics are magnetic and the epithermal alteration that extends up to 50 m from the veins along the Vera-Nancy structure is magnetite destructive. Results of a high-resolution magnetic survey clearly delineate the major structures including the Vera-Nancy structure.

The quartz veins are within broader zones of silicification and gradient array resistivity surveying has been used to map these zones. Generally the high resistivity zones due to silicification are coincident with the structures identified in the magnetics.

High-resolution magnetics and resistivity continue to be the most useful geophysical tools in the ongoing exploration of the Pajingo Epithermal System for additional mineralised structures.

MAGNETISM - KEY TO THE WALLABY GOLD DEPOSIT

John Coggon
j.coggon@bigpond.com

The Wallaby deposit in Western Australia is now recognised as being an actinolite-magnetite alteration pipe, which is the host structure to several stacked gold lodes. Identification of the pipe geometry resulted from a combined interpretation of the aeromagnetic anomaly and drill core magnetic susceptibility measurements.

Gold was discovered at Just in Case (north of Wallaby) in 1997. By September 1999 the Just in Case - Wallaby zone had been drilled to 500 m depth, outlining gold mineralisation within magnetic basaltic conglomerate. The challenge then was to develop targets to 1000 m.

Magnetic susceptibility measurements made on all core proved invaluable. A susceptibility block model was studied in conjunction with models derived from the surface magnetic anomaly. Although the gold zones tended to be flat, susceptibilities displayed an annular pattern in plan, and a southerly dip in a central north-south section. The magnetic zone was interpreted as being a plunging pipe, with a plunge of 50° toward 190° determined from modelling the aeromagnetic anomaly. Complementary to recognition of the pipe was evidence that gold was effectively restricted to the magnetic zone. The pipe model provided a well-defined target, and drilling to 1000 m confirmed the structure as well as discovering four more gold lodes.

AEM: Difficult targets

FINDING TARGETS IN COMPLEX HOSTS USING AIRBORNE EM

Art Raiche, Fred Sugeng and David Annetts
art.raiche@csiro.au

Two basic questions lay at the heart of AEM surveys, one concerning the basic physics of the process, the other the interpreter's capability.

Is the equipment capable of exciting the target to the extent that it will produce a detectable signal above background response?

Can the presence of a target be deduced from this signal?

This study examines the response of a 400 Siemen sulphide lens in an altered ultramafic lying at the boundary of a faulted host under a moderately conductive saprolite cover. In the easy case, the surface is flat and in the other, the whole lies under moderately steep topography. The study compares the ability of fixed wing time-domain, helicopter time-domain and helicopter frequency-domain systems to differentiate between when the lens target is present and when it is absent. Constant receiver ground clearance is assumed.

In general the effect of the lens was to smooth the response horizontally so that a naïve interpreter might mistake the barren response for the target response and vice versa. For the time-domain systems, the vertical component showed the greatest differentiation whereas the in-phase, in-line coaxial component was the most effective for the idealised HEM system. HEM systems showed better anomaly localisation than did fixed wing systems due to shorter transmitter-receiver separation and lower flying heights.

Conductivity depth images and other interpretations based on one-dimensional earth models yield misleading information for the type of model studied.

THE CAWSE NICKELIFEROUS LATERITE DEPOSITS, WESTERN AUSTRALIA - A CASE STUDY ON THE APPLICATION OF AIRBORNE GEOPHYSICS IN TARGETING ZONES OF SUPERGENE ENRICHMENT IN A COMPLEX REGOLITH SETTING

Tim Munday, Jayson Meyers, Jasmine Rutherford, Andy Green, Jim Macnae and Mat Cooper
tim.munday@csiro.au

Helicopter electromagnetic (HEM) and magnetic survey data were acquired over the Cawse district in the Eastern Goldfields of Western Australia, to help define the structural controls that influence supergene mineralisation and delineate areas favourable for further exploration. The rationale for conducting the EM survey was that previous work in the area had demonstrated that local discontinuities, represented by stratigraphic and structural variations in the regolith, or related textural and/or mineralogical changes have influenced hydrogeological process and consequently the distribution mobile elements such as Ni, Co and Mn within the profile.

The observed conductivity structure in the HEM data is related to regolith heterogeneity and to the presence of hydromorphic barriers (structural, material) behind which salts and water accumulate. In places these barriers are spatially associated with Ni enrichment.

THE APPLICATION OF AIRBORNE ELECTROMAGNETICS TO THE SEARCH FOR HIGH CONDUCTANCE TARGETS

Ken E Witherly, Richard J Irvine and Art Raiche*
ken@condorconsult.com

The airborne electromagnetics (AEM) technique has been used very successfully for over 50 years to locate conductive ore bodies. For most users of the technique, the primary purpose of AEM has been to provide a rapid and inexpensive means to locate targets, whereupon the best features were then followed up with ground geophysical techniques prior to possible drill testing. In this role, as a first-pass detection tool, AEM equipment development has focused primarily on spatial resolution, depth of detection and rejection of conductive cover. Traditionally little emphasis was placed upon the need to provide quantitative information about a target's conductance. This situation has been changing in the last 10 years, driven in large part from concerns expressed from those groups exploring for magmatic nickel deposits. Drawing upon both petrophysical studies and field observations, a case is developing that magmatic nickel deposits have conductances that place them far outside the conductance bandwidth of effectively all AEM systems. This being the case, then the use of AEM as a primary target identification tool for new nickel deposits is a seriously flawed strategy. So as to better understand this issue, AEM data sets acquired over the Voisey's Bay deposits, Labrador, Canada have been analysed using standard commercial processing techniques such as CDIs and time constant analysis. Additionally, a series of numerical models have been generated to try to better explain the observed field results, as well as simulate the response that other AEM systems would produce over the deposit. While the Voisey's Bay deposit undoubtedly contains mineralisation of very high conductivity, the processing and modelling shows the AEM technique to be an effective means to locate and discriminate targets of high conductance. Although such conductance discrimination may only be achievable on a relative scale, it is seen as generally adequate for most exploration situations.

THE RESOLUTION OF SHALLOW HORIZONTAL STRUCTURE WITH AEM

Daniel Sattel
dsattel@fugroairborne.com.au

The minimum size of shallow horizontal structures detectable and resolvable with airborne electromagnetic (AEM) systems is discussed. Synthetic data were generated for the helicopter frequency-domain system RESOLVE and the fixed-wing time-domain systems TEMPEST and GEOTEM. The modelled scenarios include conductive prisms in a resistive host and resistive prisms in a conductive host. The EM responses of these models were computed for a range of prism thicknesses, side-lengths and host conductivities. Gaussian noise in amplitude comparable to actual system noise levels was added to the synthetic data followed by the derivation of conductivity-depth sections via three-layer inversion and EMFLOW conductivity-depth imaging. Where these 1-D algorithms failed to indicate the presence of the prism the data were inspected for prism anomalies in order to evaluate if 2-D or 3-D algorithms might be able to map these structures.

The results indicate that beyond a minimum prism conductance (conductivity-thickness product), prism thickness and host conductivity are much less important than side-length. For horizontal prisms to be detectable with the RESOLVE system they have to be at least 12 m wide. In order to resolve their thicknesses and conductivities with 1-D algorithms, the prisms must be at least 130 m wide. For the TEMPEST and GEOTEM systems the application of 1-D algorithms enables the detection of horizontal prisms wider than 180 m and the resolution of their thicknesses and conductivities for prisms wider than 450 m. Profile inspection shows that horizontal structures as narrow as 24 m might be detectable with more advanced algorithms.

EM / Resistivity: Problems

MAXIMISING THE USE OF INDUCED POLARISATION 2D SMOOTH-MODEL INVERSIONS

William Robertson and John Hart
robertsonb@bigpond.com.au

In this paper a line of dipole-dipole data, from the Prominent Hill Deposit, will be used to show that with minimum time and effort a more suitable inversion model can be produced that improves the geophysicists interpretation. Inversions of forward models are used to support the interpretation and to help refine inversion parameters.

The use of default parameters in an induced polarisation (IP) and resistively inversion programs should be considered the first stage and not the final outcome. The initial inversion model should be assessed critically and compared with the observed data. The inversion should be re-run adjusting default parameters to produce a better inversion.

Areas of complex geology tend to produce IP responses that are complex due to the interaction of multiple sources. The recognition and interpretation of these complex features are essential in designing a drill program to successfully test the sources.

SOME POSITIVE THOUGHTS ABOUT NEGATIVE TEM RESPONSES

John Bishop and James Reid
bishop@tassie.net.au

Negative responses recorded during moving in-loop TEM surveys, where only positive data are expected, are a regular occurrence in TEM surveys. They are however generally poorly understood and little reported. In most cases, such negatives are ascribed to induced polarisation (IP) effects, but we suggest that there is at least one other cause of negative TEM response, one which is associated with very resistive terranes containing little if any polarisable material.

This paper presents some examples of this negative resistive response where there is little or no polarisable material present and where a source other than IP should be sought. A series of tests have been proposed to try and isolate the cause.

THE EFFECT OF DIPOLE POSITION ERRORS ON E-FIELD MEASUREMENTS IN ELECTRICAL GEOPHYSICAL SURVEYS: IS CLOSE ENOUGH GOOD ENOUGH?

*Michael A. Hatch and Andrew J. Mutton**
zonge@ozemail.com.au

Anomalous conductive responses that could not be related to obvious geological sources were observed in field data from a CSAMT survey in the Cobar area, New South Wales. Repeat measurements over the anomalous stations were made, yielding a substantially different resistivity response. Approximate positioning of the E-field dipole stations due to the presence of thick scrub was believed to be one possible source of error contributing to the differing responses.

Subsequent test measurements in which the E-field dipole angle was varied by 10 degrees east and west of the correct direction demonstrated that such an orientation change resulted in resistivity variations of up to 50% from the true value. This is significantly larger than expected from simple theory, which suggests that the results from location errors up to 10 degrees from correct should only be a few percent. This large variation observed in the Cobar area is believed to be due to a strong geo-electrical anisotropy within the steeply dipping and highly cleaved meta-sedimentary rocks of the Cobar Basin.

It was concluded that relatively small errors in receiver orientation could have a large effect on the magnitude of the received signal, which can potentially generate 'false' anomalies in the derived resistivity pseudosections and inversions. It is possible that such location errors are commonly made when a standard GPS is used to locate stations on a grid. Based on the experience from the Cobar area, accurate station positioning is clearly a pre-requisite for reliable electrical surveys in any geological terrane.

This paper presents field examples demonstrating the potential errors, and the results of applying more-accurate positioning techniques. Recommended methods to gauge the magnitude of the potential errors in any survey area are proposed.

TWO AND THREE-DIMENSIONAL RESISTIVITY IMAGING IN A SHALLOW COASTAL SAND AQUIFER

GREG DASEY AND IAN ACWORTH
greg_dasey@urscorp.com

Surface resistivity imaging was proposed to map the saline interface produced by the interaction of a tidal creek and a shallow fresh water aquifer. Forward modelling was used to determine the relative merits of using two and three (2D and 3D) dimensional electrode arrays. The results of the forward modelling indicate that under ideal circumstances the surface techniques can resolve the conceptual saline interface near the tidal creek.

One 3D and four 2D surveys were completed on the bank of Korogoro Creek. The 2D surveys were orientated parallel (3) and perpendicular (1) to the creek. The apparent resistivity data was inverted using RES2DINV and RES3DINV.

The resulting 2D images demonstrate that the conceptual model used in the forward modelling oversimplified the distribution of saline water in the subsurface. The 2D images indicate that freshwater is discharging into the creek via preferred pathways at several locations along the creek bank. The 3D image shows that the distribution of saline water is constrained to an area close to the creek. Neither the 2D or 3D images were able to clearly identify the thin saline wedge observed using downhole techniques (EM39).

The results of the resistivity surveys indicate that the techniques are useful in identifying relatively large-scale saline patterns but are unable to identify relatively small anomalies. Most importantly the results highlight the critical need to control interpretation of high- resolution surface resistivity data with downhole techniques.

SEISMIC MIGRATION

A VISUAL BASED CONNECTION BETWEEN SEISMIC INVERSION AND SEISMIC MIGRATION

JOHN C. BANCROFT
bancroft@geo.ucalgary.ca

The Kirchhoff migration algorithm is heuristically derived using the mathematics of least squares inversion and the concept of matched filters. These concepts are visualized with cartoon descriptions that describe inversion using linear algebra and time-varying deconvolution. The time varying wavelets are then replaced with diffractions, to form a diffraction matrix that is used to model seismic data. The product of the transpose of this diffraction matrix with the seismic data produces a band-limited inversion that is identical to a Kirchhoff migration. Simple modification to the diffraction matrix illustrates the use of variable velocities and constant offset prestack migration.

ANISOTROPIC PRESTACK DEPTH MIGRATION IN PRACTICE

PETER WHITING, UWE KLEIN-HELMKAMP, CARL NOTFORS AND OSMAN KHAN
peter_whiting@veritasdgc.com

Conventional prestack depth migration involves building a velocity model for the subsurface using velocities that are assumed to be isotropic. When the earth is anisotropic, it is impossible for this conventional earth model to correctly predict the seismic raypaths and hence to accurately migrate the recorded data.

Common problems with conventional prestack depth migration are overcorrected common-image point gathers and depth misties with available well data.

Applying anisotropic prestack depth migration involves making some assumptions about the symmetry of the anisotropy and then determining the vertical velocity and the anisotropic parameters, delta and epsilon. These parameters were determined using a combination of well information, higher moveout analysis and migration scans.

The results of a successful anisotropic prestack depth migration tie the available well information, have flat common-image point gathers and have higher resolution and improved focussing.

3D PRESTACK DEPTH MIGRATION BY WAVEFIELD EXTRAPOLATION METHODS

JAMES SUN, YU ZHANG, SAM GRAY, CARL NOTFORS AND JERRY YOUNG
james_sun@veritasdgc.com

After a decade in which Kirchhoff migration has been the workhorse method for structural imaging, the industry has found that this method fails to image the most structurally challenging geology. Wavefield extrapolation based approaches have shown promise in complex structural imaging, but many of their assumed advantages have been found inadequate. In this paper, we review the progress made by these approaches, and we survey various implementations that are available. We also review several key issues that are critical if the wavefield extrapolation approach is to be useful in generating high-fidelity production-scale images. Some of these issues include: true amplitude formulation, imaging condition aliasing, sail line aliasing, and angle-gather computation. We use results from both synthetic and real data to illustrate the advantages and challenges facing wavefield extrapolation based migrations.

NON-SEISMIC PETROLEUM EXPLORATION

IN SITU STRESS FIELD, FAULT REACTIVATION AND SEAL INTEGRITY IN THE BIGHT BASIN, SOUTH AUSTRALIA

SCOTT D. REYNOLDS, RICHARD R. HILLIS AND EVELINA PARASCHIVOIU
reynolds@ncpgg.adelaide.edu.au

The *in situ* stress field and consequent risk of reactivation has been evaluated in the Bight Basin in order to assess the risk of fault seal breach at seismically mapped prospects. Borehole breakouts interpreted from dipmeter and image logs in five wells in and around the Bight Basin indicate a 130° N maximum horizontal stress orientation. The large variation in water depths across the Bight Basin required the use of effective stress magnitudes. A depth-stress power relationship is used to define the effective vertical stress based on density log data from 10 wells. The effective minimum horizontal stress was estimated at 6 MPa/km using effective pressures from leak-off tests. An upper bound (18.7 MPa/km) for the effective maximum horizontal stress was determined using frictional limits to stress. Pore pressure in wells in the region is hydrostatic except in Greenly 1 where over pressure occurs below a depth of 3600 m.

The risk of fault reactivation in the Bight Basin was evaluated using the FAST technique. The risk of fault reactivation and consequent seal breach is expressed in terms of the pore pressure increase that would be required to induce failure for three different in situ stress cases. In all three cases faults striking 40° N (±15°) of any dip are the least likely to be reactivated.

IS THERE ANY ROOM FOR GRAVITY IN PETROLEUM EXPLORATION?

SERGEY I. SHEVCHENKO AND ROBERT P. IASKY
sergey.shevchenko@mpr.wa.gov.au

A detailed gravity survey has been carried out by the Geological Survey of Western Australia over seismic grids covering the Beharra Springs and Mondarra gas fields in the northern Perth Basin. In this part of the northern Perth Basin, where the near surface Tamala Limestone is present, seismic data are poorly imaged whereas major structural elements are easily recognised using gravity data.

The new gravity data reveal a major transfer zone and three distinctive zones with specific signatures, coincident with the Dongara Terrace, Beharra Springs Terrace, and Allanooka High. The gravity lineaments within these tectonic units correlate strongly with major faults interpreted from detailed seismic data. Additional features interpreted from gravity, but not identified on seismic sections, may lead to a revision of previous seismic interpretation. Furthermore, positive residual gravity anomalies correlate well with seismically mapped structural highs that coincide with known hydrocarbon fields. Other positive gravity anomalies may correspond to yet unidentified fields. Thus, gravity data provide a cost-effective tool in the search for hydrocarbons in areas with little or poor quality seismic data.

AUGMENTING SATELLITE ALTIMETER DATA WITH SHIP AND LAND GRAVITY DATA IN THE NORTHWEST SHELF OF AUSTRALIA

Jon Kirby
jfk@vesta.curtin.edu.au

High-resolution maps of the marine gravity field can be produced for oil and gas exploration. Ship and airborne gravity data collected by oil companies in the preliminary stages of a survey may be combined with existing public-domain satellite altimetry data, greatly increasing the resolution potential of the latter, and providing a regional gravity field for emplacement of the exploration data. The combination of altimeter data with land and ship gravity data is an iterative process, designed to seamlessly match the data sets. The method is quick and easy to implement, and avoids laborious crossover adjustments of the ship data.

Environmental: Towed Array

A FLOATING ELECTRODE ARRAY FOR CONTINUOUS GEOELECTRICAL IMAGING

David A. Allen and Noel P. Merrick
david.a1@bigpond.com

Hydraulic connectivity between watercourses and aquifers can be rapidly imaged in great detail using a floating electrode array. Below watercourses, the salinity contrast between rising groundwater and sinking surface water is clear on electrical conductivity images. Interpretation is complicated by conductivity variations related to clay percentages and sediment porosity.

A new robust floating electrode array design ("Blue Eel") using air filled layflat tubing addresses many of the problems that have previously prevented productive surveying of watercourses, most of which contain many navigation hazards. A modified dipole-dipole array with exponentially spaced and sized receiver dipoles can provide optimal signal levels and depth resolution. Additional data from a GPS receiver and sonar depth profiler are important for managing the large volume of data acquired.

The data acquired can be presented as a vertical 2D inverted conductivity image with a water depth trace overlain. Because watercourses generally meander, this image is best wrapped like a ribbon along the track of the watercourse. If the ribbon is presented in orthographic projection, it can be overlain easily on airphotos and map layers.

SALINITY MONITORING OF THE MURRAY RIVER USING A TOWED TEM ARRAY

Brian Barrett, Michael Hatch, Graham Heinson and Andrew Telfer
brian.barrett@adelaide.edu.au

Successful implementation of a salt interception schemes (SIS) requires monitoring to determine locations where the scheme needs revision. Current monitoring methods involve near-surface water-salinity measurements, which are affected by water-flow displacement. A survey method that can determine the salinity of water contained in the top few metres of alluvial sediments immediately beneath the river would be a more accurate tool for SIS monitoring.

A fast sampling Transient EM technique is investigated as a potential tool for imaging the conductivity of the top 5 m of sediment, and thus monitoring the Waikerie SIS in South Australia's Riverland. A towed TEM array was used to collect 9 km of data that shows resistive anomalies correlating with SIS production bores. The system has the advantage of being a small, manageable array and the short inversion time allows same-day interpretation.

IRRIGATION CHANNEL SEEPAGE INVESTIGATIONS

Gregory J. Street, Stephen Parsons, David Allen and Michael Hatch
gstreet@iinet.net.au

Most irrigation channels in Australia are earth lined and leak water to the surrounding terrain. The cost of lost water can be high in economic and environmental costs. The solution is to completely line the canals or replace them with pipes, both expensive options. An alternative is to focus on areas of highest seepage. In this study we trialed a dipole-dipole resistivity array towed behind a dinghy in the canal. The approach followed trials using electromagnetic techniques in previous years that showed conductivity changes below and around the canals in part reflected seepage. We inverted the resistivity results to sections and statistically analysed the data from various depths in the ground by correlating the resistivity against pondage seepage results. Our conclusion was that the resistivity worked best where there was a diffuse seepage from the canal. The greatest effect was around the watertable. Where seepage rates were low there was no correlation with resistivity. The correlations improved with increasing seepage particularly where the inverted sections indicated the seepage rates were uniform along the channel.

Radiometry / Spectrometry

ACCURATE NOISE REDUCTION FOR GAMMA-RAY SPECTROMETRY

Brian Minty
brian.minty@ga.gov.au

Three hypotheses are tested for the pre-conditioning of airborne gamma-ray spectra to improve the accuracy of principal component-type (PC) spectral noise-reduction methods. First, I show that the distribution of the input variables (channel count rates) has little effect on the accuracy of the noise-reduction methods. Second, if there are insufficient spectra of a particular shape to form a statistically significant sample, then this shape will not be resolved by the noise-reduction methods, and will be removed as noise. However, by padding the data space with spectra exhibiting the full range of possible spectral shapes, an improvement in accuracy can be achieved. Third, the low signal-to-noise ratio in raw gamma-ray spectra limits the effectiveness of PC methods for removing the noise. If the signal-to-noise ratio in the input spectra is improved, the PC methods better remove the noise. Along-line summing of spectra improves the signal-to-noise ratio by exploiting the high correlation in signal between successive airborne gamma-ray spectra along each flight line. Summing spectra to optimum channels also improves the signal-to-noise ratio, but at the expense of spectral resolution. In both cases, spectral summing prior to the application of PC-type noise reduction results in a significant improvement in the accuracy of the noise-reduced spectra.

CALIBRATION, PROCESSING AND INTERPRETATION OF HYPERSPECTRAL DATA OVER THE BROKEN HILL REGION

DAVID ROBSON, PETER COCKS AND GEOFF TAYLOR
robsond@minerals.nsw.gov.au

In March 2002, the New South Wales Department of Mineral Resources contracted an airborne hyperspectral remote sensing survey of the Broken Hill region in New South Wales. It covered 4 000 km² and involved the acquisition at a ground sampling distance of 3 m.

HyMap™ was selected as the hyperspectral system as it is a 126-band sensor that provides a combination of high spatial resolution, spectral coverage, signal-to-noise ratio and image quality. The HyMap™ sensor utilises four 32-element detector arrays to provide 126 spectral channels covering the 450 nm to 2 500 nm spectral range over a 512-pixel swath. The HyMap's instantaneous field of view of 3 m x 3 m, corresponded to a flight altitude of 1.4 km above ground level and an aircraft ground speed of 110 knots. The ground swath coverage corresponded to 1.6 km for each flightline resulting in a 20% overlap.

The data processing and data products were radiance calibrated, atmospheric corrected and geometric corrected. Spectral and radiometric calibration of the HyMap™ sensor was accomplished prior to the survey and this information was used to allow the conversion of the raw DN counts to radiance values in μW/cm²/nm/sr.

Using the ENVI image processing package, preliminary lithology maps have now being generated using the Mixture Tuned Matched Filtered method. The maps identify stratigraphic units; regolith; alteration zones; sulphate; hydroxyl-bearing minerals; iron oxides; and green and dry vegetation. These maps will now be taken into the field for verification and then released to the mineral industry as a GIS set of geo-referenced mineralogical map layers, along with other geological and geophysical data.

IMPROVING THE QUALITY OF AERIAL GAMMA-RAY SURVEYS

BRUCE DICKSON
b.dickson@dem.csiro.au

A review of the parameters used in processing aerial gamma-ray survey data from a number of recent surveys showed that many surveys were processed with incorrect values. Many of the problems arise from unrecognized variations in concentrations of airborne radon during the collection of the calibration data. These problems may be overcome by:

1. Testing values against expected values to flag potential problems,
2. Deriving the height attenuation coefficient for U from the average values for K and Th if the value does not fall between those for K and Th, and,
3. Calculating the sensitivity coefficients at various heights and plotting the K/U and K/Th ratios to reveal any radon effects.

If necessary, a U sensitivity value can be obtained by appropriately scaling the Th value.

SOLID EARTH: DEEP STRUCTURE

THREE-DIMENSIONAL EXTENSION OF THE HILL END TROUGH BASED ON THE MODELLING OF THE REGIONAL GRAVITY DATA

VLADIMIR DAVID, RICHARD GLEN AND ROSS SPENCER
davidv@minerals.nsw.gov.au

Computer modelling was used to establish basement architecture of an inverted sedimentary basin using regional gravity and interpreted geology. The gravity data reflect the response of the Ordovician volcanic basement of the Hill End Trough. The three-dimensional model of basin opening indicates "chocolate-tablet" type extension in response to opening of the Trough along a small circle about a pole of rotation to the northwest. There is a strong correlation between the basement architecture and plunge changes in surface folds and also with mineral deposits in the Silurian-Early Devonian fill of the Hill End Trough.

WIDE-ANGLE REFLECTION EXPERIMENT WITH VIBROSEIS SOURCE AS PART OF A MULTIDISCIPLINARY SEISMIC STUDY OF THE LEONORA-LAVERTON TECTONIC ZONE, NORTHEASTERN YILGARN CRATON

TANYA FOMIN, ALAN CRAWFORD AND DAVID JOHNSTONE
tanya.fomin@ga.gov.au

A wide-angle reflection seismic survey coincident with a regional transect through Northeastern Yilgarn Craton focused on the Leonora-Laverton Tectonic Zone, Western Australia, was carried out to supplement deep seismic reflection studies. The major objectives were to:

- Collect high-density refraction information for offsets of up to 60 km;
- Carry out a comparative study of near-vertical and wide-angle seismic images of the crust in the study area; and
- Obtain velocity information for the upper crust.

The survey deployed 120 short period recorders with a 500 m spacing. Acquisition parameters used for the wide-angle reflection experiment were selected so that it would to fit into the schedule and technology of the conventional reflection survey. The same vibrations were recorded in both surveys simultaneously. The major challenge in processing the wide-angle data was to manage the huge volume of information. The processing sequence included sorting into receiver and source gathers, cross-correlation with reference sweeps and stacking original seismic traces to form single source point traces, producing seismograms from individual traces and finally creating seismic record sections from separate seismograms.

High amplitude seismic signals from Vibroseis sources were recorded at least up to 45 km offsets in the first arrivals, and later arrivals were observed down to 12 s next to sources. A preliminary upper crustal model developed from the wide-angle data shows that the thickness of a high velocity layer, corresponding to the greenstone rocks, is 4.0-4.5 km. The boundary separating this layer from a low velocity layer below it is possibly a compositional boundary between greenstones and underlying felsic gneisses. There is no evidence for high velocity material below this boundary. Assuming the Moho belongs to the deepest reflections modelled, total crustal thickness in the region can be speculatively estimated in the range 32-37 km. This model will be refined when more processed data become available for modelling.

KEYNOTE / SEISMIC TECHNICAL FORUM 4: CONVERTED WAVE / AZIMUTHAL SEISMIC

OBSERVATIONS ARISING FROM THE USE OF FULL-OFFSET AZIMUTHAL 3D SEISMIC: ONSHORE AUSTRALIA

I DJAMALUDIN AND S BREW
irwan.djamaludin@santos.com.au

During recent years Santos Ltd has acquired three full-offset azimuthal 3D seismic surveys over onshore Australia. Two of these were in the Cooper Basin and one in East Queensland. The techniques for achieving cross-line offsets equal to in-line offsets are reviewed, together with the considerations for processing such data. The acquired data sets demonstrate that there is considerable anisotropy present in the data and that the degree of anisotropy varies both spatially and in two-way-time. The anisotropy manifests itself as differences in such parameters as stacking velocities, two-way-time and horizon amplitudes at intersections of stacked or gathered data binned at different azimuths. The implications of such anisotropic effects on 2D seismic surveys are considered.

Other investigations include the application of azimuthal processing techniques to conventionally acquired 3D data (that is, surveys in which the cross-line offset is not as large as the in-line offset) and a comparison of two different anisotropic analysis techniques on the same data set.

As anisotropy of P-wave seismic data is considered to be caused by the impact of seismic waves passing through vertical fractures at different azimuths, maps which show the variation in estimated direction and density of fracturing are reviewed during the course of this presentation.

Potential Fields: Feature Extraction

DAP - Large Volume Spatial Data Discovery and Distribution over Networks

*Ian MacLeod, Roger Amorim and Nick Valleau**
ian.macleod@geosoft.com

The Internet, Intranets and general globalisation of networking technology have produced a dramatic increase in the type and volume of geo-data that are available to geoscientists. The development of useful protocols and underlying technologies for computers to access and share geo-data, both privately within organizations, and globally on the Internet is key to our ability to use this information efficiently.

In this paper, we describe the Data Access Protocol (DAP), which is a suite of server applications that enable geoscientists to find and evaluate data, and automate windowing, reprojection and reformatting the data to suit a specific requirement. DAP technology addresses a variety of network situations including:

1. Simple web-browser based discovery and retrieval of data of interest in a specified format and coordinate system;
2. Support for Open GIS Consortium Web Map Server (WMS) interface to allow any WMS compatible application to retrieve "images" of the data for use as layers in a GIS application; and
3. Direct support for DAP-enabled thick clients, such as Oasis montaj, to optimally retrieve data directly for their own use, and transfer data to a hosting DAP environment.

When communicating with DAP-enabled client applications, DAP addresses the movement of data (lossless compression, encryption and streaming) both to and from a data server over a network. The core DAP protocol effectively abstracts data formats to allow client applications to work in whatever environment is required, and DAP servers to connect to data in whatever native format is in use by a hosting organization. This makes DAP suitable for use in many data storage environments. DAP also includes a number of spatially optimised data stores that can be used to deliver extremely high performance for data extraction and retrieval.

Semi-Automated Magnetic Image Retrieval

A. J. Buckingham, M. C. Dentith and R. D. List
abucking@geol.uwa.edu.au

Image retrieval systems provide an effective tool for signature mapping and retrieval that can be applied to magnetic images to assist with preliminary interpretation of large datasets. Image retrieval is currently a very active field of research, motivated by the significant increase in the size of digital image databases in a wide range of image-based fields. It has emerged as a powerful tool for searching and locating a desired image, or part-image, from a large image database. Locating discrete circular anomalies sought after when exploring for kimberlites is an example of a potential geophysical application.

A model for content-based magnetic image retrieval (CBMIR) using texture and shape descriptors has been developed. Region and boundary-based shape information is extracted using various edge detection techniques, and texture content is derived using statistical and wavelet transform-based methods. The model has been incorporated into a Matlab-based system for image retrieval and results using an experimental magnetic database are presented. The system is interactive, allowing the users intentions to be incorporated into the retrieval results.

Tests on the experimental magnetic database, demonstrate that CBIR has the potential to be a powerful tool in magnetic image interpretation, as it has been in other image-based fields.

Semblance Filtering of Airborne Potential Field Data

Asbjorn N. Christensen
asbjorn.n.christensen@bhpbilliton.com

Airborne Gravity Gradiometer (AGG) data and Total Magnetic Intensity (TMI) data are acquired simultaneously by the BHP Billiton FALCON™ system.

An important step in the joint interpretation of AGG and TMI data is to identify and discriminate geological structures from the geophysical signatures in the data sets. Hence, the local similarity - or lack thereof - between the AGG and the TMI data is an important clue in the geological interpretation of the data.

A spectral semblance filter computes the resemblance of the two data sets individually for each wave number in the Fourier domain. Spectral semblance filtering enables the interpreter to separate and isolate events that are coherent in two different data sets, such as gravity and magnetic.

An example, using data from a FALCON™ survey over the Hardey Syncline in the Hamersley Basin, demonstrates the use and the advantages of the spectral semblance filtering of airborne potential fields data.

Feature Detection Using Sunshading

G. R. J. Cooper and D. R. Cowan
006grc@cosmos.wits.ac.za

Horizontal derivatives of potential field data are routinely used to sharpen the edges of linear features such as dykes and faults. They are also used as input to the sunshading filter. Given the azimuth and elevation of a source of illumination, this filter calculates the reflectance from a surface composed of the data to be interpreted. Linear features orthogonal to the illumination azimuth are enhanced, while those lying parallel to it become less apparent.

As the sunshading filter is relatively insensitive to features of different azimuth from that being searched for, this paper first describes how to tune the angular sensitivity to any desired degree.

Secondly, the field gradients are calculated in a cylindrical polar coordinate system rather than the usual Cartesian one. This allows both the enhancement of circular anomalies of any radii, and of linear features of any orientation. The cylindrical gradients may also be used with the sunshading reflectance algorithm. The new filters are demonstrated on various gravity and magnetic datasets.

AEM Accuracy

An Assessment of the Accuracy of Boundaries Picked by AEM Sounding, with Application to Salinity Mapping

James Macnae, Ashley Grant and Richard Lane*
james.macnae@rmit.edu.au

The vertical distribution of conductivity in the ground exhibits varied characteristics. Abrupt changes may occur at geological unconformities, and gradational changes are also common with saturation and salinity gradients, or with clay content through the weathering profile.

This paper describes a rapid, automatic method of picking probable vertical locations for abrupt changes in conductivity using the conductance-depth curve derived in an approximate conductivity-depth transform of airborne EM data. The method is based on identifying the location of slope changes.

The location of probable layer boundaries shows good agreement with synthetic data when the conductance contrast is adequate and boundaries are well separated. Correspondence of structures picked on separate x and z components increases the confidence of interpretation on a conductivity depth image (CDI).

In field data, the quantitative usefulness of including probable layer boundaries on a CDI display is yet to be determined, qualitatively however it appears to provide very useful information where conductivity contrasts are poorly imaged by choice of colour bar.

CORRECTING DRIFT ERRORS IN HEM DATA

Andy Green
greenaa@ozemail.com.au

Much HEM survey data suffers from low (spatial) frequency along-line variability in amplitude caused by slow changes in the system geometry and electronic drift. Even though the system is periodically taken up to a sufficient altitude to re-zero the primary field correction, the errors are not totally removed. This paper describes a procedure to reduce the effect of these errors.

Each flight line is corrected by subtracting a slowly varying function of time that has been chosen so that the between-line differences over the whole survey area are minimized. The parameters of the correction functions are estimated using weighted, damped least squares. The procedure produces a marked improvement in the quality of the images of low frequency, in-phase channels that have been corrupted by drift noise.

THE IMPORTANCE OF ACCURATE ALTIMETRY IN AEM SURVEYS FOR LAND MANAGEMENT

Ross Brodie and Richard Lane
ross.c.brodie@ga.gov.au

Airborne electromagnetic (AEM) systems are increasingly being used for mapping conductivity in areas susceptible to secondary salinity, with particular attention on near-surface predictions (i.e. those in the top 5 or 10 m). As the measured AEM response is strongly dependent on the height of both the transmitter loop and receiver coil above conductive material, errors in measurements of terrain clearance translate directly into significant errors in predicted near-surface conductivity.

Radar altimetry has been the standard in airborne geophysical systems for measuring terrain clearance. In areas of agricultural activity significant artifacts up to 5 m in magnitude can be present. One class of error, related to surface roughness and soil moisture levels in ploughed paddocks and hence termed the "paddock effect", results in overestimation of terrain clearance. A second class of error, related to dense vegetation and hence termed the "canopy effect", results in underestimation of terrain clearance.

A survey example where terrain clearance was measured using both a radar and a laser altimeter illustrates the consequences of the paddock and canopy effects on shallow conductivity predictions. The survey example shows that the combination of the dependence of AEM response on terrain clearance and systematic radar altimeter artefacts spatially coincident with areas of differing land-use may falsely imply that land-use practices are the controlling influence on conductivity variations in the near surface.

A laser altimeter is recommended for AEM applications since this device is immune to the paddock effect. Careful processing is still required to minimise canopy effects.

Downhole Resistivity / EM Methods

CROSS-WELL ELECTROMAGNETIC IMAGING IN THREE DIMENSIONS

Michael S. Zhdanov and Ken Yoshioka
mzhdanov@mines.utah.edu

In this paper we develop a new technique for 3-D cross-well electromagnetic imaging based on the localized quasi-linear (LQL) approximation introduced by Zhdanov and Tartaras, 2002. This approximation was specially designed for modelling the electromagnetic field generated with a moving transmitter. Using the LQL approximation, which is independent of the source position, one can model and invert the EM data for all transmitter and receiver positions at once. This remarkable property of the LQL approximation makes it a practical tool for 3-D imaging of the cross-well EM data. In the numerical inversion algorithm we implement the options for smooth or focusing regularized imaging, which helps generating a clear focused image of the geological target.The numerical examples demonstrate effectiveness of this technique in 3-D cross-well electromagnetic data interpretation for imaging both conductive and resistive targets.

INVERSION OF CROSS-HOLE RADIO FREQUENCY DATA IN A LAYERED EARTH

P. K. Fullagar and B. Zhou
p.fullagar@mailbox.uq.edu.au

Cross-hole frequency domain electromagnetic (EM) methods are most commonly applied at high frequencies (> 1 kHz) for definition of petroleum and coal deposits. Interpretation is often based on tomographic reconstruction of the data, assuming far-field, ray-like behaviour. In some cases these assumptions are untenable. Conventional tomography is also questionable if data are recorded at depths, which are small in comparison to a wavelength, i.e. if surface reflections are appreciable.

In order to address these limitations of tomography, a program has been written to invert cross-hole data from a vertical magnetic dipole transmitter in a layered earth. 1D inversion and conventional tomography are applied to the same radio frequency data set to illustrate the advantages of the more rigorous approach at shallow depths and short ranges.

USING THE LOKI 3D EDGE-FINITE-ELEMENT PROGRAM TO MODEL EM DIPOLE-DIPOLE DRILL-HOLE DATA

Art Raiche, Fred Sugeng and Heikki Soininen
art.raiche@csiro.au

Electromagnetic drill-hole measurements are an important tool for locating conductive orebodies in detailed exploration scale. Dipole-dipole systems have good spatial resolution, especially if all three magnetic components are measured over a wide frequency range. Interpretation of field data requires the use of sound 3D modelling tools capable of dealing with high conductivity contrasts and the close proximity of boundaries to the source or receiver. We modelled the response of the SlimBoris dipole-dipole drill hole system going through a block target using Loki, a 3D, full-domain, edge finite-element approach based on vector shape functions and scalar unknowns. This method achieves considerable speed advantage over conventional finite-element methods since only the one tangential component rather than three orthogonal components need be solved at each "node". Moreover, since no boundary conditions are violated in this approach, contrasts in excess of one million to one can be layered earth solutions. Computation time can be reduced by a further factor of five by solving initially for Schelkunoff potentials rather than electric or magnetic fields. This is due to the superior condition number of the resulting matrices. Accuracy is maintained using Green's function projectors to obtain the fields at the receivers rather than differentiating the potentials. A 30 000 cell model takes 20 s on a 1.9 GHz Intel chip per frequency per transmitter position. Control files for complex models can be set up rapidly using either the Encom EMGUI or Maxwell from EMIT. The results were in close agreement with scale model results at all contrast ranges. Another check was made using a 3D integral equation program. As expected, close agreement was obtained at contrasts of less than 300 but the integral equation results deteriorated at high contrast.

Minerals Case Studies: Base Metals

THE ELECTRICAL PROPERTIES OF THE SCUDDLES VHMS DEPOSIT

Michael Roach and Andrew Fitzpatrick
michael.roach@utas.edu.au

In-situ and laboratory measurements were used to characterise the electrical properties of the Scuddles VHMS Deposit, Western Australia. A major emphasis of this investigation was to study the scale variation of electrical properties.

Massive pyrite and pyrite-chalcopyrite ores were highly conductive and the underlying intense stringer mineralisation only slightly less conductive. Some sphalerite-rich ore zones were moderately resistive as expected but others with similar grade and mineralogy were highly conductive. Laboratory current mapping and connectivity measurements, together with petrographic investigation indicate that the high conductivity Zn-rich ores at Scuddles owe their unusual properties to very small amounts of well-connected pyrrhotite.

At all measurement sites, irrespective of mineralogy, there was a clear trend of decreasing resistivity with increasing electrode spacing. At some sites resistivity variations of more than three orders of magnitude were apparent between small and large-scale measurements.

Laboratory samples from most sites also display clear bimodal resistivity distributions. The most conductive laboratory samples have properties similar to in-situ measurements at large electrode spacings while the resistive end members have properties consistent with small-scale in-situ measurements. The connectivity of the conductive phases clearly increases with increasing measurement scale.

In-situ and laboratory measurements at Scuddles demonstrate the difficulty of using traditional statistical approaches to estimate bulk electrical petrophysical properties from laboratory scale measurements.

ELECTRICAL IMAGING OF PERIDOTITE WEATHERING MANTLES AS A COMPLEMENTARY TOOL FOR NICKEL ORE EXPLORATION IN NEW CALEDONIA

C. Savin, B. Robineau, G. Monteil, A. Beauvais, J. C. Parisot and M. Ritz*
robineau@noumea.ird.nc

The first 2-D electrical resistivity tomography (ERT) survey on the well-explored (for Nickel ore) lateritic mantle of a new Caledonian ultramafic massif shows a good fit between the geoelectrical sections and the core loggings.

Data collected along several 1 km long profiles, with 10 m electrode spacing to reach about 100 m penetration depth, are reliable and the preliminary interpretation of resistivity models indicates:

- Well-defined geoelectrical layers with significant resistivity contrast;
- A very good fit of the above layers with the various units of a weathering mantle, i.e. ferricrete, saprolite and bedrock;
- The suspected geometry of horizons, deduced from core logs, is better defined by the continuous ERT imaging; and
- A transverse (section to section) continuity of saprolite troughs and bedrock ridges along N140° strike, which is the main structural feature of Tiebaghi ultramafic massif.

2D Electrical Resistivity Tomography appears to be an appropriate geophysical method to investigate the structure of weathering mantles of ultramafic massifs in New Caledonia. It should become a useful complementary tool to locate favourable zones, i.e. the saprolite horizon where Ni accumulation can be found, or, at least, to economise on drillings.

Seismic Processing 2

SEISMIC MULTIPLE ATTENUATION BASED ON PRE-STACK REFLECTIVITY MODELLING

Daryn Voss and Steve Hearn
dvoss@ velseis.com.au

A particular method of pre-stack multiple attenuation, based on generalised linear inversion (GLI) and the Haskell-matrix formulation, is investigated. The method uses GLI to obtain a 2-D earth-reflectivity function, which produces a synthetic seismic record as close as possible to the observed seismic data. The forward model employs the Haskell-matrix method to compute the entire elastic response, including primaries and multiples, corresponding to an input reflectivity. The final reflectivity is used to generate a multiples-only signal, which is subtracted from the original.

Initial trials have been carried out on noisy synthetic pre-stack gathers. Despite erroneous starting earth models, the inversion iterates robustly to provide an output record exhibiting excellent agreement with the observed record. This leads to effective multiple attenuation.

The Haskell matrix method is naturally formulated in terms of wave slowness, and hence the inversion algorithm is most conveniently carried out in either the τ-p domain, or the f-p domain. Our experimentation suggests that, in the presence of noise, the f-p domain is more robust than τ-p.

This method is computationally more expensive than conventional multiple removal strategies, such as those based on differential moveout or predictive deconvolution. Hence it is likely to have most potential where these approaches fail.

MANAGING THE THREE P'S OF SEISMIC DATA: PROLIFERATION, PERVASIVENESS, AND PERSISTENCE

Jess B. Kozman
jkozman@kuala-lumpur.oilfield.slb.com

The use of large three-dimensional seismic datasets in oil and gas exploration puts enormous strain on data storage systems and strategies. The purpose of this study was to determine the factors that contribute to challenges in storage of large seismic datasets, to collect information about strategies being successfully implemented to meet these challenges at large international oil and gas companies, and to document best practices and procedures for planning for continuing expansion of these datasets. Schlumberger Information Solutions (SIS), as a division of the world's largest provider of services to the oil and gas industry, is in a unique position to collect this information. SIS currently has seismic data management implementations with over 50 organizations in all major oil and gas exploration locations across the world. These engagements have produced a set of strategies for managing large seismic datasets that include hierarchical storage management (HSM), near line tape robotic systems, and web-based Geographic Information System (GIS) metadata analysis tools. Effective implementation of these strategies allows major exploration organizations to effectively manage and plan for continued growth and propagation of seismic data across the life cycle of their exploration and production projects.

OPTIMUM FOCUSING FROM FILTERED DENSE VELOCITIES PICKING

D. Le Meur A. Delorme, N. Mudge and P. Herrmann
dlemeur@cgg.com

Over the past few years, efficient methods have been developed to estimate densely sampled stacking velocity fields with the aim to improve the S/N ratio, the spatial resolution and the frequency content of the stack. As a by-product, this densely sampled attribute cube also becomes open to interpretation. However, the raw estimates of the automatically derived velocities are often too noisy for immediate use. Fortunately, due to their dense nature we can make use of efficient geostatistical techniques such as Factorial Kriging to perform quality control and to remove noise. We will show on a real data example that these techniques can have a clear impact on the NMO stack result.

Anisotropy/Multicomponent

3-D FRACTURE ASSESSMENT USING AV AZ AND LAYER-STRIPPING APPROACH

Mu Luo and Brian J. Evans
mluo@geophy.curtin.edu.au

Subtle variations in P-wave multi-azimuthal seismic reflections can be used to map lineations in a horizon, representing seismic amplitude changes as a result of the presence of vertical fractures. This paper shows how the amplitude maps were used to determine if layers were fractured or not, and presents a layer-stripping approach to reduce the interference of upper-horizon fracture effects on lower horizons, allowing greater clarity in mapping the deeper horizons. The technique is demonstrated using physical modelling data.

AN APPROACH TO COMPUTING THE DISPERSION OF WAVESPEED FOR THE MOST GENERAL 3D ANISOTROPIC MEDIA

Bing Zhou and Stewart Greenhalgh
bing.zhou@adelaide.edu.au

In this paper, we develop a method to calculate the dispersion of seismic wave speed (phase velocity and group velocity) for a general anisotropic medium, which is defined by twenty-one elastic moduli. The solution includes, as special cases, the isotropic and transversely isotropic problems. We apply the plane-wave analysis to the general 3D anisotropic medium and obtain explicit expressions for three eigenvalues (phase velocities) and their corresponding group velocities, which are the propagation speeds of the wavefronts and the energy fluxes (ray-paths) of one qP wave and two qS waves. Basing on the solutions, we show that the phase and group-velocity vectors generally have different directions and they depend on twenty-one elastic moduli and the direction cosines of the incident wave. As examples of using the eigenvalue solutions, we numerically calculate the phase velocities and the group velocities for an isotopic medium, a VTI-medium and a qTI-medium. Two real models (clay shale and phenolic) were used for moduli selection. These results clearly show that the wave speeds vary with the azimuthal angle and the vertical angle of the incident wave, as well as the elastic moduli. This means that the solutions may be applied to investigation of kinematic features of real samples of rocks and the sensitivity of the wavespeed to each elastic modulus. We also show the application of the eigenvalue solutions to the 2D/3D ray tracing in the most general anisotropic media.

A NEW MODEL FOR FLUID SUBSTITUTION IN FRACTURED RESERVOIRS

Boris Gurevich
boris.gurevich@geophy.curtin.edu.au

One of the main issues in the characterisation of fractured reservoirs is the ability to predict the effect of fluid properties on seismic characteristics. Background porosity can significantly affect the elastic properties of fractured rocks. This effect is studied using the model of fractures as linear-slip interfaces in an isotropic porous background. Such a medium represents a particular case of a transversely isotropic (TI) porous medium, and can be described by equations of anisotropic poroelasticity. An analysis based on these equations yields explicit analytical expressions for the low-frequency elastic constants and anisotropy parameters of the fractured porous medium saturated with a given fluid. The five elastic constants of the resultant TI medium are derived as a function of the properties of the dry (isotropic) background porous matrix, fracture properties (normal and shear excess compliances), and fluid bulk modulus.

Analysis shows that:

(1) for penny-shaped cracks in a non-porous host medium the results reduce to the classical equations for isolated cracks;

(2) for the same case of penny-shaped cracks but with background porosity, the expression for P-wave anisotropy parameter ε has the form similar but not identical to that given by the model of Thomsen; and

(3) the compliance matrix of the fluid-saturated fractured medium with considerable background porosity is not equal to the compliance matrix of any solid medium with a single set of parallel fractures. This effect is caused by the wave-induced flow of fluid between pores and fractures.

These results can be used for fluid substitution in porous rocks with parallel fractures, which is important, in particular, for AVO analysis in naturally fractured reservoirs.

EXPERIMENTAL VERIFICATION OF THE ANISOTROPIC GASSMANN MODEL FOR FLUID SUBSTITUTION IN FRACTURED RESERVOIRS

Luke Brown and Boris Gurevich
lbrown@geophy.curtin.edu.au

Porous reservoirs with aligned fractures exhibit frequency dependent seismic anisotropy due to wave induced fluid flow between pores and fractures. We model this frequency dependent anisotropy by combining the low-frequency anisotropic Gassmann model with the Hudson et al. model for frequency dependent properties of a porous material with penny-shaped cracks.

The predictions of the anisotropic Gassmann model are compared with experimental measurements of elastic wave velocities as function of angle for a synthetic sample with aligned disc-like cracks. The properties of the host rock and fracture compliances are obtained from P, SV, and SH velocities measured on the dry sample. The dry fractured porous rock properties serve as input to anisotropic Gassmann fluid substitution model, which is used to compute the saturated rock properties. The stiffnesses of the saturated fractured porous rock are used to calculate the angular dependent compressional and shear wave velocities. The predicted velocities are then compared to the measured velocities. The agreement is reasonably good for both S-wave velocities, but P-wave anisotropy is overestimated by about 25%.

This discrepancy can be explained by the fact that the low frequency assumption of the anisotropic Gassmann model does not account for the fluid diffusion effects occurring at relatively high frequencies used in the experiment (100 kHz). A combination of the low frequency anisotropic Gassmann model with the Hudson *et al.* frequency dependency accounts for fluid diffusion effects and results in an excellent agreement for P- as well as S- waves.

MODELLING

THE DEVELOPMENT OF SYNTHETIC CIPS SANDSTONES FOR GEOPHYSICAL RESEARCH

DONALD H. SHERLOCK AND ANTHONY F. SIGGINS
don.sherlock@csiro.au

This paper describes recent developments in the manufacturing of synthetic sandstones for a range of geophysical research applications. The artificial rocks, known as CIPS (Calcite *In-situ* Precipitation System) can be fabricated with systematic, controllable and reproducible variations in a single parameter, while keeping all other parameters constant. CIPS rocks have been shown to reproduce the acoustic and geomechanical response observed in natural sandstones, and provide us with the experimental capability necessary to validate theoretical and numerical modelling predictions of geophysical properties. Existing and potential research applications range from theoretical studies in seismic wave propagation, petrophysics, NMR, geomechanics and analog reservoir modelling.

SEISMIC NOISE MODELLING IN THE DAMPIER SUB-BASIN

JARROD DUNNE, TOM RIDSDILL-SMITH* AND MARKO VAN DER VEEN
jarrod.dunne@woodside.com.au

Exploration efforts in the Northwest Shelf of Australia are hampered by the presence of strong, coherent noise that overprints the reservoir section and deeper intervals. The limited success of attempts to improve seismic data quality in this region suggests that complicated noise waveforms are involved. We gained insight into the noise problem using realistic synthetic seismograms, upon which processing methods could be fully tested and the results judged objectively using known primaries.

Full-waveform synthetics were generated using the reflectivity method at several wells in the Dampier Sub-Basin and tied to field records from nearby seismic surveys. In addition, we used a finite-difference modelling technique to separate individual multiple modes from primary events in the synthetic data. We identified interbed multiples as the most cumbersome of the various multiple modes. They have similar amplitudes to weak primary events and are generated within high reflectivity packages in the overburden. They have similar moveout to the primaries and are not suppressed by stacking over the available offsets. Other significant noise sources identified include both P- and S-wave guided waves and mode-converted arrivals generated between carbonates in the Tertiary section.

Processing tests were applied to the synthetics and the results were assessed visually and by correlation with the known primaries. Routine processing largely suppressed the guided waves and mode-conversions and, to a lesser extent, the water bottom multiples. Gap deconvolution in the tau-p domain helped to suppress the interbed multiples, which are difficult to remove due to their lack of velocity discrimination from the primaries. Poor image quality and velocity uncertainty could remain at the target level as a result of weak primaries and imperfect noise elimination over the available offset range.

THIN-LAYER SCALING EFFECTS ON AVO MODELLING

BINGWEN DU AND ANDREW S. LONG
bdu@cgg.com

In AVO modelling with log data, it is a general practice to upscale the log data for reasons such as computational efficiency. In this study, we investigate the AVO sensitivity to thin-layer effects by upscaling log data at different scales. A series of Kennett-based reflectivity modelling exercises are conducted using the resulting elastic 1D models.

In the presence of thin layers, it is essential to incorporate interbed multiples (including converted wave modes) and therefore, primary-only Zoeppritz modelling could lead to misleading results. On one hand, very fine scale models involve a complex wavefield tuning that renders the theoretical Zoeppritz plane-wave reflection coefficients meaningless. On the other hand, wavefield complexities due to thin-layer multiple scattering also introduce uncertainties in the modelled AVO behaviour. In contrast, with increasing layer scales, Zoeppritz plane-wave reflection coefficients become more applicable, and interbed multiple and tuning effects also have less influence upon the AVO behaviour. At such scales, primary-only AVO modelling by ray tracing where reflection amplitudes are determined by Zoeppritz equations could be an efficient alternative to full-wavefield reflectivity modelling. In our synthetic examples, this occurs at layer scales (d) satisfying a relation to dominant frequency (λ) of $\lambda/d \leq 4 \sim 5$. However, λ and d are interdependent, as the effective velocity used to calculate wavelength λ depends on scale d. To resolve this dilemma in practice, surface seismic data could be analysed and a Q sensitivity analysis may be necessary to determine the dominant wavelength at different target levels.

KEYNOTE: EM INVERSION

NEW ADVANCES IN GEOPHYSICAL INVERSION IN MINERAL EXPLORATION

MICHAEL S. ZHDANOV
mzhdanov@mines.utah.edu

The geophysical inversion is an ill-posed problem. The solution of this problem requires the application of the corresponding regularization methods (Tikhonov and Arsenin, 1977). The traditional way to implement regularization in the solution of the inverse problem is based on a consideration of the class of inverse models with a smooth distribution of the model parameters. Within the framework of classical Tikhonov regularization, one can select a smooth solution by introducing the corresponding minimum norm, or ``smoothing'' stabilizing functionals. This approach is widely used in geophysics and has proven to be a powerful tool for stable inversion of geophysical data.

The traditional inversion algorithms providing smooth solutions for geological structures have difficulties, however, in describing the sharp boundaries between different geological formations. This problem arises, for example, in inversion for the local mineral target with sharp boundaries between the ore body and the host rocks, which is a typical model in mining exploration. In these situations, it can be useful to search for a stable solution within the class of inverse models with sharp geological boundaries. The mathematical technique for solving this problem was described in Zhdanov (2002). It is based on introducing a special type of stabilizing functionals, the so-called focusing functionals.

This new technique was successfully applied in the solution of different inverse geophysical problems, including gravity and magnetic inversion, gravity gradiometer data inversion, electromagnetic geophysical data inversion, etc. In this paper I present several examples of model study and case histories illustrating the effectiveness of the new inversion technique in 3-D interpretation of geopotential and electromagnetic field data. The case histories include 3-D inversion of the gradient gravity data collected by BHP Billiton World Exploration in the Cannington Ag-Pb-Zn ore body in Queensland, Australia, and 3-D inversion of airborne and MT data collected by INCO Exploration in the Voisey's Bay area of Canada.

IMPROVING THE ACCURACY OF SHALLOW DEPTH DETERMINATIONS IN AEM SOUNDING

JAMES MACNAE
james.macnae@rmit.edu.au

Conductivity-depth images are finding application in salinity, groundwater and environmental mapping. Hydrological modeling demands are for a much higher vertical resolution than the 10+m accuracy that was adequate in CDIs used for mineral exploration.

Contractors are increasingly confident of system waveform, geometry, and some provide corrections for factors such as pitch, roll and yaw. This increased system accuracy is the trigger for efforts in increasing the accuracy of processing.

The CDI process makes a number of approximations in order to increase the speed of processing. One of the most critical in program EMFlow is an assumption that the transmitter and receiver are entirely within the current system induced in the ground at all delay times. This assumption equates to all components of the secondary field decaying monotonically with time. For typical fixed-wing AEM geometries, this assumption is poor for the z component of the response, and in fact on a CDI, z component data may predict to top of a surficial conductor to be several metres in the air. Allowing for part of the induced currents to lie between the transmitter and receiver leads to an accurate prediction of surficial conductors to lie at or below surface.

A COMPARISON OF SHIPBORNE AND AIRBORNE ELECTROMAGNETIC METHODS FOR ANTARCTIC SEA ICE THICKNESS MEASUREMENTS

J. E. Reid, J. Vrbancich and A. P. Worby
james.reid@utas.edu.au

The three-dimensional modelling program MARCO_AIR has been used to calculate the response of idealised pressure ridges to practical airborne and ship-borne electromagnetic systems. The model results clearly show the superior resolution of the horizontal coplanar ship-borne system compared to airborne measurements. However, sea ice keel thicknesses estimated via inversion of ship-borne single-frequency electromagnetic data are strongly dependent on relatively small variations in survey altitude.

Inversion of helicopter electromagnetic data over 3D pressure ridge models shows that the maximum keel thickness is consistently underestimated, although airborne EM methods yield reliable thickness estimates over level ice. The vertical coaxial coil survey geometry offers excellent lateral resolution of multiple targets, but the anomalies of typical Antarctic sea ice pressure ridges would be too small to detect in practical surveys using a close-coupled (2 - 3 m) geometry. For a system with a coil separation of 8 m, the vertical coaxial responses are larger, and lateral resolution of the measurements at a flight height of 20 m is superior to a close-coupled system flown at an altitude of 10 m.

General Interest

WHAT IF YOUR INVERSION HAS NO NUMERICAL TARGET?

Chris Wijns, Fabio Boschetti and Peter Kowalczyk
cwijns@geol.uwa.edu.au

We present a system for inverting geological models in cases where there are no established numerical criteria to act as inversion targets. The method of interactive evolutionary computation provides for the inclusion of qualitative geological expertise within a rigorous mathematical inversion scheme, by simply asking an expert user to visually evaluate a sequence of model outputs. The traditional numerical misfit is replaced by a human appraisal of misfit. A genetic algorithm provides optimal convergence into the target parameter space, while optimising an ensemble of solutions, so that the non-uniqueness of the problem may be explored.

In order to facilitate analysis of the results, we employ a visualisation technique known as self-organised mapping to represent the parameter space covered by the numerous model outputs. The result is a simple view of an otherwise complicated multi-dimensional problem. A user may infer much about the controlling parameters in the model through a few graphical displays of the data. The potential of this interactive inversion and visualization technique is demonstrated when we invert a geodynamic model for a conceptual pattern of fault spacing during crustal extension. We also present an example where the interactive scheme is linked to a numerical inversion of induced polarisation data. In this case, we are exploring for the numerical inversion parameters, which lead to a particular geological output.

A CONCEPTUAL FRAMEWORK FOR INTERPRETATION OF AIRBORNE GEOPHYSICAL DATA

Ann-Marie Anderson-Mayes and Gregory J. Street
ama.mayes@bigpond.com

The new generation of high quality airborne geophysical data are rich in information reflecting the complexity and variability of the subsurface, yet methodological approaches to extracting this geological information have remained largely unchanged and poorly documented. The vast majority of literature either discusses computational interpretation techniques or reports the results of a geological interpretation of geophysical data. In this paper we address this problem by presenting a conceptual interpretation framework to represent the general transformation of geophysical data into geological knowledge. The framework is based on five fundamental tasks - spatial pattern identification, spatial correlation, computational interpretation, geological inference and target identification.

Our purpose in developing this framework is to enable the development of robust, repeatable computer-assisted interpretation methodologies. For a specific interpretation problem, the framework can be used to design an appropriate interpretation methodology that clearly identifies which tasks are assigned to which data set(s), and how these tasks are linked to produce the required outcomes of the interpretation. In particular, it enables the interpreter to consider using computer-based analysis to complete some aspects of the interpretation that might normally be completed using a conventional, manual approach. For example, in this paper we apply the framework to develop an interpretation methodology for a multivariate geophysical study of dryland salinity. This structured approach does not sacrifice the vital human-centred elements of the interpretation, but rather enables the interpreter to explore avenues to integrate those human-centred tasks with computer-assisted processes.

APPLICATION OF SAR INTERFEROMETRY TO A GEOTHERMAL FIELD

Yasukuni Okubo, Hidehisa Watanabe, Nobuhiko Shiga and Shuichi Rokugawa
yasu-okubo@aist.go.jp

To measure the land deformation, we applied SAR interferometry to a geothermal field, where a geothermal plant has operated since 1995. Interferometric fringes were generated by the difference in radar phase acquired at different times by the JERS-1 SAR. We constructed interference patterns from the difference of two pairs of SAR images of '94/09/19-'95/04/27 and '95/04/27-'95/09/06. The coherence of the '94/09/19-'95/04/27 pair is degraded probably by the spatial baseline noise. The interference patterns partly suffer from a spatial change of moisture. To evaluate the results, we compare the interferometric fringes of '95/04/27-'95/09/06 pair with the level changes during 1994 - 1995 observed by levelling.

The levelling shows a local subsidence of several centimeters. There is a good correlation in the comparison, however, the amplitude of the leveling during September 1994 - October 1995 is about two times greater than the slant range of interferometry.

I interpret that the ground has been subsiding constantly during September 1994 - October 1995 and that the interferometric fringes correspond to the land deformation in the order of cm during about a half period of the leveling observation.

GEOPHYSICAL MONITORING OF TREE ROOT ZONES

ANTON KEPIC AND TRISTAN CAMPBELL
kepic@geophy.curtin.edu.au

Understanding the extent and influence of tree root zones is very important to soil scientists and biologists studying a range of agricultural problems, such as salinity remediation. Unfortunately, most current methods of examination involve digging up the root system and kill the tree in the process. Thus, time-lapse studies are almost impossible. Information that we would like to know is how far do the roots extend to and how they influence soil moisture levels, and what are the effects of competition over time for water and nutrients?

Geophysical methods are generally non-invasive and may provide a means to study tree systems over time. We have implemented, with varying degrees of success, self-potential, ground penetrating radar (GPR), resistivity and misse-à-la-masse methods. The research is still at a very early stage, but shows encouraging results. GPR and resistivity appear to show some promise in monitoring changes in moisture levels in the soil. Self-potentials due to the chemical/osmotic processes in the up-take of water and nutrients also shows promise, but noise from other sources and difficulties in interpretation limit the method. Misse-à-la-masse appears to uniquely solve the very difficult problem of mapping the extent of the root-zone of a particular tree, without having to resolve individual roots.

KEYNOTE / SEISMIC TECHNICAL FORUM 5: STRUCTURAL INTEGRITY

ON STRUCTURAL INTEGRITY IN SEISMIC DATA

HELMUT JAKUBOWICZ
helmut_jakubowicz@veritas.com

The industrialist Peter Scotese once said, "Integrity is not a 90 percent thing, not a 95 percent thing; either you have it or you don't." In the case of seismic data, structural integrity derives from the combined accuracy of the migration algorithm and velocities used. Indeed, these two components are complimentary. For example, even the most accurate migration method cannot provide reliable structural images if the velocities used are obtained by simply scaling stacking velocities by 90 percent or 95 percent!

The nature of the velocity field is, of course, a major factor in determining the detail, sophistication and intensity required for velocity analysis. However, it also influences the accuracy of the structural image in other, subtler ways. In particular, although the range of velocity variations dictates the complexity of the imaging method that should be used, it can also influence what parts of the earth can be imaged, and, by implication, even place constraints on the data acquisition. Finally, because the focusing aspect of migration is relatively insensitive to certain (anisotropic) aspects of the velocity field, this limits the accuracy with which migration velocities alone can be used to convert directly to depth, and can even introduce lateral mispositioning in the final image. Indeed, this is one of the major reasons why migrated data often do not tie wells correctly.

In this paper, we consider the impact and interaction of velocity variations and migration algorithms on structural imaging. Specifically, we review different migration algorithms, and show how more detailed and accurate consideration of the velocity behaviour on the underlying physics can lead to more reliable images and improved velocity determination. We also show that fundamental limitations in data-derived velocities can be overcome using well information, and that, when this is done, anisotropic prestack depth migration can provide exceptionally accurate images in depth. As General Norman Schwartzkopf once said about integrity, "The truth of the matter is that you always know the right thing to do. The hard part is doing it."

SEISMIC IMAGING UNDER THE DARAI LIMESTONE IN THE PNG THRUST-BELT

GREG BERESFORD AND FRANK NICHOLSON*
frank.nicholson@santos.com.au

Seismic exploration in the Papua New Guinea Highlands has experienced a 'mini renaissance' over the last few years where the permit operators have engaged a group of independent contractors to acquire several hundred kilometres of 2D seismic. The cost of acquisition is upwards of US$ 50 000 per kilometre, which generally rules out in-field experimentation and places a greater emphasis on processing and pre-survey modelling. Many of the seismic programs have traversed thick, (massive, from 500 m->1000 m) karst Darai Limestone at surface. The karst limestone, combined with the structural complexity of the thrust belt produces seismic images which range from clear to undecipherable. Full waveform elastic modelling based on wells at Gobe, Gobe-1X and Hides provides insights into seismic propagation through the limestone and lead to better acquisition design. In turn this may improve data quality to the point where pre-stack migration can be applied successfully.

Elastic seismograms computed using the method of Kennett (1979) reveal that thick columns of buried limestone typical of the Gobe area do not in themselves produce a serious barrier to imaging targets underneath. The models use a simple replacement velocity from the depth at which reliable logs exist in the limestone. In all cases this depth is below the water table. Transmission loss through the limestone can be as little as 10dB depending on the degree of karsting. The composite wavelet produced by both short period multiples and mode conversions will produce useable reflections off target out to offsets as high as 5 km. These large offsets are important to include as the near offsets are more contaminated by multiples generated by the limestone.

The S/N estimated from the elastic modelling is higher than what we might guess it to be from the field data. From this we conclude that many of the problems for exploration in PNG arise in the first 100 m (or even less) below the surface. The limestone above the water table may be producing most of the transmission problems due to scattering. It is critical for the success of future exploration to measure the elastic properties of the shallow limestone and determine the mechanism by which the data are being degraded.

FROM DEPTH MIGRATION MODEL BUILDING THROUGH TO STRUCTURAL UNCERTAINTY ANALYSIS: AN INTEGRATED WORKFLOW

MATTHEW G. LAMONT, JAMES GUNNING, MICHAEL E. GLINSKY AND JAMES H. ROBINSON
matt.g.lamont@bhpbilliton.com

- When evaluating prospects, some of the questions to which we would like answers are:
- What is the shape of the container?
- What are the potential volumes in a prospect?
- Where is the spill point?
- What is the best position to site the well/s?

Naturally there are not single answers to any of the above questions, as the seismic inversion problem for structure is inherently non-unique (the velocity/depth ambiguity). Rather what we would like to know is the distribution of potential answers and their likelihood.

A quantitative evaluation of uncertainties based on a PreSDM workflow is proposed. Reflection tomography together with PreSDM allows velocities to be constrained at each point within a volume. The proposed workflow utilises a reflection tomography scheme, which generates a system of constraint equations for the velocity model based on raytracing and pick uncertainty. These constraints acting alone produce an unstable and non-unique inverse problem, but if these constraints are used as a likelihood in a Bayesian scheme which imposes a realistic geostatistical model for the prior spatial distribution of velocities, the instability is removed. The resulting Bayesian posterior distribution is then a compact expression for the distribution of structural maps which satisfy the tomographic constraints and the requirement of geological realism.

Mineral Case Studies: Other

A GEOPHYSICAL SIGNATURE FOR TIN DEPOSITS IN SOUTH-EAST AUSTRALIA - REVISITED

Steve Webster
swebster@sneaker.net.au

Webster (1984) showed "*that hardrock tin deposits in south-east Australia have a characteristic magnetic signature in the vicinity of each deposit*". This magnetic signature was concluded to be due to the high temperature of related granitoids imposing a remanent magnetism on rocks within the metamorphic aureole. The paper also discussed the main granitoid classifications and associated mineralisation in relationship to geophysical parameters and the use of the regional data for geological mapping in New South Wales and Tasmania.

The case examples utilised in the original paper have been re-examined using modern airborne geophysical data acquired by Mineral Resources Tasmania (MRT) and the NSW Department of Mineral Resources. The magnetic and radiometric character of the granitoids and local lithology patterns are better contrasted in the new data sets, which allows for mapping of geology and structure to finer resolution.

A significant feature of the new MRT data is the magnetic and radiometric aureole, up to 2 km wide, now observed to encircle S-type granites, in particular the Meredith Granite. A metamorphic aureole was known from earlier geological mapping; however, the geophysical response was only poorly expressed in earlier datasets. The new data in the vicinity of these tin deposits are presented and profile modelling is used to confirm that remanence effects are involved in the source of the anomalies. The radiometric data sets show complimentary patterns in the vicinity of tin deposits that enhance the recognition of the mineralised target zones.

In the central NSW tin-belt the S-type granites are intruded into weakly magnetic Ordovician meta-sediments, however, the zero magnetic response of the granites is well contrasted with the north-south linear fabric of the meta-sediments. The tin and gold deposits generally occur in quartz reefs located along sheared contacts of the granite with the meta-sediments and cross cutting east-west structures appear to be related to the source of the tin and gold mineralisation. The application of the radiometric data is restricted by the lack of outcrop.

EVALUATION OF MULTIFREQUENCY AIRBORNE EM FOR OPAL PROSPECT DEFINITION AT LIGHTNING RIDGE, NSW

Michael Moore, James Macnae and Gary Burton
moorem@minerals.nsw.gov.au

The New South Wales Department of Mineral Resources has been evaluating the use of geophysical techniques as a tool to better understand controls on opal formation in the Lightning Ridge district of NSW. A detailed study over the Gurley Ridge, approximately 25 km southwest of the Lightning Ridge Township, commenced in June 2001. This Cretaceous sedimentary ridge hosts the Coocoran Opal Field and includes the productive Allahs and Natelies Dream prospects. Current geological understanding predicts opal occurrence at the interface of clay and sandstone horizons within the sedimentary package. The study included a compilation of historic drill records, detailed surface geological mapping, lithofacies mapping, and acquisition of detailed airborne electromagnetic data. An electrical model of the subsurface generated from previous ground work was used to guide selection of the transmit-receive frequencies employed in the airborne survey. The acquired multifrequency airborne data were inverted and conductivity depth images for each flight and tieline produced. The CDI sections revealed the existence of a ubiquitous conductor located between 10 m and 20 m below the surface, covering the majority of the ridge area. A ground follow-up program was instigated to investigate the identified conductive zone. Eight high-resolution, detailed transient EM ground lines were acquired coincident with various conductive signatures identified in the airborne data. A small drill program was conducted to ground truth both the airborne and TEM subsurface conductive features. Drill results, downhole geophysical logs, and the detailed ground TEM data have been used to validate and refine inversion of the airborne data.

THREE SPRINGS TALC MINE: A NEW VIEW ON AN OLD DEPOSIT

Lisa Vella, Brian Evans, Milovan Urosevic and Don Emerson
lisa.vella@wmc.com

A successful application of the high-resolution seismic reflection method for talc exploration is demonstrated using an experimental seismic line, recorded over the Three Springs talc deposit. Since 1973, a variety of ground and airborne geophysical techniques had been applied to talc exploration at Three Springs, with limited success. However, wireline logging and laboratory petrophysical measurements have provided new insights into the physical properties of talc and contrasts between talc and adjacent dolomite and dolerite rocks. In particular, P-wave velocity measurements demonstrated that the elastic contrast between the talc mineralisation and surrounding rocks might be sufficient for the application of seismic reflection methods to talc exploration. Between 1989 and 1993, seismic reflection and refraction surveys were acquired on a single profile across the Three Springs talc deposit. The results of this work were disappointing, apparently contradicting physical property measurements. Greatly improved results from re-processing of the 'old' seismic data, in 2000, suggested seismic reflection might indeed assist in mapping of the talc mineralisation, as well as providing important detailed structural information. Additional experimental data acquisition, undertaken in 2000, confirmed the potential application of the seismic reflection method to deposit - scale talc exploration. However, whether the seismic technique can be routinely applied, in a cost - effective manner, providing the required geological detail, remains to be seen.

Potential Fields: Inversion

3D GRAVITY AND AEROMAGNETIC INVERSION, PILLARA REGION, W.A

Peter Fullagar, Glenn Pears, David Hutton and Andrew Thompson
p.fullagar@mailbox.uq.edu.au

Constrained 3D gravity and magnetic inversion has been applied to an area of approximately 11 km x 4.5 km straddling the Pillara gravity ridge, Lennard Shelf, Western Australia. The main aim was to better define the depth to top limestone. The starting point for inversion was a simplified geological model based on three generalised litho-stratigraphic units: Shale/Siltstone, Limestone, and Basement.

A staged inversion procedure was adopted. First the effects of the large property contrasts were accounted for, most notably the density contrast between limestones and clastics. Subsequently the residual gravity and magnetic data were inverted to define more subtle contrasts within the sediments.

Gravity inversion involved adjustment of the Limestone contact geometry as well as model densities. The contact was fixed where pierced by drill holes, and a priori upper and lower bounds were imposed on the densities of the geological units. The inferred Limestone contact is a strong determinant of prospectivity, both in terms of depth and in terms of fault displacements. Final stage inversion highlighted coherent intra-sedimentary density trends oriented NE and NNE; these features could be associated with mineralising faults.

Aeromagnetic inversion defined a basement susceptibility distribution generally decreasing from the SW to the NE, reflecting the character of the TMI data. More subtle susceptibility trends attributed to the sediments may reflect the underlying structural fabric, though the most pervasive residual gravity features are not strongly developed in the residual magnetic data.

3D gravity inversion is effective the Lennard Shelf as a means for defining the depth to limestone. The reliability of the inversion will be enhanced in areas where the gross geometry of the Limestone contact and basement unconformity are constrained by sparse drilling and/or seismic, and where the densities are well known from drill core determinations or wireline logging. Magnetic inversion can play a supporting role, insofar as it defines the basement topography.

ORIGIN OF MAGNETIC ANOMALIES ASSOCIATED WITH THE YALLALIE IMPACT STRUCTURE, PERTH BASIN, WESTERN AUSTRALIA

P. J. Hawke, A. J. Buckingham and M. C. Dentith
phawke@geol.uwa.edu.au

The Yallalie impact structure is located within the Mesozoic sedimentary rocks of the Perth Basin, Western Australia. A high-resolution aeromagnetic survey across the structure at a 200 m line spacing and 60 m flying height has defined a series of concentric anomalies centred on the structure.

The causes of magnetic anomalies associated with meteorite impacts in sedimentary basins are poorly understood in comparison with those into crystalline basement rocks. Modelling suggests the most likely source of the magnetic anomalies at Yallalie is either an injected melt sheet or new magnetic species created by hydrothermal alteration of pyrite or glauconite within the Cretaceous marine sediments of the Leederville Formation or Parmelia Formations.

A METHODOLOGY STUDY IN DETERMINATION OF DEPTH TO BASEMENT BY INVERSION OF SELECTED DISCRETE MAGNETIC FIELD ANOMALIES

C. Foss
clive@encom.com.au

Magnetic field depth-to-basement studies are important for investigation of basin architecture in petroleum exploration, and to excise areas from mineral exploration where basement is too deep. Many methods are used to obtain estimates of depth to basement, including spectral analysis, Werner and Euler deconvolution, Naudy analysis and modelling. All methods require anomalies of limited overlap and high signal to noise, caused by discrete bodies of appropriate shape. Many magnetic field data sets contain only a few such suitable anomalies. Given this often-sparse resource of suitable anomalies and the high computing speeds now available, it is feasible to replace these older, completely automated batch processes with interactive inversion of user-selected anomalies. Inversion of selected anomalies results in far fewer depth solutions, but each solution is of greater reliability and has more geological information, including estimates of source susceptibility, width, dip and depth extent. The modelling process is self-adaptive for each individual anomaly as opposed to the batch methods that rely on fixed source assumptions, such as structural indices. Furthermore in generating those solutions, the user comes to a better appreciation of the data and of the ambiguities of its interpretation.

Where depth to basement exceeds the spacing between survey lines, any smoothing during the gridding process has a negligible effect on depth estimation. In such cases it is often more convenient to generate magnetic depth estimates from grid data rather than the primary profile data. Examples of depth estimation by selective inversion of anomalies in TMI grids are presented from a study of the Ngalia Basin in the Northern Territory. These examples illustrate the issues involved, and the capabilities and limitations of the method.

AEM Interpretation

APPROXIMATE 2D INVERSION OF AEM DATA

Peter Wolfgram, Niels B. Christensen and Daniel Sattel
pwolfgram@fugroairborne.com.au

Airborne electromagnetic (AEM) data are presently inverted with one-dimensional (1D) models either as Conductivity Depth Images (CDI) or with full non-linear inversion to build model sections of concatenated 1D models. If lateral conductivity changes are small, 1D models are justified. However, AEM investigations are often carried out specifically to find localised conductors and in this case 1D inversion is insufficient and will often produce artefacts in the model section.

We have developed an approximate inversion method that deals with laterally inhomogeneous sections. The method is based on the Adaptive Born Approximation previously applied by one of the authors (NBC) to the interpretation of central-loop ground EM profiles. The technique reproduces synthetic models of moderate conductivity contrasts without the artefacts typically seen in CDI sections. The computing speed is comparable to that of stitched 1D inversions.

An example of processing field data over a massive Nickel Sulphide deposit shows promising results for routine application on large AEM data sets.

WESTERN TASMANIAN REGIONAL MINERALS PROGRAM (PART 2): AIRBORNE ELECTROMAGNETIC DATA - QUALITY CONTROL AND INTERPRETATION

J. E. Reid, J. R. Bishop, R. Richardson, P. Fullagar, A. D. Fitzpatrick and D. L. Griggs
james.reid@utas.edu.au

Recent regional scale helicopter electromagnetic (HEM) data acquired on the west and northwest coasts of Tasmania have demonstrated the powerful geological mapping capabilities of the HEM technique.

Quality control for the survey was provided by analysis of repeat data from daily test lines, and comparison with surface geophysical data. Data have been interpreted by conductivity-depth imaging, complemented by layered-earth inversion of selected lines. The maximum depth of investigation for the HEM survey has been determined to be around 150 m, based on both theoretical calculations and the results of conductivity-depth imaging.

A preliminary interpretation of the HEM data is presented for the Balfour region. The HEM survey has clearly differentiated previously unmapped units within the Proterozoic Rocky Cape Group, and has defined several major structural trends within the survey area. A large number of bedrock conductors have been identified in the HEM data, particularly close to the historic copper mining centre of Balfour.

MODELLING AND MATCHING THE AIRBORNE EM RESPONSE OF HARMONY AND MAGGIE HAYS

David Annetts, Fred Sugeng and Art Raiche
david.annetts@csiro.au

Using two examples, we show good matches between field and 3D modelling data. The 3D models were small enough to reduce runtimes, yet incorporate sufficient complexity to model complex environments more accurately than plate or layered-earth based models. Time and effort involved in this modelling, although greater than for simple models, is not excessive, and can easily be accomplished on a PC-class computer.

TOPOGRAPHIC MODELLING AND CORRECTION IN FREQUENCY-DOMAIN AIRBORNE ELECTROMAGNETICS

Yutaka Sasaki and Hiroomi Nakazato
sasaki@mine.kyushu-u.ac.jp

Many helicopter-borne electromagnetic (HEM) surveys have been carried out in mountainous areas. However, the effects of topography on the HEM response have not been reported in the literature for a long time. We simulate the response to topography using a staggered-grid finite-difference method. Modelling shows that a hill produces a high-resistivity anomaly over its top and a low-resistivity anomaly over its foot (when the magnetic-field response is transformed into the apparent resistivity) and that topographic effects increase with increasing frequency. In order to reduce those effects, a simple correction procedure is presented and tested on synthetic data. Results indicate that the corrected data do not reproduce the effects of the actual resistivity structure accurately enough to permit the quantitative interpretation assuming a flat-earth model. The reason for this is that the geometrical relationship between the coil system and the subsurface structure changes. The most rigorous and accurate approach to interpreting HEM data with topographic effects is to incorporate a forward-solution scheme capable of modelling topography into inversions. A 3-D inversion method is successfully tested on synthetic data.

Groundwater: New Technologies

GROUNDWATER EXPLORATION WITH THE MAGNETIC RESONANCE SOUNDING METHOD

J. Bernard and A. Legchenko
iris@iris-instruments.com

The Magnetic Resonance Sounding method (MRS) has been used in the past years with success in various geological and geographical contexts for groundwater surveys. This method has indeed the ability of directly detecting the presence of water through the excitation of the hydrogen protons of water molecules.

The frequency to which the H protons react depends on the magnitude of the Earth's magnetic field, while the intensity of the excitation determines the depth of investigation. The amplitude of the magnetic field generated in return by the water of a layer is proportional to the porosity of this layer, and the time constant of the relaxation curve is linked to the mean pore size of the material, that is to say tightly related to its permeability.

A loop laid on the surface of the ground is used for both transmitting the excitation pulse and measuring the response of the H protons. The linear relation between the measured signal and the layer porosity permits to interpret the 1D sounding as soon as the readings have been collected in the field.

The main applications of this method concern the determination of the water level and of the total quantity of water available down to 100 to 150 m depths. Magnetic Resonance Soundings can also help to select the best place for drilling, to predict a yield using a calibration, and to determine the geometry of an aquifer layer for hydrogeological modelling

A set of field examples acquired in various countries (Africa, Asia, Europe) points out both the advantages and the limitations of this method and suggests the place it should take among other geophysical methods in the methodology of groundwater investigations.

AN AUGER TOOL TO ESTIMATE HYDRAULIC CONDUCTIVITY USING A RESISTIVITY ANALOGY

Kurt I. Sørensen, Louise Pellerin, Esben Auken and Flemming Effersø*
pellerin01@aol.com

A field instrument and analysis method was developed to estimate the vertical distribution of hydraulic conductivity, K, in shallow unconsolidated aquifers. The field method uses fluid injection ports and four pressure transducers in a hollow auger that measure the hydraulic head outside the auger at several distances from the injection point. A constant injection rate is maintained for a duration time sufficient for the system to become steady state. The novelty of this method lies in the fact that K is determined while the drill string is in the ground and the change in hydraulic head is monitored in the same drill stem. Dense vertical sampling and the application of four transducer offsets provide a detailed resolution of the vertical variability in hydraulic conductivity. Exploiting the analogy between electrical resistivity in geophysics and hydraulic flow, data are processed with a 1-D inversion algorithm for the pole-pole resistivity method resulting in models consistent with the known geology.

The injection methodology, conducted in three separate drilling operations, was investigated for repeatability, reproducibility, linearity, and for different injection sources. Repeatability tests, conducted at ten levels, demonstrated spreads of generally less than 10%. Reproducibility tests conducted in three closely spaced drilling operations showed a spread of less than 20%, which may be due to lateral variations in hydraulic conductivity. Linearity tests, made to determine dependency on flow rates, showed no indication that the applied flow rate biased the measurements given the uncertainty of repeated measurements. In order to obtain estimates of the hydraulic conductivity by an independent means, a series of measurements were made by injecting water through screens installed at two separate depths in a monitoring pipe near the measurement site.

NUCLEAR MAGNETIC RESONANCE: APPLICATIONS FOR GROUNDWATER EXPLORATION IN QUEENSLAND

S. Dippell, H. Golden and G. Jenke
susan.dippel@wmc.com

Nuclear Magnetic Resonance (NMR), also known as Proton Magnetic Resonance, is observed when the magnetic dipole moments of single protons resonate in a magnetic field with a frequency proportional to the strength of that field. Typically, an artificial magnetic field is used to align the proton moments in a direction different from the ambient field and terminated abruptly, after which the resonant frequency can be observed with a decaying amplitude. This effect is exploited in proton precession magnetometers, as well as in medical imaging.

The magnetic field of a large electric current in a wire loop on the surface of the Earth will excite protons in the subsurface (usually in the form of water) in the same way. The relaxation of the protons can be observed and used to determine water content as a function of depth.

The aquifer at WMC's Phosphate Hill Mine in northwest Queensland is associated with a siliceous facies of both the Monastery Creek Phosphate and Lower Siltstone Members of the Beetle Creek Formation with a maximum thickness of 60-80 m, and is confined by the overlying Inca Shale. The groundwater is contained in fine joints, bedding partings and interstices of sandy beds, and the water table depth is about 30 m below the surface throughout the area. In this article we examine the results of NMR measurements using 100 m loops to delineate the aquifer and determine its hydrogeological parameters.

The test indicated an excellent correlation between the results of one dimensional layer inversions of NMR results data and the known aquifer geometry. The inversion utilised the amplitude E_0 of the proton relaxation field after turn-off of the excitation (directly indicative of the water content), the decay time constant T_2^* of the relaxation field (related to pore size), and phase shift φ_0 of the relaxation field with respect to the

excitation current in the loop (related to resistivity). The top of the aquifer and the water content were both defined within known parameters from drilling, while the base of the aquifer was inferred to be consistent with current estimates of its position in almost 50% of the locations.

ENVIRONMENTAL MONITORING USING ELECTRICAL RESISTANCE TOMOGRAPHY

Tania Dhu, Graham Heinson, Craig Simmons, Stewart Greenhalgh and Todd Halihan
tania.dhu@student.adelaide.edu.au

Landfill sites and saline disposal basins are just two of the numerous situations in which the escape of fluids from the system can contaminate soils and groundwater. Techniques to map fluid flow, delineate the extent of contamination and monitor changes during remediation are needed for environmental monitoring applications. Theoretical and laboratory-based testing of Electrical Resistance Tomography (ERT) was undertaken to examine the capabilities and limitations of this method.

The performance of a series of two-dimensional numerical models led to the conclusions that a contaminant plume can be imaged, that downhole current transmission sites with both downhole and surface potential measurement sites is preferable and that smaller scale fingering effects associated with free convection are not readily resolved. It also highlighted the importance of electrode configuration for successful ERT surveying. An ERT survey conducted in a glass tank to monitor the development of a dense, saline plume was also conducted. Visual comparison of photographs with ERT images agreed with theoretical results.

Seismic Processing 3

SEISMIC REPROCESSING AND PRESDM IN THE GIPPSLAND BASIN

Jarrod Dunne Terry Folkers and Paul Webster*
jarrod.dunne@woodside.com.au

Woodside holds significant equity in the VIC/RL2 and VIC/RL6 permits, which are located in the Gippsland Basin, Australia. These permits contain several fields that are spread over an area of 300 km^2. This area is covered by two overlapping 3D seismic surveys within which 11 wells have been drilled. Our recent reprocessing, merging and PreSDM of these surveys produced a single seismic data volume of high quality over the study area.

During the reprocessing we were afforded the chance to remove striping effects and suppress coherent noise more strongly than before. Full-waveform synthetics were computed from wells in the survey and used to optimise the design of a Radon filter with more 'p traces' than used in the initial processing only a few years before. When compared to the field gathers, the synthetics revealed persistent multiples in the deep section and often these had been inadvertently picked during previous velocity analyses. Careful QC of the velocity picking also resolved a major problem in the overlap zone between the two surveys.

PreSDM clearly improved fault definition over both the PreSTM and PosTM applied to the respective surveys during the initial processing. Time-variant spectral whitening helped to restore the bandwidth after migration and deliver a large improvement in temporal resolution. Interval velocities from the PreSDM depth model were used to shape the depth conversion away from well control. Subsequent re-interpretation, amplitude studies and seismic inversion have identified new prospects and have narrowed the large range of uncertainty in developing this area.

INTRODUCTION TO VECTOR-PROCESSING TECHNIQUES FOR MULTI-COMPONENT SEISMIC EXPLORATION

Natasha Hendrick and Steve Hearn
natasha@velseis.com.au

Conventional multi-component seismic analysis simply relies on appropriate component selection to provide P- and S-wave images. However, this ignores the potential cross-contamination of P-wave energy on the horizontal components, and S-wave energy on the vertical component that may occur in certain geological situations.

Where wavefield cross-contamination occurs, there is potential to achieve cleaner P- and S-wave images by more fully exploiting the true vector nature of multi-component seismic data. Vector processing for exploration-scale data typically combines frequency and slowness information, together with particle motion, to distinguish different wave types. Three such multi-trace, multi-component wavefield separation schemes, termed MUSIC, IWSA and PIM, are considered here. These vector techniques all utilise a parametric approach whereby wavefield slowness and polarisation are modelled simultaneously in the frequency domain. The PIM algorithm is considered to be the most generally useful of the three algorithms.

Synthetic and ocean-bottom data examples are used to demonstrate practical issues relating to the use of these vector separation schemes. In cases where there is significant cross-contamination, vector wavefield separation produces P- and S-wave records that differ significantly from the vertical and horizontal components, respectively. Where cross-contamination is less problematic, production vector processing is not warranted. In these cases, however, vector processing still provides valuable quantitative validation of the natural-separation assumption.

ANISOTROPIC SEMBLANCE ANALYSIS AND NMO CORRECTIONS FOR LONG OFFSET DATA

Fanmin Zhang and Norm Uren
zhangf@geophy.crutin.edu.au

Sedimentary rocks can be regarded as transversely isotropic (TI) media. One difficulty in seismic processing is how to flatten the events for long offset data. P-wave reflections from horizontal reflectors in transversely isotropic media have non-hyperbolic moveout. For a multi-layered model, the reflection moveout formula is usually expressed as a Taylor series with higher order terms ignored. Alkhalifah and Tsvankin (1995) developed a three term Taylor series formula to calculate reflection travel times from a horizontal reflector in TI media with vertical symmetry axis (VTI). Using this formula, NMO correction works well for short spread lengths, but not so well for long spreads.

Zhang and Uren (2001 a, b) developed an approximate explicit analytical P-wave ray velocity function for transversely isotropic (TI) media. From this ray velocity function, a reflection travel-time formula from a horizontal reflector in TI media was derived. This formula can be used for anisotropic NMO correction. It works well for both large offsets and small offsets. In order to obtain the unknown parameters required for seismic processing, a 3D-semblance analysis technique has been developed. We tested this method with numerical data from TI models with a single horizontal reflector and from multi-horizontal reflector models. The method was also tested with an isotropic model with multi-horizontal reflectors. The results show that the events can be completely flattened even for very large offsets and that both multi-layered TI and isotropic models may appear to be anisotropic.

Stress/CO_2 Sequestration

VELOCITY-EFFECTIVE STRESS LAWS AND HYSTERESIS IN CARNARVON BASIN SANDSTONES

Anthony F. Siggins, David N. Dewhurst and Boris Gurevich
tony.siggins@csiro.au

P-wave and S-wave velocities, attenuation and the V_P/V_S ratio show different responses in saturated and dry Carnarvon Basin sandstones under increasing differential pressures. At low differential pressures, V_P/V_S ratios are high under oil saturation but low in the same rocks under dry (gas-saturated) conditions. Velocities and attenuation are also shown to be sensitive to pore pressure, not just differential pressure. Under identical low differential pressure conditions, velocity is higher in sandstones when pore pressure is high during simulation of inflationary overpressure conditions. Thus the velocity- differential pressure relationship is not unique. However, the use of the measured Biot effective stress coefficient results in a unique relationship. It is postulated that higher velocity and different V_P/V_S ratios are caused by loss of compliance in microfractures due to stiffening by increasing fluid pressure.

PREDICTING THE CHANGE IN THE SEISMIC RESPONSE AS A CONSEQUENCE OF CO_2 SEQUESTRATION INTO SALINE AQUIFERS

Jason McKenna, Boris Gurevich, Milovan Urosevic and Brian Evans
jason.mckenna@geophy.curtin.edu.au

Geological sequestration of CO_2 into brine-saturated reservoirs is an immediate option to reduce anthropogenic CO_2 emissions into the atmosphere. It is anticipated that time-lapse 3-D seismic technology will form the foundation for monitoring CO_2 migration within the subsurface. The success of seismic monitoring will be determined by the magnitude of the change in the elastic properties of the reservoir during the lifecycle of CO_2 storage. In the short-term, there will be a strong contrast in density and compressibility between 'free' CO_2 and brine. The contrast between these fluids is greater at shallower depth and higher temperature. The change in the elastic moduli of the reservoir will enable time-lapse seismic methods to readily monitor structural trapping of CO_2 below an impermeable seal. However, because the acoustic contrast between brine saturated with CO_2 and brine containing no dissolved CO_2 is very slight, dissolved CO_2 is unlikely to be detected by any seismic technology, including high-resolution borehole seismic. The detection of porosity increases associated with dissolution of susceptible minerals within the reservoir may provide a means for qualitative monitoring of CO_2 dissolution. Conversion of aqueous CO_2 into carbonate minerals should cause a detectable rise in the elastic moduli of the rock frame, especially the shear moduli. The magnitude of this rise increases with depth. Forward modelling suggests that the optimal reservoir depth for seismic monitoring is between 1000 and 2500 m. Higher reservoir temperature is also preferred so that 'free' CO_2 will resemble a vapour.

GEOPHYSICAL MONITORING OF SUBSURFACE CO_2

Don Sherlock and Kevin Dodds
don.sherlock@csiro.au

Geological storage of CO_2 will require accurate, high-resolution geophysical monitoring to map the subsurface flow paths and the phase state of the fluids. Existing and potential monitoring methods include seismic (both surface and borehole), electromagnetics, gravity, and well logging.

Seismic methods are expected be the main form of monitoring as it is cost effective and covers the whole area of interest. When used in a time-lapse sense, areal mapping of the injected CO_2 is possible with existing technology. However, improvements in resolution are required to detect leakage and identify preferential flow paths. Multi-component seismic acquisition may be necessary to discriminate between changes in saturation and pressure within the CO_2 reservoir. Passive monitoring of induced microseismic events may prove to be an effective way to evaluate the effects from the injection of CO_2 on the integrity of the cap rock and provide early warning of fracturing or fault reactivation.

Supporting geophysical methods will be needed for accurate quantitative interpretation of the seismic data. The geological setting and the availability of wells and pre-existing baseline data will have a profound influence on the choice of any additional geophysical methods. Electromagnetic methods have lower resolution than seismic, but are far more sensitive to changes in fluid saturation and may detect anomalies that are too subtle to interpret from seismic data alone. Gravity surveys are relatively cheap to acquire on land, but improvements in measurement sensitivity and constrained inversion methods are required before gravity can be of value for monitoring subsurface CO_2 in the supercritical state.

Keynote: UXO, Forensic Arch

MINERALS EXPLORATION METHODS MODIFIED FOR ENVIRONMENTAL TARGETS

Norman R. Carlson and Kenneth L. Zonge
norm@zonge.com

In recent years, several traditional mining exploration methods have been successfully modified for use in the environmental geophysics field. In these cases, "successfully modified" refers primarily to acquiring data fast enough, and therefore economically efficient enough, to accommodate the relatively small budgets that are available in most environmental studies.

For example, transient electromagnetics (TEM) methods have been increasingly applied to environmental problems, particularly in unexploded ordnance (UXO), underground storage tank (UST) and utilities detection. Small, in-loop, cart-mounted TEM measurements are excellent for these deep metal detection applications. A major research effort is now underway to use, among other methods, multi-component, multi-time-gate mobile TEM systems (measuring Hx and Hy, as well as the standard Hz) in order to discriminate targets of interest (UXO, for example) from non-UXO objects such as metallic debris.

A second good example is the induced polarization (IP) method. Although resistivity has been used extensively in shallow environmental applications, IP data acquisition has always been too slow, and therefore too expensive, for most environmental targets. Multi-channel receivers, multiplexers, and laptop computers now allow us to acquire IP data at rates of 2500 to 3000 data points per day (in the dipole-dipole configuration, for example), providing low cost, high density data. IP data have been shown to be particularly useful in delineating buried waste, such as at old landfills. In numerous surveys, resistivity data have provided useful information on buried, back-filled pits and trenches, while IP data have been used to discriminate which of the pits and trenches located with resistivity actually contain waste material.

3D IMAGING OF THE MUWEILAH ARCHAEOLOGICAL SITE, UNITED ARAB EMIRATES (UAE)

Ryz Evangelista and Eric Wedepohl
revangelista@today.com.au

The sand covered Muweilah archaeological site in the United Arab Emirates (UAE) is a unique Iron Age site, and subject to intensive excavation. However, this time consuming process would require up to 20 years to complete. This paper presents preliminary results of geophysical surveys with the ultimate objective of characterising the site far more quickly.

Ground penetrating radar (GPR) was trialled as a primary imaging tool with a very shallow time domain EM (MetalMapper) system in a supporting role. Dense 3D GPR datasets were migrated at 10 cm intervals to produce horizontal (plan view) slices, which are conceptually similar to the excavation methodology used by archaeologists. The objective here was to delineate extensive linear and planar features. In addition, isolated scatterers were classified. Finally, MetalMapper images were used to discriminate between metallic and non-metallic scatterers.

The highly resistive sand cover provided GPR depth penetration of up to 5 m. GPR successfully mapped floor levels, walls and isolated anthropogenic activity, although in some cases crumbling walls were difficult to track. From this study two possible courtyard areas were recognised. The MetalMapper was less successful due to the limited depth penetration of 50 cm. Despite this, the system was still useful in detecting modern day ferruginous waste and bronze artefacts.

The results (subject to ongoing ground-truthing) indicated that GPR was optimal for sites like Muweilah, which are buried under a few metres of sand. The 3D survey methodology proved essential to achieve line-to-line correlation for tracking walls. Although MetalMapper surveys were not as useful as hoped, they certainly indicated the value of including other geophysical data to constrain interpretation of complex GPR features. Practically, a significant improvement in data quality accrued when survey areas were flattened and de-vegetated.

DRAMATIC IMPROVEMENTS IN UXO DETECTION USING DISCRIMINATION AND DUAL-MODE SENSOR TECHNOLOGY

John M. Stanley and Stephen D Billings
jstanley@g-tek.com.au

Regulators in Australia will need to take note of new technologies being introduced into the USA that are achieving significant improvements to the detection of Unexploded Ordnance (UXO) with fewer false alarms due to geological or metallic fragmentation sources. In a litigation conscious environment, US regulators are beginning to demand that two sensor types (typically magnetic and electromagnetic) be used because this increases the probability of UXO detection. While this adds to the data acquisition cost when two conventional detector systems are used, the principal cost in UXO remediation is the excavation of targets that prove not to be UXO.

Research conducted in the USA and Australia by Australian scientists is being recognised as capable of dramatically reducing the incidence of false alarms while at the same time, improving detection performance. The result is better performance at lower cost.

Significant advances in discrimination (identification of UXO from other targets) have been achieved under the auspices of the Montana Army National Guard using advanced magnetometer and data processing technologies. In two case studies at large UXO contaminated sites in Montana, false alarm rates of between 3 and 5 (false alarms per UXO) were achieved - compared to the 50:1 average obtained across the US industry. Key to the success of this discrimination is our understanding of the effect that entering the ground ballistically has upon the remanent magnetization properties of the UXO.

G-tek has also been developing its patented Sub-Audio Magnetics (SAM) technology originally developed and currently used for high definition mineral exploration. SAM simultaneously provides co-registered Total Field Magnetic Intensity (TMI) and Total Field Electromagnetic (TFEM) data at little more cost than performing conventional magnetic detection. It detects ferrous as well as non-ferrous metals and meets the requirements of a dual-mode sensor. SAM is soon to be deployed by the US Army Corps of Engineers for full-scale evaluation.

These results have the potential to dramatically reduce the costs of UXO decontamination and remediation while also improving the detection performance. However, in order for owners of contaminated property, especially the Government, to benefit from the advances, regulators will need to fully acquaint themselves with these new technologies so that they can be included in their approval methodologies.

Solid Earth Geophysics: Seismic Hazards

GEOPHYSICAL STUDIES OF AN EARTHQUAKE FAULT SCARP IN THE SOUTHWEST OF WESTERN AUSTRALIA

Mike Dentith, Kostia Galybin, Adam O'Neill, Karl Wyrwoll, Dan Clark and Will Featherstone
mdentith@geol.uwa.edu.au

Fault scarps created by prehistoric seismic events are potentially important source of information for seismic-hazard assessment. Establishing the type of faulting responsible for the scarp and its structural setting allows other earthquake prone areas to be identified. Dating the scarp, along with estimates of the magnitude of the event responsible for its formation based on accurate mapping of the structure, allow recurrence intervals to be estimated.

Aeromagnetic data flown over a fault scarp at Hyden allow the geological structures reactivated in the scarp-forming events to be identified. At Hyden, thrust faulting occurred on a pre-existing structure, one of several similar structures in the area. A GPR survey allows sedimentary materials deposited adjacent to the scarp to be located in the subsurface. Dating of these materials will allow the age of the scarp-forming event to be established.

RECENT ADVANCES IN THE MODELLING OF EARTHQUAKE HAZARD IN AUSTRALIA: PART 1 - SOURCE, ATTENUATION AND SITE RESPONSE MODELS.

Trevor Dhu, Trevor Jones, Cvetan Sinadinovski, Andrew Jones, David Robinson and John Schneider
david.robinson@ga.gov.au

This paper is the first in a series of two companion papers describing the techniques currently being used to estimate earthquake hazard in Australia. This paper focuses on advances in creating the models that form the basis of any earthquake hazard assessment, specifically:

- *a source model* that defines the probability of an earthquake of a given magnitude occurring in a year;
- *an attenuation model* that describes how earthquake ground shaking or intensity decreases with distance away from an earthquake source, and;
- *a site response model* that describes how local regolith affects the ground shaking experienced during an earthquake.

The models are described with examples from a recent earthquake hazard assessment of Newcastle and Lake Macquarie, NSW.

Previously in Australia, source models have been developed largely on the basis of historical seismicity. However, in Newcastle and Lake Macquarie expertise from structural geologists has been incorporated into the development of source models. Consequently, the resultant source model highlights regions of seismicity associated with local geological structures and structural provinces.

The attenuation of earthquake energy is poorly defined in Australia, and hence the hazard assessment of Newcastle and Lake Macquarie has adopted a model for central and eastern North America. The adopted model is from a similar tectonic environment to Australia and is able to account for the variability that is inherent in natural processes.

Detailed geotechnical data has been used to create geotechnical models of the regolith in Newcastle and Lake Macquarie. These geotechnical models were used in an equivalent-linear analysis of the regolith's response to earthquake ground shaking. Unlike previous attempts to model site response, this model also includes the variability in site response due to natural variations in the regolith.

Part 2 of this series describes how these models are amalgamated and used to estimate earthquake hazard in Newcastle and Lake Macquarie.

RECENT ADVANCES IN THE MODELLING OF EARTHQUAKE HAZARD IN AUSTRALIA: PART 2 - ESTIMATING THE HAZARD.

David Robinson, Andres Mendez, Glenn Fulford, Trevor Dhu, Trevor Jones and John Schneider
david.robinson@ga.gov.au

This paper is the second of two companion papers that describe recent advances in the modelling of earthquake hazard in Australia. Earthquake hazard is a function of the source, attenuation and site response models which have been described in Part 1. Part 2 describes how these models are integrated to estimate the earthquake hazard. Estimating the hazard leads to a better understanding of the risk posed by earthquakes and assists in the management of risk.

The paper concludes with an application to the Newcastle and Lake Macquarie region, NSW where the new estimates of hazard are larger than those previously predicted. The attenuation and site response models used in Newcastle and Lake Macquarie both include measures of variability. Variability is incorporated by allowing random variation about the median attenuation and site response models. The results also demonstrate that the presence of regolith increases the earthquake hazard in the Newcastle and Lake Macquarie region.

Seismic Processing 4: Multiple Suppression

AMPLITUDE PRESERVING V(Z) PRE-STACK KIRCHHOFF MIGRATION AND DEMIGRATION

Yu Zhang, Matthew Karazincir, Carl Notfors, James Sun and Barry Hung
yu_zhang@veritasdgc.com

We analyze true amplitude weights in time migration and demigration for a v(z) medium based on Bleistein's Kirchhoff inversion and modelling formulas and we discuss proper anti-aliasing formulas honoring sampling theory to preserve fidelity for 3-D migration and demigration.

SEISMIC IMAGING: SCIENCE AND ART

Binzhong Zhou and Peter Hatherly
binzhong.zhou@csiro.au

Seismic imaging is a process of geophysical inversion and consists of data acquisition, processing and interpretation. Errors introduced in any of these stages can have a serious impact on later stages and the final results. The processing stage probably has the greatest scope for error. Modern processing packages allow considerable freedom in the selection of processing algorithms and parameters. Even if essentially the same processing/work flow is followed, different results may be obtained from different data processors. End-users of the data can be unwittingly placed in a very difficult position.

The seismic method itself is firmly based on the theory of elastic wave propagation. However the data processing and interpretation stages can be viewed as requiring the application of scientific art based on experience, a thorough understanding of the data in question, the field parameters, the options available for processing and the geological setting. This is not a new observation or theme, but in the light of recent experience in the application of seismic methods in mining, we revisit it in this paper. We use real data examples to illustrate the non-uniqueness of seismic data processing and the consequences of choosing different processing algorithms and parameters. The objective of this paper is to provide an awareness to some important issues in the contemporary use of seismic surveying in the hope that through this, better and more reliable results can be delivered and exploited by the end-users.

Groundwater: Case Studies

GEOPHYSICAL EVALUATION OF POTENTIAL REFUSE DISPOSAL SITES: A CASE STUDY FROM GEORGE TOWN, NORTHERN TASMANIA

Noel Carpenter, Michael Roach and James Reid
noel.carpenter@utas.edu.au

Geophysical techniques were applied at the George Town municipal refuse disposal site in northern Tasmania to delineate areas of thick Jurassic dolerite-derived clays and colluvial material for future waste disposal trenches. A variety of techniques were applied including seismic refraction, magnetics and frequency domain electromagnetics (EM31).

Seismic refraction surveys effectively discriminate zones of thick clay and colluvial sediments from near-surface dolerite bedrock and residual core stones. Travel-time curves are typically complex due to the irregular dolerite surface and data was interpreted by tomographic inversion. Correlation of refraction tomograms with engineering data, auger drilling and point load measurements suggest that the boundary between "easy" and "difficult" excavation corresponds to a seismic velocity of ~2000 m/s.

Areas of near-surface dolerite are characterised by high total magnetic intensity and low apparent conductivity while zones of thick colluvial material and clay are conductive and have lower total magnetic intensity. The results of magnetic and EM surveys are complementary and correlate closely with the seismic interpretation.

In this geological environment the combination of magnetic and frequency-domain EM surveys provide the most cost-effective geophysical exploration strategy for rapid delineation of suitable sites for waste disposal.

CROSSHOLE ELECTRICAL IMAGING OF AQUIFER PROPERTIES AND PREFERENTIAL FLOW PATHS AT THE BOLIVAR ASR SITE

Jingping Zhe, Stewart Greenhalgh and Bing Zhou
jingping.zhe@adelaide.edu.au

A time-lapse crosshole resistivity tomography trial was conducted at the Bolivar Aquifer Storage and Recovery (ASR) trial site, north of Adelaide between 1999 and 2001, to image aquifer properties and preferential flow paths. A bipole-bipole electrode configuration was used in order to reduce the effect of the top layers in the experiment. Five monitor wells were drilled on a circle of radius 75 m for acquiring the crosshole resistivity data.

In total, seven time-lapse crosshole resistivity surveys were carried at different stages of fresh water injection. All survey data were processed, inverted and interpreted with the aid of numerical resistivity modelling and inversion code. It appears that the injected water flows in all directions, but mainly flows towards the south and the north; the injected water reached wells in the north and south but did not reach wells in the east and west by the end of the water injection. In general, the resistivity distribution in the region decreases with depth in the aquifer. A thin high resistivity layer at a depth of 130 m was detected, which separates the T2 aquifer into two parts.

From this project, we learnt that resistivity inversion is a very necessary tool for crosshole resistivity data interpretation. There is no better way to analyse and interpret the data properly and accurately. However, to obtain a good inversion result, adequate data and the right survey configuration are crucial.

3D GEOPHYSICAL PROCESSING, VISUALISATION AND INTERPRETATION OF RICE IRRIGATION IMPACTS

Fabienne d'Hautefeuille, Noel Merrick, Megan McLachlan and Anita Hodson
fdhautefeuille@dlwc.nsw.gov.au

The National Centre for Groundwater Management at the University of Technology, Sydney has completed a 3-stage research project at a field site near Griffith NSW, which included an examination of the dynamics of groundwater levels and salinisation adjacent to an irrigated rice paddock. The site had 22 piezometers and was instrumented with 16 dataloggers from October 1999 to September 2001. Ten resistivity imaging and EM34 surveys were conducted during the period October 1998 to June 2001 - before, during and after irrigation. Some EM31 was also done. This paper will concentrate on the collation and qualitative interpretation of the resistivity imaging data. Each imaging survey comprised 15 lines (during winter) or 10 lines (during irrigation) each of about 200 m in length. The lines were generally 10 m apart (sometimes 5 m). The results from each survey have been assembled into a movie (using SURFER and SLICER software), which shows the 3-D heterogeneity in resistivity across the site. A couple of movies have been produced showing the variation with time along representative sections. Snapshots of the differential apparent resistivity between surveys before and after irrigation show definite incremental salinisation in the fallow paddock adjacent to the irrigated rice paddock.

UXO, Forensic Arch.

DETECTING BURIED BODIES USING NEAR-SURFACE GEOPHYSICAL INSTRUMENTS

Kathryn Powell
kathpowell@ozemail.com.au

Remote sensing instruments have increasingly been applied to assist police locate buried murder victims, particularly during the last ten years. For the forensic investigator it is still a problem to identify the exact location of buried human skeletal remains within a large targeted search area. This presentation describes unique Australian research in forensic anthropology that is currently examining the application and effectiveness of geophysical instruments for the detection of buried skeletal remains.

Three aspects of the research are covered in this discussion: a national survey of Australian police jurisdictions conducted to establish how clandestine graves are located and the extent of the application of geophysical instruments in forensic case situations; the controlled experimental gravesites used to test the effectiveness of selected geophysical instruments representative of forensic case scenarios; and a situation in which resistivity was successfully applied to the detection of a 150 year old burial.

The national survey of police investigation section reveals that no reported locations of bodies have used geophysical instruments. This research will have significant impact on being able to provide data on reliable techniques for criminal investigations.

The experimental gravesites contain kangaroos, pigs and cadavers, and on the animal graves, ground penetrating radar and electromagnetic induction have presented positive results in locating the burials. This is the only known international research in this field that involves the burial of cadavers and presents a unique opportunity to establish a base of working field knowledge.

LOCATING PIONEER GRAVES WITH GPR

Anton Kepic and Dominic Howman
kepic@geophy.curtin.edu.au

There is a remarkable amount of interest in locating old graves: either for archaeological/restoration purposes or in aiding property development. Usually there is minimal information available about the location of grave plots so geophysical methods by their non-destructive nature are an important tool in locating graves. Ground penetrating radar (GPR) is the method of choice as it is rapid and generally provides good information both in the vertical and lateral extent. GPR surveys in the East Perth (WA) area and at Greenough (near Geraldton, WA) conducted by us were able to detect many "lost" gravesites.

Our experience is that it is the reflection from either the coffin or the materials used in the grave construction (such as brick lining) that provides the identifying signal. The pioneer graves we have encountered vary in construction from holes with coffins to family vaults. The latter would seem fairly easy to identify; however, many sites are cluttered with wrought iron fences and other artefacts that may have been moved from the original gravesite location. These surface obstacles interrupt the survey lines and produce interference from unshielded antenna. Thus, even normally easy targets can be tricky to identify amongst the clutter. Another complication is the practice of stacking coffins to reuse the grave plots. This may lead to the conclusion that there are more graves yet to be found when in fact some have been reused. We have some (unconfirmed) evidence that GPR can detect stacked coffins in the East Perth Cemetery.

TRIAL GEOPHYSICAL SURVEYS AT THE PORT ARTHUR HISTORIC SITE, TASMANIA

Michael Roach, Fiona Links, Noelene Dorn, David Gibbons, Luisa D'Andrea and Greg Jackman
michael.roach@utas.edu.au

The Port Arthur Historic Site is the most visited tourist attraction in Tasmania and Australia's premier convict heritage site. It is located on the Tasman Peninsula in southeast Tasmania approximately 70 km east of Hobart. The site covers an area in excess of 50 Ha and is managed by the Port Arthur Historic Site Management Authority (PAHSMA). The Port Arthur Penal station at Mason Cove and its satellite juvenile establishment at Point Puer operated during the period 1830-1877. During these 47 years, approximately 13 000 convict men and boys spent time at the Port Arthur settlement, which at its peak supported a population of up to 3500 people.

Trial geophysical surveys have recently been conducted at Port Arthur to assist archaeological investigations and to systematically assess the potential of geophysical methods for delineating subsurface cultural heritage. Geophysical surveys have been carried out over a wide range of archaeological features using a variety of techniques including magnetometry, resistivity, frequency-domain electromagnetics and ground penetrating radar. In many cases, geophysical interpretations have been directly tested by archaeological investigations. Some subsurface features and structures are well delineated by the geophysical techniques but others have little geophysical expression.

This paper presents geophysical data from a number of sites at Port Arthur, an assessment of the suitability of the techniques trialled together with recommended survey geometries and acquisition parameters. Geophysical investigations at Port Arthur are ongoing.

Solid Earth Geophysics

PLATYPLUSPLUS - RECONSTRUCTION SOFTWARE WITH A DIFFERENCE

Cecile Duboz, Siew Ching Tan, Steve Quenette, Gordon S. Lister and Bill Appelbe
cecile@mail.earth.monash.edu.au

Existing packages that allow plate scale reconstruction deal with a host of individual objects, abstracted from geological and geophysical data. The typical approach is to show existing continental outlines and to represent their movement through a few hundred million years of history, to provide a reconstruction based on rigid plate motion. This work presents the release of a new reconstruction package, PlatyPlusPlus, designed to provide a new way to carry out tectonic reconstruction. Based on the first version of PlatyPlus, PlatyPlusPlus has been designed with a client-server architecture, allowing reconstructions to present a degree of complexity not reached before. In this paper we will present:

(1) The architectural complexity of the software;

(2) Some of the new features;

(3) An analysis their merits in comparison with classical reconstruction; and

(4) The first results of this new technology.

EXPECTED IMPROVEMENTS TO REGIONAL GRAVITY FIELD DETERMINATION FROM THE GRACE, CHAMP AND GOCE SATELLITE MISSIONS

W. E. Featherstone
w.featherstone@curtin.edu.au

The current and planned dedicated satellite gravity field missions (i.e., GRACE, CHAMP and GOCE) will make significant improvements to long-wavelength global models of the Earth's gravitational field. Used together, they will provide a more homogeneous, accurate and near-complete spatial coverage than was ever-achievable using 'classical' techniques. GRACE and CHAMP will also measure temporal variations in the gravitational field. These data will offer considerably improved constraints on global and regional geophysical models, and the time varying components will offer a totally new dataset on contemporary geodynamic processes. This paper describes the concepts of dedicated satellite gravimetry and summarises the GRACE, CHAMP and GOCE mission parameters. Using published syntheses of the error degree variances of these new data, attempts will be made to quantify the level of improvement offered. This will then give an indication of how much more weight can be placed on these new data in geo-physical studies. Finally, a strategy will be proposed to integrate these new data with terrestrial gravimetry using spherical harmonic filters.

Biographies

Section 5

ASEG 2003

GROWTH THROUGH INNOVATION

Keynote Speakers

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 is 2002-2003 SEG President. He serves on advisory boards at VPI and Stanford University,

NORMAN R. CARLSON is Chief Geophysicist for the Tucson, Arizona office of Zonge Engineering & Research Organisation, Inc. Prior to joining Zonge 23 years ago, he was a Party Chief and Quality Control Seismologist for Western Geophysical Company and United Geophysical Company, where he gained field experience ranging from Iranian deserts to winter work on Arctic-ice crews. His current work emphasis is on shallow geophysics for environmental and engineering applications, concentrating mostly on rapid acquisition of IP data for landfill and contaminant mapping, as well as fast-turnoff TEM for deep metal detection in unexploded ordnance, underground tank, and utilities location.

MARK EGAN is the Chief Geophysicist in Marketing for WesternGeco. He is stationed in Gatwick, England. Prior to this assignment, he held Area Geophysicist positions in Dubai, Dhahran and Houston. Mark holds a PhD in Geophysics, an MSc in Acoustics and a BSc in Physics. He is a member of the SEG, EAGE and SPE.

JOHN ELLICE-FLINT was appointed Managing Director of Santos Limited in December 2000. John holds a BSc (Hons) from the University of New England, New South Wales and also completed the Advanced Management Program at the Harvard Business School. He joined Unocal in 1974 in Indonesia as a geologist and rapidly progressed to Exploration Manager in the UK in 1984, Regional Exploration Manager for Southern US in 1989, Group Exploration Manager for Europe, the former Soviet Union, Central Asia and the Middle East in the early 1990's, Vice-President and General Manager for East Kalimantan, Indonesia in 1994 to Unocal's Senior Vice-President, Global Exploration and Technology in 1997. In these roles he has been involved in major commercial discoveries and has promoted innovative techniques for evaluating prospects and mitigating risk.

FRED HILTERMAN received engineering and doctorate degrees from Colorado School of Mining. He worked at Mobil from 1963-1973. He joined the University of Houston and co-founded Seismic Acoustics Laboratory. In 1981, he co-founded GDC and is VP - Development. Fred is also a Distinguished Research Professor at UH and lectures on seismic amplitude interpretation.

HELMUT JAKUBOWICZ has over twenty years experience in the seismic industry and is currently Manager of External Research for Veritas DGC. His professional interests include wave theory, multiple removal and data acquisition. Helmut is an Associate Editor for "Geophysical Prospecting", and a member of the Institute of Physics, EAGE and SEG.

KEN LAWRIE received his PhD from Glasgow University studying the structure and geochemistry of a copper ore deposit in Finland. He then spent two years as an oil exploration geologist. From 1987 through 1993 Ken did a post-doc at James Cook University studying structural controls on ore deposits. From 1993 to 1995 he was a lecturer in economic geology and geochemistry at the University of Papua New Guinea. From 1995 on he has been with AGSO/Geoscience Australia in various capacities. From 1995 to 1999 he worked as a mineral system specialist. From 1999 through 2001 he was the GILMORE Project Leader, and since July 2001 has been the Program Leader in CRC LEME for salinity mapping.

WALT LYNN received a BSc (with high honors) in Geology and Geophysics from Princeton University in 1973, completed his MSc in Geophysics while studying at Oceanography Department at Oregon State University in 1975, and obtained his PhD in Geophysics from Stanford University in 1979. Subsequent to finishing his degrees, Walt has spent his career in the seismic service sector of the oil and gas industry - 11 years with Western Geophysical and 10 years with Petroleum Geo-services, PGS. He has held geophysical positions within R&D groups, has managed R&D divisions, and has run operations for worldwide data processing. He currently holds the position of Senior Vice President Technical Marketing for PGS Corporate.

YORAM SHOHAM is a Vice-President of Shell International Exploration and Production for External Technology Relations. Yoram joined Shell in the Bellaire Research Centre, Houston, in 1983 and has since held several senior positions. He has earned a PhD in Mathematical Geophysics from the Tel-Aviv University, Israel, and conducted postdoctoral studies in Electrical Engineering at the University of Texas, Austin. Yoram is an honorary member of the Russian Academy of Natural Sciences and Vice President and Life Member of the SEG. He is a member of several academic advisory boards including the School of Earth Sciences at Stanford University, MIT, The University of Texas, The Colorado School of Mines, Rice University and the Civil Research and Development Foundation (CRDF).

ROBERT R. STEWART received a BSc in Physics and Mathematics from the University of Toronto and a PhD in Geophysics from the Massachusetts Institute of Technology. Since 1987 he has been a Professor of Geophysics at the University of Calgary and held the Chair in Exploration Geophysics from 1987 to 1997. He is director of the CREWES Project. His professional interests include exploration seismology, vertical seismic profiling, multicomponent seismic analysis, tomography, signal processing, median filters and inverse theory.

PHILIP WANNAMAKER is Research Professor at the Energy and Geoscience Institute, University of Utah, in Salt Lake City, U.S.A. His areas of professional interest include electromagnetic theory and practice, numerical modelling and inverse theory, relation of resistivity structure to physicochemical state of the Earth, mineral deposits, geothermal resources, and global tectonism. Philip has been a lead scientist for the EMSLAB Group MT observations across the Juan de Fuca subduction system, for MT studies at Long Valley Caldera in California, MT investigations of the Southern Appalachians Orogenic Belt, the Ruby Mountains metamorphic core complex, South

KEYNOTE SPEAKERS

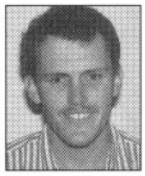
Pole Antarctica, and the New Zealand Southern Alps. He is Scientist-in-Charge for the National Science Foundation Instrument Facility for Electromagnetic Study of the Continents (EMSOC) and serves on the scientific review panel for the NSF/EAR/Continental Dynamics Program. He was General Co-Chair of the Second Quadrennial Symposium on Three-Dimensional Electromagnetics (3DEM-II) at the University of Utah, and serves as a Trustee for the Gerald W. Hohmann Memorial Trust.

ROY WOODALL graduated from the University of WA in Geology before completing an MSc in Mining at the University of California. He worked as Chief Geologist and then Director of Exploration for Western Mining Corporation Limited until 1995 and is now a consulting geologist at Earthsearch Consulting Pty Ltd. He has been the recipient of a number of awards including the Office of the Order of Australia and the Mawson Medal.

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.

ALPHABETICAL INDEX OF AUTHORS

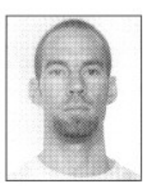
AUTHORS



DAVID ALLEN received a BSc (Hons) in Applied Geology from the University of NSW in 1992. He worked for Geoterrex Dighem/Fugro Ground Geophysics for 10 years acquiring and processing ground electromagnetic, induced polarization, gravity, magnetic and radiometric data. In 2002 he commenced a PhD in hydrogeology at the National Centre for Groundwater Management at the University of Technology, Sydney.

ANN-MARIE ANDERSON-MAYES completed her BSc (Hons) in Physics at the University of Western Australia in 1989 and her PhD in Geographical Sciences at the University of Queensland in 2000. She worked with World Geoscience Corporation in both Australia and North America between 1989 and 1994 on a range of projects associated with data and image processing of airborne geophysical data. In particular, she was involved with research on the SALTMAP project and application of AEM to environmental studies. Between 1996 and 2000 World Geoscience Corporation supported her PhD research into improving interpretation of airborne geophysical data for dryland salinity studies. Most recently, Ann-Marie has co-edited the special issue of Exploration Geophysics (Vol. 33, No. 2) on Salinity and Land Management.

TORILL ANDERSEN received her BSc (1989) from the Stavanger University College (HiS) and her MSc (1991) from the Norwegian University of Technology (NTH), both in acoustics. She worked in Statoil, Norway as a reservoir and exploration geophysicist from 1992-2001. In January 2002 she joined Woodside Energy Ltd. in Perth, where she works as a Quantitative Interpretation Geoscientist. Her main areas of interest are quantitative interpretation, AVO modelling and inversion, rock physics and borehole seismic. She is a member of SEG and ASEG.



DAVID ANNETTS has degrees in Geophysics from The University of Sydney (BSc and MSc) and Macquarie University (PhD). He has worked for CSIRO, Geoterrex Pty. Ltd. and C3TD. Currently, he is with CSIRO's Division of Exploration and Mining. His interests lie in the application of electromagnetic methods to exploration and environmental problems, applications of computer algebra and in computer systems and graphics. David is a member of the ASEG, the SEG and of the IEEE.

ESBEN AUKEN is currently an assistant research professor and member of the HydroGeophysics Group at the Laboratory of Geophysics, Department of Earth Sciences, University of Aarhus, Denmark. He gained an MSc (1991) and a PhD (1996) in Geophysics from the University of Aarhus. From 1996 to 1998 he was assistant professor at the Technical University of Denmark in Copenhagen. Research interests include: 1D and 2D inversion of electromagnetic data, development of user-friendly inversion and data processing software. He is author of the electromagnetic inversion engine em1dinv.exe (Fortran) that serves as the core of the inversion software developed by the HydroGeophysics Group.

JOHN BANCROFT obtained a BSc (1970) and MSc (1973) from the University of Calgary and a PhD (1976) from Brigham Young University. He commenced his work in the seismic industry as a director of research at Geo-X Systems Ltd, and then at Veritas. John is currently a faculty member of the University of Calgary, a Senior Research Geophysicist with the CREWES Project, an industry consultant, and an instructor for the SEG. Two of his course notes on seismic migration have been published by the SEG. He has developed software for the seismic processing industry and has specialized in the areas of static analysis, velocity estimation, and seismic migration. He continues to develop a fast prestack migration for conventional and converted wave data, prestack migrated statics analysis, and prestack migration of vertical array data. He received honourable mention for a best paper at the 1994 SEG convention, won the best paper award at the 1995 CSEG National Convention, and the Laric Hawkins Memorial Award at the 2001 ASEG conference. John is a member of ASEG, CSEG, SEG, EAGE, IEEE, and APEGGA.

BRIAN EDWARD BARRETT graduated with a BSc from the University of Adelaide in 2000, with majors in Physics and Geophysics. He completed Honours in Geophysics with the Department of Geology and Geophysics at the University of Adelaide in 2001, winning the Normandy Prize in Geophysics. Brian is currently a CRC LEME scholar, studying for a Masters degree in Geophysics at the University of Adelaide, with a focus on electrical and electromagnetic exploration techniques for salinity and hydrology applications.

JEAN BERNARD obtained Engineering degrees at Ecole Centrale de Lyon, France and Institut Français du Pétrole (IFP geophysics option, Paris 1973). He worked for BRGM, the French Geological Survey, for 15 years, first as a research geophysicist in electrical and electromagnetic methods for geothermal and mineral exploration. He then spent a couple of years in South America (Peru, Uruguay) as a chief geophysicist for massive sulphide exploration and later has been involved in the design and the tests of new geophysical instruments. He joined IRIS Instruments at its creation in 1991 as the marketing then executive vice-president and participated to the development of resistivity, IP, EM and Magnetic Resonance instrumentation applied to mining, groundwater, geotechnical and environmental applications. Since 2000, he has been the President of IRIS Instruments, remaining directly involved in the implementation of the Magnetic Resonance method to groundwater investigations. He is a member of ASEG, SEG, SEG Japan, AGU, EAGE, EEGS, and EEGS European Section.

JOHN BISHOP is the principal of Mitre Geophysics Pty Ltd, which has advised the mining and exploration industries on geophysical matters, specialising in electrical and electromagnetic techniques, for more than 20 years. John has a BSc from the University of Sydney and a PhD from Macquarie University. He is a member of ASEG, AIG, AusIMM, GSA and SEG. John has published more than 25 papers and has conducted courses in geophysics in Africa, Australia, South America and Europe.

IAN BRANDES is completing his PhD research at the Water Research Laboratory (UNSW). He received his BSc (Hons) at the University of Sydney in 1994. He has working with geophysical exploration teams based in Western Australia, and as a GIS operator with Georeality. Most recently, he has worked as a geologist at Sons of Gwalia's Laverton and Southern Cross operations.

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 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.

LUKE BROWN graduated from Curtin University of Technology, Australia, with a BSc in Exploration Geophysics. He was given the Petroleum Exploration Society of Australia (PESA) award for the highest overall results in third year Petroleum Geophysics. He is currently completing his honours in Petroleum Geophysics at Curtin University of Technology, researching effective medium theory. His honours thesis, "Numerical analysis of fractured porous rock theory", details the application of anisotropic Gassmann fluid substitution in fractured porous rocks. Luke hopes to continue his research in the future while completing a doctoral thesis in Petroleum Geophysics.

AMANDA BUCKINGHAM received a BSc with first class honours in Geophysics from the University of Sydney in 1994. She subsequently worked on base-metal exploration projects in the Mt Isa district for Rio Tinto Exploration. After leaving Rio Tinto, she took up a position in Toronto, working with High-Sense Geophysics (now Fugro Airborne Surveys) as a geophysicist/airborne survey manager working in Southern Africa, South and North America. In mid-1999 she left High-Sense to commence a PhD at the University of Western Australia. Amanda has recently joined SRK Consulting in Perth.

JOCK BUSELLI received a BSc (Hons) in Physics in 1967 and a PhD in 1972 from the University of Adelaide, South Australia. He is now a Principal Research Scientist in CSIRO Exploration and Mining in Sydney. For over 30 years, he has worked on problems in electromagnetic (EM) and electrical geophysics related to minerals exploration, analogue electromagnetic modelling, and groundwater quality in Australia and overseas. He is a joint holder of patents on the SIROTEM instrument, and has collaborated on the development of SALTMAP, an airborne EM system for mapping near-surface conductivity variations. As a member of CRC AMET, he investigated new methods for reducing noise contaminating EM measurements. Recently, he has been researching applications of environmental geophysics at minesites and in agricultural areas affected by salinity. He is an active member of SEG, Near Surface Geophysics, and ASEG, and a member of the editorial board of Journal of Applied Geophysics.

ASBJORN N. CHRISTENSEN received his BSc in Physics and Chemistry (1987) and his MSc in Geophysics in 1991 from University of Aarhus, Denmark. He received his PhD in Geophysics from Colorado School of Mines in 1995. He then joined BHP Research working on algorithms for semi-automated interpretation of airborne magnetic and electromagnetic data in mineral exploration. From 1999 to 2001 Asbjorn was actively involved with processing and interpretation of airborne gravity gradiometry data with BHP Minerals Discovery Technologies. Since 2001 he has been working as a Senior Project Geophysicist with BHP Billiton Minerals Exploration, operating in Australia, Asia, and Africa. He is a member of the SEG and ASEG.

JOHN COGGON was intrigued by Geophysics as a means of seeing into the Earth when a student at the University of Otago in New Zealand, working on an oil shale exploration project. He received a BE (Hons, Mineral Engineering) and a BSc from Otago before going on to the University of California at Berkeley. There he obtained an MS, and then DEng in Geophysics (1971), with research into induced polarisation and the Kambalda nickel deposits. Since then he has practised, carried out research in, and taught, Exploration Geophysics at Otago, Western Mining Corporation (now WMC Resources), and the WA School of Mines. He has published several papers, on magnetic, gravity, IP and EM modelling techniques, drill hole EM methods, crustal structure, and exploration for nickel, gold and other metallic mineralisation. Since 1991 he has provided exploration and technical expertise to over 20 companies in Australia and overseas, through his business Mines Geophysical Services.

STEVE COLLINS completed his MSc at Macquarie University in 1974. He spent two years as company geophysicist for Cities Service and eight years with Amoco Minerals. This involved field surveys, and interpretation in Australia, New Zealand and Pacific Islands. In 1985 Amoco became Cyprus Minerals and Steve became a consultant, but continued a close association with Cyprus. Since then he has continued as a consultant, working for a variety of clients. His consulting work over the last decade has been mostly in Eastern Australia and Southeast Asia in exploration for copper, gold and base metals. Steve has been closely involved in the discovery of several deposits including Red Dome and the Selwyn copper/gold deposits, the Junction Reefs gold deposits and the Tritton and Larsen's East copper deposits at Girilambone NSW.

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 cellullar automata.

DUNCAN ROBERT COWAN graduated from the University of Nottingham, England with BSc Hons in 1963 and a PhD in 1966. He has over 35 years experience in exploration geophysics and geology and has worked on all continents except Antarctica. Recent exploration experience includes projects in Finland, Australia, Canada, Brazil, Botswana, Mauritania and Tanzania. He works as a consulting geophysicist specializing in the 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 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, IAMG and the AusIMM.

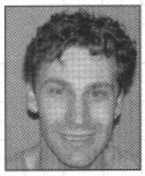
GREG DASEY is currently working as an engineer in the Sydney office of URS Australia. He has five years work experience in the environmental consulting industry in Australia. His primary role is related to hydrogeological investigations of contaminated sites and groundwater remediation projects. The major activities have included projects utilising specialist skills related to geophysical methods. Greg is also currently completing a PhD at the University of NSW in the field of Coastal Groundwater. The project has involved the extensive use of resistivity and electromagnetic techniques to map the saline interface. In addition, Greg's experience includes groundwater modelling for dewatering, tunnel inflow and contaminant transport. He is proficient in the use of start-of-the-art modelling packages, including FEFLOW, Visual Modflow, SEEPW and PMWIN as well as natural attenuation packages such as Bichlor and Bioscreen.

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. He then worked for the Institute of Geology, Zagreb as a structural geologist in a regional mapping team. From there he worked in a number of mines in New Zealand and Australia as a mine geologist, most recently at the Elura mine, Cobar from February 1997 until late 2001. He is currently employed at the New South Wales Department of Mineral Resources 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. The subject of the thesis is Basin Architecture, Sedimentology, Structure and Mineralisation of the Cobar Basin in central-western NSW.

MIKE DENTITH is responsible for geophysical teaching and research in the School of Earth and Geographical Sciences at the University of Western Australia. He teaches all aspects of exploration and solid-earth geophysics at undergraduate and Masters level and currently supervises 6 postgraduate students. The research group at UWA has interests in inversion, automated interpretation, mineral exploration, site investigation and seismic hazard assessment.

FABIENNE D'HAUTEFEUILLE is an agronomy engineer from ENSA Rennes (Ecole Nationale Supérieure Agronomique de Rennes, France), with a one-year master-equivalent degree of rural engineering and surface hydrology in the same engineering school in France. During this period she worked for different companies in France and overseas, including the French Embassy in Washington DC, some consultancy companies in hydrology in France and the Department of Mines, Geology and Water Resources in Vanuatu in 1999. Having a training that was mostly in surface water, and being interested in working on the whole aspect of the water resources, she completed a master of Groundwater Management at UTS in 2001. She is now a contractor within the NSW Department of Land and Water Conservation in the CNR (Centre of Natural Resources) hydrogeology unit.

BRUCE DICKSON obtained his MSc from Wellington University, New Zealand, and received a PhD from Imperial College, London in 1973. He moved to Australia where, after a short time at ANU, he joined CSIRO to work 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.



NICK DIREEN is the new Lecturer in Exploration Geophysics at the Mawson Laboratories, University of Adelaide. There he is working on applications of potential field geophysics to regolith, environmental and mineral exploration problems under the auspices of CRC-LEME. Prior to his appointment, Nick was a Research Scientist at Geoscience Australia for almost four years, working in the Petroleum & Marine and Minerals & Geohazards Divisions. Nick's roles at GA included time in the National Gravimetry, AGCRC-Lachlan Orogen, Great Australian Bight Law of the Sea, Gawler Craton Mineral Promotion, and Australia-Antarctica Southern Ocean Profiling Projects. Nick graduated with a PhD from the Centre for Ore Deposit Research in 1999, and BSc (Hons) in Geology & Geophysics from the University of Tasmania in 1995. Nick's research interests include geophysical signatures of continental breakup; geometry of fold and tectonic geophysics; regional-scale geophysical signatures of mineral systems; and tectonic evolution of the Phanerozoic Tasmanides and Archaean-Proterozoic Gawler Craton.

IRWAN DJAMALUDIN worked for Mobil, Phillips, CSR Petroleum and AGL Petroleum before joining Santos in 1992. He is currently working as a geophysicist with Santos, Brisbane. He is a member of ASEG, EAGE, PESA and SEG.

MARK DRANSFIELD graduated from the University of Western Australia in 1981 with a BSc (Hons) in Physics and joined Seltrust Mining Corporation as a geophysicist. Mark's major interest since 1985 has been in airborne gravity gradiometry. He worked for nine years on the development of an airborne gravity gradiometer at the University of Western Australia including four years on a PhD focussing on the geophysics of airborne gravity gradiometry. In 1995, CRA Exploration employed Mark as a senior geophysicist working in airborne gravity gradient modelling and in airborne EM and radiometrics. In March 1998, Mark joined BHP's Falcon team in the early phase of the airborne testing of their gravity gradiometer. The first Falcon system was delivered in October 1999 and Mark is now project leader of the Falcon technical support team. The Falcon team, including Mark, was awarded the CSIRO Medal for external research in December 2000.

BINGWEN DU received his MSc in Geophysics from RIPED, China in 1995. During 1995-1998, he worked on cross-borehole seismic imaging for his PhD program at the Memorial University of Newfoundland, Canada. In 1998, he joined PGS Research as geophysicist in Perth, Australia. Since October 2002, he has been working as a research geophysicist with CGG Borehole in the UK.

CECILE DUBOZ first joined the Australian Crustal Research Centre (School of GeoSciences, Monash University) in 1996 to develop PlatyPlus, a 3D reconstruction software that enables interactive plate reconstructions involving rigid displacement as well as internal deformation. She is now working in the ACRC in close collaboration with the Victorian Partnership for Advanced Computing (VPAC) to develop PlatyPlusPlus, a re-engineered and improved version of PlatyPlus.

JARROD DUNNE completed a BSc (Hons.) in Geophysics at Melbourne University in 1992. In 1996 he completed a PhD at Melbourne University titled Subcoal Seismic Exploration in the Gippsland Basin. Jarrod then worked for Shell Australia as a seismic processing geophysicist before moving to Perth to join Woodside Energy to work in the quantitative interpretation team. Jarrod is currently on secondment to Shell International in The Hague, where he has joined in an integrated field and basin studies team. He is a member of the ASEG and SEG and has received an award for the best student poster at the 1995 SEG conference in Houston.

PETER ELLIOTT graduated with a BSc (Hons) in Geology and Geophysics from the University of Melbourne (1976). He was later awarded an MSc from the University of Melbourne in 1984, and a PhD from Macquarie University in 1997. He started his profession as a Cadet Geologist with the Geological Survey of Victoria in 1975. He worked as a geologist in Regional Mapping for a couple of years and then as a Geophysicist with the newly formed Geophysics Section in the Dept. of Mines, Victoria (1977-1980). He later joined the Shell Company (Australia) Ltd. in 1981 where he worked as a Regional Geophysicist with the Metals Division (1981-1987). During this time he worked out of Melbourne, Perth and Adelaide. In 1987, Peter left Shell to set up his own exploration services company. This company is now represented by Elliott Geophysics International Pty. Ltd., PT Elliott Geophysics Indonesia, and Independent Exploration Services Inc. (Philippines). Peter Elliott has spent the last 10 years working in SE Asia. Most of this time has been spent in Papua New Guinea, Indonesia and the Philippines. He has recently moved his Australian office to Perth, in Western Australia. Peter has worked in Indonesia since 1992, and established a permanent branch office in Jakarta in 1996. He has given courses in Electrical Geophysics at the University of Adelaide and has published more than 20 scientific papers. Peter currently holds three patents in: Canada, USA, and Australia.

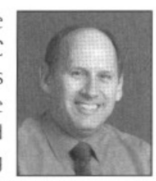
RYZ EVANGELISTA graduated from Sydney University in 2002 with a double Arts/Science degree. During her undergraduate studies she studied a broad spectrum of subjects including languages, archaeology, geology and geophysics. In her Honours Year she took on the challenge of running geophysical surveys in the United Arab Emirates and graduated with first class Honours. Starting out on her career, she worked with MIM Exploration in Mt. Isa, where she assisted with some DHEM and downhole magnetics surveys. Her interests include environmental geophysics and promoting the increased use of geophysics in archaeology.

GARY NOEL FALLON graduated from WAIT (now Curtin University) in 1985 and then worked for 5 years in mineral exploration across Australia, based in Perth, as a contractor with Scintrex and as a staff geophysicist with Whim Creek consolidated and Dominion mining. Then he was appointed as a senior geophysicist for MIM Exploration based at Mount Isa. Activities ranged from regional target generation to in-mine investigations in NW Queensland and the Northern Territory. After moving to Brisbane he took a two-year secondment as senior research officer to the University of Queensland. This position was primarily to form part of a research team completing the AMIRA P436 project Application of geophysics to mine planning and ore body delineation. This initiated a part time study toward a PhD titled Volume balanced petrophysical interpretation of mineralogy for grade estimation in metalliferous deposits. On returning to MIMEX he continued the application of high resolution geophysics to mining operations, which has included borehole logging, 3D seismic and environmental applications. He is currently manager of coal geophysics, responsible for geophysics applied to MIM's coal operations.

WILL FEATHERSTONE is Professor of Geodesy and Director of the Western Australian Centre for Geodesy at Curtin University of Technology. He received a BSc (Hons1) degree in Geophysics and Planetary Physics from the University of Newcastle-upon-Tyne and a DPhil in Geophysical Geodesy from the University of Oxford. His research interests include physical geodesy, satellite positioning and coordinate systems, and he has published widely in all these fields. Notably, he was responsible for producing the most recent gravimetric geoid model of Australia, called AUSGeoid98, which is now the national standard for the transformation of GPS heights. Will is also a Fellow of the Royal Astronomical Society, International Association of Geodesy and Institution of Surveyors Australia, Vice-President of the Australasian Surveying and Mapping Lecturers' Association, and Chair of the International Association of Geodesy's Special Study Group on Synthetic Modelling of the Earth's Gravity Field.

TANYA FOMIN, has worked with Geoscience Australia since 1996. She holds an MS degree in Geophysics from the St-Petersburg Mining Institute in Russia. After graduation she was involved in processing and interpretation of reflection, refraction and vertical seismic profiling (VSP) data from the Kola Superdeep Bore Hole and its region. Later on her projects included work on seismic processing and interpretation in the Broken Hill region, Northern Yilgarn Project and an ocean-bottom seismograph survey on the Australian North West Shelf. At present Tanya is involved in processing, modelling and interpretation of wide-angle Vibroseis reflection data from the northeastern Yilgarn.

CLIVE FOSS is Principal Consultant with Encom Technology, where he works both with the consulting group and in software development and maintenance. Clive has a BSc in Geophysics from Reading University, and a PhD from the University of Leeds for palaeomagnetic studies in southern Africa. From 1979 to 1987 he lectured in Applied Geophysics at the University of Malaya, and from 1987 to 1990 he was senior geophysicist with the Indonesian-Australian Geological Mapping Project, responsible for regional gravity mapping in Kalimantan. Clive provided consulting services to petroleum exploration companies in Indonesia and Malaysia from 1990 to 1995, both as an independent consultant and for ARK Geophysics, before joining Encom Technology in Sydney in 1995. His interests are in the geological interpretation of gravity and magnetic data, gravity gradiometry, and the modelling and inversion of gravity and magnetic fields. Clive is a member of the ASEG, SEG, PESA and GSM.



PETER FULLAGAR holds a PhD in Geophysics from the University of British Columbia. He worked in WMC Exploration Division for 12 years, including 3½ years as Chief Geophysicist. After a period as Chair of Borehole Geophysics at Ecole Polytechnique, Montreal, he returned to Australia and worked with CSIRO Exploration & Mining and Rio Tinto Exploration. In 1998 he established Fullagar Geophysics Pty Ltd in Brisbane, and now provides consulting, software, and research for exploration and mining companies.

ASHLEY GRANT graduated from Monash University in 2000 with a BSc (1st Class Hons) majoring in Geophysics. He then worked at the Department of Natural Resources and Environment (Geological Survey of Victoria) where he compiled a petrophysical database of Victoria and worked on the initial stages of the NAP for salinity mapping and management using remotely sensed datasets (preliminary airborne EM). Other activities involved the development of a 3D visualization scheme to help in the interpretation of airborne EM data. This involved testing many medical imaging software packages developed for the visualization medical imaging data. Ashley now works at GHD Pty Ltd as a consultant geophysicist and has been involved in many environmental, geotechnical and groundwater projects throughout Australia.

STEWART GREENHALGH is Professor of Geophysics and Head of the Department of Geology & Geophysics at the University of Adelaide. He holds a PhD degree in Geophysics/Mathematics from the University of Minnesota and MSc and DSc degrees from the University of Sydney. He has been an academic for over twenty years and has also worked as a geophysicist in government and industry as a consultant. He has published widely in both theoretical and experimental geophysics. He is a Fellow of the Australian Academy of Technological Sciences and Engineering, and is also a member of various professional societies, including AGU, SSA, SEG, and EAGE.

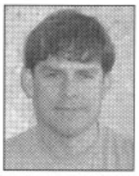
BORIS GUREVICH received his MSc in Exploration Geophysics from Moscow University in 1981, and PhD in geophysics from the Institute of Geosystems in Moscow in 1988. From 1981 until 1993 he worked as a researcher for the Institute of Geosystems. He was a visiting scientist at the Geophysical Institute 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 Institute 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, the theory of seismic/acoustic wave propagation in rocks and other porous materials, and seismic imaging. He is a member of SEG, AGU and EAGE.

BEN HALL graduated from Royal Melbourne Institute of Technology in 1996 with a BSc (Geology). After working in Eastern Australia as a junior Geologist in 1997-1998 he returned to study in 1999. Ben completed a Bachelor of Geophysics (Hons) in 2000 from Curtin University of Technology, Perth. While studying Ben worked for Homestake Gold of Australia (1999-2000) as a Junior Geophysicist where his main tasks were processing airborne geophysical data and collating previous geophysical surveys over the Plutonic Well Greenstone Belt. After graduating from Curtin University he worked for a short time for Surtron Technologies conducting downhole geophysical surveys in the Telfer region. Ben commenced employment with Southern Geoscience Consultants in early 2001 where his main tasks included processing and modelling ground and airborne geophysical data and providing project support to the Consulting Geophysicists. Ben joined Rockwater Pty Ltd in September 2002 where he oversees downhole, surface and airborne geophysical surveys.

JAMES E HANNESON received his PhD in 1981 from the University of Manitoba. From 1977 to 1984 he worked for Gulf Minerals (Canada) Ltd and Getty Canadian Minerals Ltd with involvement in gold and base metals exploration programs in Canada. He carried out research in electromagnetic methods at the Ontario Geological Survey from 1984 until 1989 when he joined WMC Resources (Exploration Division) in Adelaide, SA. Since 1998 he has been a consulting geophysicist and a director of Adelaide Mining Geophysics Pty Ltd.

PHIL HARMAN holds an Honours degree in Geology and Geophysics (Geophysics) from the University of Sydney. He spent more than thirty years working for BHP Billiton in a broad number of roles 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 the airborne geophysics, to the exploration group. In late 1988 he moved into general exploration management, firstly as Exploration Manager Western Australia for three years, then as Manager Exploration South America, based in Chile. Over a period of six years he was responsible for re-invigorating the company's South American exploration activities. The introduction of new geophysical and geochemical approaches to the South American programs led to the discovery of a number of new mineralised targets, including the as yet undeveloped Agua Rica deposit in Argentina. Business development initiatives also led to the identification of several acquisition opportunities that the company pursued. Phil led the development of BHP Billiton 's deployment strategy for the FalconTM airborne gravity gradiometer that eventually led to his new career outside the BHP Billiton as Managing Director of Gravity Capital Limited which has an agreement with BHP Billiton concerning the deployment of Falcon™ in Australia.

JOHN HART obtained a BSc (Hons) in Geology from the University of Western Australia in 1992. He worked with BHP Minerals Exploration from 1993 to 2001. During that time he was involved in geophysical programs in the Mt Isa Block, WA and the Northern Territory, Botswana, Rajasthan and South America. The main focus of these exploration programs was base metals. In November 2001, he joined Minotaur Resources as Chief Geophysicist and is involved with Cu-Au and Pb-Zn exploration throughout South Australia. He has been involved predominantly in the interpretation of potential field data and electrical data.



PHIL HAWKE graduated from the University of Adelaide with a BSc (Hons) in Geophysics in 1993. He work for the Rio Tinto Group of companies for seven years, exploring for iron, base metals and gold primarily in the Hamersley, Mt Isa and Broken Hill/Curnamona mineral provinces. He commenced a PhD at The University of Western Australia in 2000, where he is researching the geophysical responses associated with meteorite impact craters. During this time he has been involved in ongoing geophysical programs with Robe River Iron Associates.

STEVE HEARN received his Applied Sciences (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 has just completed his honours degree in Geophysics at the University of Adelaide, and may be continuing as a post-graduate in the same department later this year. His interests include potential field theory, inversion methods and Geostatistics. 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 hopes to undertake further study as either a Masters or PhD student, and construct programs for geophysical inversion. 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) (Hons I) 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 and SEG.

ROB HEWSON initially studied geophysics at Melbourne University and worked for Shell Australia for 7 years within their Coal and Metals Divisions before returning to complete an MSc (Hons) in Geophysics at Macquarie University. Later he completed a PhD at the University of New South Wales on geological remote sensing chiefly using thermal infrared systems. He has worked part-time for the NSW DMR and Surtec whilst studying, and has worked for CSIRO, Division of Exploration and Mining since completing his PhD in 1998. Within CSIRO he has been involved with the CERBERUS Project, developed jointly with Fugro, (formerly World Geoscience) and is now involved with validation and case study investigations using ASTER satellite imagery.

BEN HOPKINS is a Senior Hydrogeologist based in Adelaide with groundwater consultants Australian Water Environments. Ben graduated from the South Australian Institute of Technology in 1990 with a BE in Civil Engineering. After undertaking research into on-site urban stormwater retention and re-use in Adelaide, he moved to Sydney to complete a Master's degree in Hydrogeology at the University of New South Wales. He worked with New South Wales Department for Land and Water Conservation in Sydney before spending two and a half year as a driller's offsider and later as a driller, drilling irrigation bores in western New South Wales and north eastern Victoria. Since his return to Adelaide his work with Australian Water Environments has concentrated on the investigation, design and construction of various saline groundwater interception schemes along the River Murray, at Waikerie, Bookpurnong and Loxton. He has also been involved with the design of extensions to a shallow watertable control scheme at Wakool in NSW. During the course of these salt-interception scheme investigations, Ben has worked alongside Mike Hatch from Zonge Engineering who has conducted a series of field trials of fast sampling TEM at Bookpurnong in the Riverland region of South Australia. These trials have tested fast-sampling TEM as a tool for mapping subsurface hydrogeology and salinity along the River Murray.

TERRY HOSCHKE graduated from the University of New England with BSc (Hons) in 1980. He joined Geopeko exploring for gold, base metals and uranium mainly in Northern Australia. With Geopeko he was involved in the development and implementation of a drill hole magnetometer system in Tennant Creek and managed the exploration office in Darwin for three years. He subsequently explored for porphyry Au-Cu deposits in Indonesia with North Limited. After two years as a consultant he joined Normandy Exploration in 1991 in Townsville exploring for epithermal gold deposits in Queensland and New Zealand. He currently works for Newmont Exploration based in Perth.

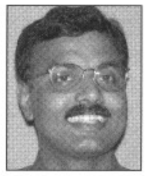
JOHN HUGHES graduated from UCW Aberystwyth in 1969 with a BSc (Hons) degree in Geology. From 1969 to 1981 he worked with GSI, based in the UK, travelling and working extensively in Europe, Africa and Middle East. Responsibilities included land and marine processing plus interpretation services. In 1981 he transferred to Australia as GSI's Land Data Processing Manager and in 1983 joined Delhi Petroleum with responsibility for processing and subsequently acquisition. He transferred to Santos when they took over the Cooper Basin operatorship in 1987 and is currently their Chief Operations Geophysicist responsible for acquisition and processing. He is an active member of ASEG, SEG and PESA and is on the ASEG2003 Conference Organising Committee.

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 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.

RICHARD (DICK) IRVINE graduated from Sydney University in 1964 with a BSc degree. After 2 years with the NSW Mines Department he travelled overseas and gained his MSc in Geophysics from the University of London (UK) in 1968. He then spent 4 years working for several different companies in North America in mineral exploration, concluding with 18 months with Amax in the Manitoba Nickel Belt. Returning to Australia in 1972 at the end of the nickel boom he then spent several years based in Perth exploring for nickel and base metals in WA. In 1978 he joined BHP Minerals and spent 21 years with them as a geophysicist, initially working in Australia but later in SE Asia, China, India, Pakistan and South Africa in a wide variety of exploration programs. He is now Vice President of Condor Consulting, Inc. in Denver USA, a consulting group that specializes in airborne EM processing and interpretation. He is a member of ASEG, SEG, and EAGE and is also an RPGeo of AIG.

GRAHAM JENKE obtained his BSc (Hons 1st class) in Geophysics and Geology at the University of Adelaide in 1972. He has over 25 years experience in the mineral exploration with major Australian mining companies and the airborne survey contracting industry. He joined CRA Exploration in 1973, and over the next 13 years was based in Kalgoorlie, Perth, Darwin, Canberra and Adelaide providing geophysical support in exploration programs for nickel, gold, copper, zinc, uranium and diamonds in a wide variety of geological terranes across Australia, PNG and New Zealand. He was a core member of the team, which discovered the Ellendale lamproite province and the Argyle diamond mine subsequently. In 1987, he joined the newly formed Kevron Geophysics as manager, and oversaw its emergence as a successful provider of airborne geophysical surveys to the exploration industry. He returned to mineral exploration with Western Mining in Kalgoorlie in 1989, working on nickel and gold exploration projects and mine sites in the Yilgarn before moving to Perth in 1994 where he became part of the company's hydrogeological group exploring for water resources, and undertaking site characterization and environmental monitoring surveys at the company's mine sites in WA, SA and Queensland as well as mineral exploration work for base metals and gold. Graham joined Southern Geoscience in 2002, and is an active member of SEG, ASEG, EAEG and EEGS.

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) and the Predictive Mineral Discovery Cooperative Research Centre (pmd*CRC).

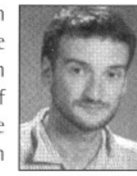


E JOHN JOSEPH obtained his BSc (1st class) in Geology from University of Kerala, India in 1984. He was awarded an MSc (1st class and 1st rank) in Marine Geology from Cochin University of Science and Technology, India, in 1986. He obtained a DSc in Geophysics (Earth and Planetary Physics) from The University of Tokyo, Japan, 1998. John was a Research Associate at the Indian Institute of Geomagnetism, Department of Science & Technology, Govt. of India from 1988-1994, when he moved to the Ocean Research Institute, at The University of Tokyo, Japan, where he was a Research Student until 1998. From 1998-2001 he worked as a proposal-based researcher of NEDO at the Geological Survey of Japan, in Tsukuba. During the period 2001-2002 he was a Post Doctoral Researcher at Tokai University. Currently he is a JSPS Fellow at the Institute of Geosciences, AIST, Tsukuba, Japan. His research interests include; seafloor electromagnetic (SFEM) induction studies, including EM data processing, EM modeling (1-D, 2-D, 3-D and thin-sheet) and geological interpretation, and; airborne geophysics and GPS studies, including the development of helicopter borne gravimeter system, participation in airborne gravity surveys, airborne data processing and the compilation of geophysical maps. He has also conducted real-time DGPS and interferomeric GPS observations and data processing. He is currently working on airborne magnetic, electromagnetic and gravity studies.

NAOMI KANO is a research geophysicist who has worked with Geological Survey of Japan (GSJ) since 1977. His projects are focused on work related to seismic reflection surveys. His current interest is on S-wave structure surveys, using an S-wave source or P-S converted waves. He is a member of SEG, EAGE, SEGJ and JAPT.

MARTIN KIM is currently employed at Woodside Energy Ltd in the Quantitative Interpretation Team where he works on AVO studies and inversions. He gained employment in January 2002. Martin completed a BSc (Hons) in Geophysics in 2001 and a BSc in Geophysics in 2000. His high marks granted him a position on the Vice Chancellor's list and membership of the Golden Key International Honour Society.

JOHN KINGMAN graduated from the Colorado School of Mines with a BSc Eng. - Geophysics in 1979, having started working for the Anaconda Copper Co. well before he graduated. At Anaconda he was first exposed to the innovative research and thinking of Mark Halverson and E.O. (Mac) McAlister and the wonders of large channel capacity electrical geophysical systems. Later, working at the research laboratories of the Atlantic Richfield Co. (ARCO) he played a role in building and testing perhaps the first distributed acquisition system applied to electrical prospecting. During most of 1986 he consorted with Texas Instruments, endeavoring to incorporate electrical geophysical capabilities (especially induced polarization) into their existing optical fiber based distributed seismic systems. Such a system was never built. He also began championing the development of distributed acquisition for mining geophysics, unsuccessfully until 1994 when he met Nick Sheard at MIM Exploration and two years later the first distributed electrical geophysical system, MIMDAS, was tested at Mt. Isa. Today with his partner Stephen Garner, John consults to companies in a wide variety of technologies and businesses, including: measurement-while-drilling telemetry, drilling vibrations and mechanics, soil mechanics, tubing inspection, and electrical geophysics.



JON KIRBY is a Research Fellow in the Western Australian Centre for Geodesy at Curtin University of Technology. He has a BSc in Physics from the University of Durham, an MSc in Exploration Geophysics from the University of Leeds, and a PhD in Geophysical Geodesy from the University of Edinburgh. Since arriving in Australia seven years ago he has also enjoyed a Lectureship at the University of Melbourne. Jon's research interests include isostasy and lithospheric deformation, the gravity data combination methods, terrain corrections, and geoid determination. He is a member of ASEG, the AGU, and several International Association of Geodesy special study groups.

KLAAS KOSTER is the head of 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.

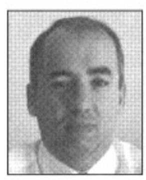
JESS B. KOZMAN is a Principal GeoScientist and Service Delivery & Support Manager for the Middle East and Asia region of Schlumberger Information Solutions, where he specializes in best practices and peer review of oil and gas information management projects. He is based in Kuala Lumpur, Malaysia, and has 22 years experience in the oil and gas industry, as a seismic interpreter, systems administrator, and data manager. His employers before Schlumberger included a major international oil and gas company, a large independent, and a family-owned data brokerage firm. He has contributed to the implementation of data management projects on six continents (still waiting for an exploration project in Antarctica!). He has a BSc in Geology and Geophysics from the Honors College at Michigan State University and has done shipboard field work on the carbonate platforms of Exuma Sound in the Bahamas. When he does not have his head buried in a workstation, he can usually be found hiking in the nearest geologically interesting location, so he, as he says, "never forgets that it's rocks we're looking at down there". He is supported by a stunning wife and three extremely energetic children who attend the International School of Kuala Lumpur.

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 during the development of the TEMPEST AEM system 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.

KATE LAWSON is currently working in Woodside Energy Ltd. in the Geophysics Project Management Team. During her previous position in Woodside as a quantitative interpretation geophysicist, she built seismically-constrained reservoir models for the Enfield asset and made predictions for the initial deepwater exploration campaign in Mauritania. She joined Shell in 1996 and worked for 4 years in their Dutch operating company. During this time she spent 18 months developing quantitative interpretation workflows and making reservoir and fluid predictions for the Triassic Bunter in the West Netherlands Basin. She graduated from Cambridge University with a BA in Natural Science and from Durham with a Geophysics/Geology PhD on the formation of new oceanic crust.

DAVID LE MEUR obtained his PhD in Geophysics from the Ecole Normale Supérieure de Paris in 1997. He has 8 years experience in research and development on seismic processing and the development of industrial processing software. Since 1998 he has worked with CGG on quality assessment during the 3D processing flow-chart. At the present time he is in charge of implementing geostatictics methods in the time processing flow-charts.

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, where he obtained a 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 PhD. 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 is now a Senior Fellow in the Research School of Earth Sciences. He has worked particularly in geomagnetism, and on measurements of natural electromagnetic induction in the Earth.

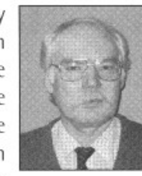


ANDREW LONG has a BSc (Univ. Melb.), PGrad. Dip. App. Physics (Curtin Univ.) and PhD (UWA), all in Geophysics. After 5 years in seismic acquisition and processing he enrolled in PhD studies in 1992. This venture allowed him to diversify his career into potential fields research, structural geology and seismic interpretation. Graduating in 1996, he then commenced a post-doctorate position at Stanford University, USA, shared between seismic imaging and interpretational geophysics research. He joined PGS Research (Perth) in 1997, where he is currently Manager Geophysics. A return visit to Stanford University as a Visiting Scholar in 2001 focused upon developing the links between his main interests in seismic modeling, seismic survey design, seismic imaging, seismic technology, and rock physics.

MU LUO recently obtained his PhD in Geophysics from Curtin University of Technology. After graduated from China Petroleum University in 1982 with a BSc, he had been working in the seismic data processing center of South China Sea Oil Co., and later Schlumberger (Singapore) as a programming and processing geophysicist. He obtained his MSc (Geophysics) in the Department of Earth Sciences, The University of Queensland and later worked with Australian Geological Survey Organisation (AGSO) as a geophysicist and with PGS Tensor as a processing geophysicist in the Houston, Bombay, and Shanghai Centers. He has 20 years experience in seismic data processing and well logging analysis. His main research interests include multi-component seismic, P- and S- wave fracture detection, reservoir imaging and sensing technique development, and pore pressure and fluid flow in fractured media. He is a member of ASEG, SEG, EAGE and CPA.

JAMES MACNAE is currently Professor of Environmental Geophysics at RMIT University in Melbourne. Prior to that he was a Professorial Fellow at Macquarie University in Sydney working with the CRC for Australian Mineral Exploration Technologies. He has over 30 years experience in mineral exploration and geophysical technology development, and continues to conduct research in this field. Current research interests also include applications of electromagnetic systems to environmental conductivity mapping, including the detailed mapping of underground fresh and saline waters.

JASON MCKENNA received a first class BSc (Hons) from Curtin University of Technology in 1999. He is currently completing a PhD in petroleum geophysics at Curtin on applying seismic methods to monitor CO_2 sequestered into saline aquifers. He has received awards for merit from APPEA, PESA, ASEG, SPE, Melbourne University and Curtin University. He is a student member of the ASEG, SEG, SPE, AAPG and PESA.



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.

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. His research interests relate mainly to the acquisition, processing and interpretation of airborne magnetic and gamma-ray spectrometric data.

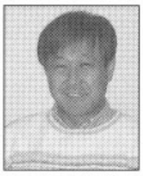
MICHAEL MOORE has been with the New South Wales Department of Mineral Resources for the past three years where he provides geophysical support to a regional geological mapping team, various coal geology programs and other geophysical initiatives. He graduated from Macquarie University in 1989, with an Honours degree in Geophysics and is currently completing a Masters in Environmental Management at the University of NSW. Following completion of his undergraduate studies, Michael worked with Western Mining Corporation as an exploration geophysicist, in the Eastern Goldfields of Western Australia and in Chile, South America. Michael then worked for Geo Instruments, predominantly in Fiji, processing airborne data acquired as part of an AUSAID mineral mapping project.

GARY MUMAW is a Senior Geoscientist at Bell Geospace Ltd / EAME in Aberdeen, Scotland since 1998. Prior to joining Bell, he spent over 20 years as an exploration geophysicist in Domestic US and International exploration and production activity in both staff and consulting roles within a variety of operating companies including Gulf Oil, Aramco, Britoil, Van Dyke Energy, Arco Indonesia, and Total Oil Marine (UK). Gary holds a BSc (Hons) (74) in Geophysics from Wright State University; an MSc (94) in Environmental Engineering from Strathclyde University; and active membership of the SEG, EAGE and PESGB. His role at Bell includes the development of 3D Full Tensor Gradient (FTG) interpretation methods and workflow to reduce risk and geologic uncertainty in prospects defined by seismic ambiguity and to conduct 2/3D FTG forward modelling and inversion interpretation studies for client surveys throughout EAME region.

Biographies

TIM MUNDAY is employed with CSIRO Exploration and Mining, and working in the CRC for Landscapes, Environment and Mineral Exploration, he has over 15years 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. He has led government funded research projects since 1983; and been a leader and participant of industry funded research projects since 1992, including multidisciplinary, multi-client projects through AMIRA and projects with individual companies. Outcomes of the research, transferred to industry by reports, seminars, workshops, publications and consultancies, have contributed to improved exploration practice. More recently he has been concerned with the relevance of geophysics, particularly airborne techniques, to defining appropriate and economic natural resource management strategies in Australia.

ANDREW MUTTON received a BSc (Hons) in Geophysics and Geology from Sydney University in 1973. From 1974 to 1985, he worked as a geophysicist for the Australian Bureau of Mineral Resources, and subsequently for mineral exploration companies within Australia. In 1986, he took on a one-year lectureship in Geophysics at Curtin University in Perth, before returning to the exploration industry with CRA (Rio Tinto). After several years of regional and prospect exploration for CRA in Queensland, he took on the role of Principal Consultant - Resource Geophysics, transferring from the Exploration Group to Rio Tinto Technical Services in 1996. In 2001, he established Mutton Associates Pty Ltd to provide specialist consulting services to the mining industry, primarily in the areas of high resolution and borehole geophysics applied to mine evaluation and development, and environmental problems. He is a member of SEG, EEGS, AIG, AusIMM and ASEG. He has held numerous Federal Executive, State Branch, or Conference Committee positions for the ASEG since 1976, and is currently Chairman of the ASEG Publications Committee. In March 2000, he was awarded the ASEG Service Medal in recognition of extraordinary service to the ASEG over many years.



YASUKUNI OKUBO received the BEng. in 1978 and PhD in 1993 both in Exploration Geophysics at the University of Tokyo, Japan. He carried out his research in magnetic surveys at the Geological Survey of Japan in 1978 and the New Energy Development Organization in 1980 and was awarded the prize from the SEG Japan (SEGJ) in magnetic surveys. He joined CCOP, the intergovernmental organization in Bangkok, in 1993 to coordinate the Asian geologic map digital-compilation project and was awarded the prize of Director General of Geological Survey of Japan in this project. He worked in the New Energy and Industrial Technology Development Organization of Japan to manage national geothermal projects in 1997. His recent research has been in areas of interpretation of geoscience data to model interior structures and environmental changes of the Earth. He is presently a senior researcher of the National Institute of Advanced Industrial Science and Technology (AIST) and a chairperson of the Foreign Relation Committee of SEGJ. He is a member of SEGJ and SEG.

ADAM O'NEILL graduated from Curtin University in 1994, and then worked in gravity contracting around Australia. From 1996 to 1999 he was the geophysicist for a small geological consulting firm in Japan, conducting groundwater, engineering and archaeological geophysical surveys. He is currently a PhD candidate at the University of Western Australia researching shallow surface wave inversion.

NAOMI OSMAN completed her BSc (Hons) in Geophysics at the University of Sydney in 1998. In 1999 she joined the Cooperative Research Centre for Mining Technology and Equipment (CMTE) as a PhD student with their geological sensing program. Naomi is based in the School of Geosciences, University of Sydney and her research interests include in-mine geophysics and geophysical imaging, particularly borehole radar imaging. She is member of the SEG, ASEG and AusIMM.

JOHN PAINE enjoys life working as a geophysical software consultant in Adelaide. The Internet allows him to work with many different groups around the world on a wide variety of projects without having to leave home. Although recent work on full time-series IP has necessitated one trip to the bush which resulted in a red pair of runners! Current interests are magnetic, gravity and IP inversions, time series IP and EM, data presentation and analysis and 3D visualisation. All of which are greatly assisted by his PhD in Numerical Analysis from ANU (1979), his Post Doctoral work with David Boyd at Adelaide University and the many clever people out there doing geophysics in the real world.

DERECKE PALMER graduated with a BSc in 1967 and an MSc in 1976 from the University of Sydney, and with a PhD in 2001 from the University of New South Wales. He is best known for his development of the GRM, a method for processing and interpreting shallow seismic refraction data. In 1992, the ASEG presented him with the Grahame Sands Award for Innovation in Applied Geoscience and in 1995, the SEG presented him with the Reginald Fessenden Award, on each occasion for the GRM. His current research interests include the use of amplitudes in shallow refraction interpretation, especially with the refraction convolution section, and three-dimensional three component shallow refraction methods. He began his career as a geophysicist with the NSW Geological Survey, and is currently a senior lecturer in geophysics at UNSW. He is a member of the SEG, ASEG and the Environmental and Engineering Geophysical Society.

MIKYUNG PARK received her MSc (1989) in Applied Geology at the Pukyong National University in S. Korea and completed her PhD (2000) in Civil Engineering at the Osaka University in Japan. In 2001 she jointed the National Institute Rural Engineering (NIRE) in Japan as a postdoctoral fellow of the Japan Society for the Promotion of Science (JSPS). Her research interests include a development of 3D inversion technique by a resistivity monitoring method with high-density data for the Geo-environmental investigation. She is member of the SEGJ.

JOHN F. PARRISH worked for the Hughes Aircraft Company in Fullerton, CA and NASA, ERC in Cambridge, MA while earning a PhD in Physics from MIT (Massachusetts Institute of Technology). He left MIT in 1969 to join the Applied Physics Department of Shell Development Company in Houston, TX. During the next 30 years, he worked on diverse projects within Shell Oil Company. He has served Shell as land party-chief, inventor (several patents), technological prognosticator, geophysical programming supervisor, and chief geophysicist of Pecten Geophysical Company (a start-up processing subsidiary of Shell Oil Company). In 1996, John received the Shell E&P Technology Company Achievement Award as a member of the Shallow Water-Flow Control Team. He has processed or interpreted seismic data from both land and marine plays in the U.S.A., Brazil, West Africa, and China. Currently, he is Chief Geophysicist of Periseis Company. His interests include 3D deconvolution, relative entropy deconvolution, quantitative signal processing for seismic imaging, suppression of multiple interferences, and processing/ interpretation pitfalls.

LOUISE PELLERIN is an independent consultant in the research and applications of electrical and electromagnetic geophysics in Berkeley, California, USA. She received her BSc from the University of California, Berkeley and her MSc and PhDs from the University of Utah, all in Geophysics. She began her career in mineral exploration in 1977, working for nearly 8 years in Alaska. After completing graduate school, she held positions as a research geophysicist with the US Geological Survey and Lawrence Berkeley National Laboratory, and a visiting professor at the University of Aarhus, Denmark. Louise is proficient in the field deployment and interpretation of electrical and electromagnetic methods. She was the principle investigator on several large projects to develop innovative techniques for use in environmental applications, and has extensive knowledge of the magnetotelluric method, having conducted both field and theoretical studies while working on crustal and geothermal investigations. She is a member of SEG, AGU, EAGE and AWG.

GEOFF PETERS received a BSc (Hons) in Geophysics from the University of Tasmania in 2001. He is currently a geophysicist with Elkedra Diamonds NL, and is a member of the ASEG. His main interests are in application of geophysical methods to environmental and groundwater problems.

PETER PETKOVIC obtained a BSc in Physics, Mathematics and Geology at the Australian National University in 1971. He worked with the Bureau of Mineral Resources, Geology & Geophysics in acquisition, processing and interpretation of data from Australia's first continental margins survey in the 1970's. In 1978 he completed graduate diplomas in Education and Curriculum and then taught high school mathematics for 10 years. Since 1989 he has worked at Geoscience Australia on the development of a long-range radio navigation system, management of processing and software development for marine gravity, magnetic and bathymetry data, development of processing and modelling systems for seismic refraction data, and compilation methods for bathymetry, potential field and seismic velocity datasets.

KATHRYN POWELL is a PhD scholar (forensic anthropology) in the Department of Anatomical Sciences, University of Adelaide. Her doctoral thesis is entitled The Detection of Buried Human Skeletal Remains in South Australia. In 2000, Kathryn was awarded the Michael Duffy Travel Fellowship by the National Institute of Forensic Sciences in support of her travel to the United States and United Kingdom to study international techniques being applied to the detection of clandestine graves. Kathryn's early background in cultural anthropology has involved her in the criminal field since 1985, working with the Department of Correctional Services in South Australia and Western Australia, and more recently the South Australia Police. Her work has included policy development, research and evaluation, the development of performance measurement systems, corporate and strategic planning at the government portfolio level and directing a private company. Recently, she has established "Anthropology - Forensic Research" as a specialised consultancy.

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 completion of the 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 two Dobermanns, an Anatolian Shepherd and a formerly feral cat, none of whom seem to get annoyed during his bouts of flute playing.

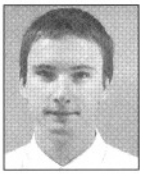
SHANTI RAJAGOPALAN is a consultant geophysicist. She specializes in the interpretation of aeromagnetic, gravity and radiometric data used in mineral exploration. Shanti also runs training programs in the use of geophysical methods. She has a PhD in Geophysics from the University of Adelaide and has worked for the National Geophysical Research Insititute, Bureau of Mineral Resources, University of Adelaide and Rio Tinto Exploration. Shanti is a member of ASEG and SEG.

HOJJATOLLAH RANJBAR received his BSc and M Sc degrees (Geology) from the University of Poona and his PhD from the University of Delhi. He joined the Department of Mining Engineering at the Shahid Bahonar University in Kerman, Iran in 1996. He is presently the Head of the Department of Mining. His interest is mainly around the application of remote sensing and GIS to exploration of mineral resources.

JAMES REID received his BSc (1991) and MSc (1994) in Geophysics from the University of Sydney and a PhD (1999) from Macquarie University, Sydney. He is currently an Associate 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.

SCOTT REYNOLDS graduated with a PhD from the National Centre for Petroleum Geology and Geophysics in 2001. In 1997 he graduated from the University of Adelaide with a BSc (Hons) in Geophysics. Scott is currently working as a postdoctoral research fellow at the NCPGG working on the Australasian Stress Map project. His current research interests include determining, characterising and modelling the in situ stress field. Scott is a member of ASEG, GSA, PESA, AAPG and AGU.

Biographies



THOMAS RIDSDILL-SMITH graduated with an Honours degree in Mathematical Geophysics (1994) and a PhD (2000) from the University of Western Australia. From 1995 to 2000 he worked for World Geoscience Corporation as a geophysicist specialising in potential-field intepretation and processing. Since early 2000 he has worked for Woodside as a seismic processing geophysicist. His interests include wavelet transforms, potential field data and seismic processing. He is a member of the SEG and PESA.

WILLIAM ROBERTSON graduated with a B.App. Sc. (1987) in Geophysics and a Post Graduate Diploma in Mineral Geophysics and Groundwater (1988) from Curtin University of Technology. CRA Exploration employed him from 1989 to 1996, principally in the search for base metals, uranium, diamonds and copper/gold mineralisation in Western Australia and Queensland. From 1996 to 1999 he was employed by North Ltd. as a team leader of the geophysical group responsible for the geophysical mineral exploration activities in NSW, VIC, QLD and the NT. From 2000 to 2001 he worked with Zonge Engineering in Australia. He is currently a geophysical consultant with Value Adding Geophysics.

BERNARD ROBINEAU was awarded a DEA (Master) of Tectonophysics in 1977 and a PhD on Tectonics in 1979 at University of Montpellier (France). In 1999 he obtained an HDR (Habilitation à Diriger les Recherches) on Tectonics and Geophysics at University of La Réunion (France). Bernard was a senior lecturer, in structural geology and geodynamics at the University of Jos, Nigeria from 1980-1983, the University of Dakar, Senegal from 1984-1989, and the University of Majunga, Madagascar from 1990-1991. He was Professor of Geology at the Faculty of Sciences and Technology, University of La Réunion, France from 1992-2001. He has worked as a Senior Research Fellow at IRD (Institut de la Recherche pour le Développement, France), posted in the Research Unit: Weathering Biogeodynamics and Tropical Geomorphology, Nouméa, New Caledonia, since February 2002. Bernard's main research interests are in geological constraints in geophysical modelling and interpretation of geoelectrical models.

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 currently the President of the ACT Branch of the ASEG.

DAVID ROBSON is Chief Geophysicist of the New South Wales Department of Mineral Resources and is responsible in providing geophysical input into the regional geological/geophysical mapping and coal exploration programs. He is also the manager of the Minerals Program for the Department's Exploration New South Wales exploration initiative. Over the past eight years, David has supervised the collection of over 1.6 million line-km of high-resolution airborne geophysical data. Before joining the Department in 1994, David worked from 1978 to 1994 for Western Mining Pty Ltd, between 1974-1978 with the Bureau of Mineral Resources (now Geoscience Australia), and in 1974 with Scintrex Pty Ltd. During 1998 to 2001, David was Honorary Federal Secretary of ASEG. He will now be a co-chair of the Workshop Program for the next ASEG Conference to be held at Darling Harbour in Sydney during August 2004.

JASMINE RUTHERFORD is studying for a PhD at the University of Western Australia, researching the role of the regolith on salt and water fluxes in several catchments in the southwest of WA. She is supported by a West Australian CSIRO-University scholarship. Prior to taking up the scholarship, Jasmine worked with the Water and Rivers Commission in WA on the hydrogeology of the North Perth Basin and the Collie and Blackwood Catchments in southwest WA. She has also worked with CRC AMET on the petrophysics of supergene mineral deposits and has been involved in the analysis and interpretation of airborne geophysical data for mineral exploration with World Geoscience Corporation.

YUTAKA SASAKI received a BSc (1974) in Mining Engineering and a DEng. (1984) in Exploration Geophysics from Kyushu University. From 1974-78 he worked with Nittetsu Mining Consultants. In 1979 he joined Kyushu University where he has been working on inversion methods and field applications of electrical and electromagnetic geophysics.

DANIEL SATTEL received his Vordiplom from Universitaet Karlsruhe, Germany in 1986 and an MSc from Oregon State University, USA in 1990, working on the interpretation of seismic refraction data. He holds a PhD in Geophysics from Macquarie University, where he specialized in electromagnetics. He is currently working for Fugro Airborne Surveys in Perth involved in the development of EM software and the interpretation of airborne EM data.

ANDREW SHEARER is currently a project geophysicist at PIRSA. He holds a BSc in Applied Geology from the University of South Australia and BSc (Hons) in Geophysics from the University of Adelaide. In 2002 Andrew was seconded to MIM Exploration. He worked on a variety of projects: acquiring and interpreting EM data from the Queensland the coalfields; acquiring and interpreting magnetic and gravity data from the Gawler Craton; and modelling magnetic data from the Mt Isa mine lease. He is the current President of the South Australian Branch of the ASEG; prior to accepting this position, he was the Secretary.

ALEX SHEPHERD is a PhD student in the Department of Exploration Geophysics, Curtin University of Technology, Perth, WA. His thesis is entitled, Time Lapse 3-D Using Legacy Seismic Data and his current research is focused on the effects of sea swell on the accuracy of seismic data for time-lapse differencing. He received an MSc at the University of South Carolina, USA in Geography (1999), where cartography, geophysics, and geology including sequence stratigraphy were studied. He undertook a 2D seismic project from an Alaskan oil field, picking stratigraphic horizons in a pro-grading sequence. He received his BSc at University of Edinburgh, Scotland in Geology (1979) and his Diploma at the University of Wales, in Cartography (1983) after which he worked as a cartographer for the Forestry Commission, UK. His MSc thesis entitled Accuracy of Interpolations for Geologic Mapping made from 3D Seismic Models Using a Geographic Information System was adapted and presented as a poster at the 15th ASEG Conference in Brisbane, 2001 and subsequently published under the title: Interpolation of Horizon Contours from Sections Sampled from 3D Seismic Data and from Parallel 2D Seismic Sections" in "Preview, issue 95 (December 2001).

DON SHERLOCK received a BSc (Hons) in Geology from the University of WA in 1995 and completed his PhD in Geophysics at Curtin University last year. He is currently working as a research scientist in geophysics at the CSIRO Division of Petroleum Resources, where is he is continuing his work on developing a theoretical and experimental capability to simulate scaleable aspects of reservoir dynamics with physical models.

RAJENDRA SHRESTHA is currently a managing consultant with Veritas Exploration Services, and is responsible for providing consulting services in projects involving seismic inversion and reservoir modeling by integrating subsurface geological, well and seismic data. He also contributes as an instructor in the Seismic to Simulation Workshop. Rajendra has over fifteen years of well-rounded experience as an Exploration/Development/Application Geophysicist with multinational oil and gas and service companies such as Exxon, Unocal, RC Squared, and Veritas in the Gulf of Mexico, West Africa, North Malay, North German, Macuspana, Michigan. Ghaba Salt (Oman), Saudi Arabia, and Kuwait Basins. He was a key contributor to Unocal's Norphlet Exploration and Development program in the Gulf of Mexico. His area of expertise include seismic interpretation, seismic inversion, AVO/DHI analysis, geostatistical reservoir property model building, attribute analysis, rock properties analysis, and special seismic data processing. Rajendra has published several papers covering a wide variety of subjects such as AVO analysis, application of geostatistical techniques in porosity prediction, seismic acquisition and processing, and pore-pressure prediction using seismic data. He holds PhD (Geophysics) and MSc (Geology) degrees from Univesity of Oklahoma, USA; an MSc in Geophysics from Osmania University, India; and a Post Graduate Diploma in Exploration Geophysics from ITC, The Netherlands. He is currently located in Houston, USA.

ANTHONY SIGGINS commenced his research career in 1967 with the Herman Research Laboratories (SECV) where he developed aspects of experimental stress analysis and non-destructive testing. Following completion of a B. Applied Science in Physics from RMIT University in 1970 and an MSc in Materials Science at Monash University in 1976, he joined the Geomechanics Division of CSIRO where he worked on the application of materials science and experimental geophysics to Mining and Civil Engineering problems. He received his PhD in Experimental and Theoretical Geophysics from the University of New England (NSW) in 1990. Anthony established a Ground Penetrating Radar (GPR) project in 1983 and managed the Geomechanics component of a joint BHP/CSIRO GPR Research Program from 1990 to 1993. In 1994 he left CSIRO and took up the position of Research Manager with ISS Pacific Pty Ltd. During the period 1994 to 1997 he was responsible for the installation and support of advanced microseismic monitoring systems in Mining operations throughout Australia. Currently, He is a Principal Research Scientist with the CSIRO Division of Petroleum Resources working in Rock Physics in support of the APCRC Abnormal Geopressure Program.

BENSION SH. SINGER received his MSc in Physics from Moscow State University (1971) and PhD (1981) in Physics and Mathematics from the Russian Academy of Sciences. From 1977 to 1991 he worked as a junior and later as a Senior Research Scientist in the Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation at the Russian Academy of Sciences. His work was associated with deep electromagnetic and magnetovariational soundings on the global and regional scale. In 1992 Bension participated as a visiting scientist in an environmental project at the University of Cologne, Germany. In 1993-1995 he was a Senior Research Scientist responsible for the provision of scientific support to the through-casing resistivity project in Western Atlas Logging Services, WAII in Houston, Texas. He joined DEM CSIRO at the end of 1995 where he held a position of a Principal Research Scientist at CRCAMET. In 2000, he joined DPR CSIRO. His scientific interests are focused on novel methods for modelling and inversion of electromagnetic data. He is a member of AGU, SEG, and ASEG.

KURT SØRENSEN is an Associate Professor and head of the HydroGeophysics Group, Laboratory of Geophysics, Department of Earth Sciences, University of Aarhus, Denmark. He gained a PhD (1979) in Geophysics from the University of Aarhus. His significant research includes electromagnetic methods and development of a number of new field instruments now widely used in near-surface hydrogeophysical mapping in Denmark, e.g. the Ellog Auger Method with level specific water sampling, the Pulled Array Continuous Electric Sounding method (PACES), the Pulled Array Transient ElectroMagnetic method (PATEM) and the High Moment Transient electromagnetic method (HiTem).

JOHN STANLEY was awarded his PhD in 1975 for the development of a cesium magnetometer and its applications to high-resolution sub-surface mapping. In 1978 he founded the Geophysical Research Institute at the University of New England and in 1987 formed Geophysical Technology Pty Ltd a company established to manufacture and commercialize products of research at the University. In 1986 John and colleague Malcolm Cattach developed the first digital UXO detection instrumentation and associated quality procedures to meet the requirements of the Australian Department of Defence. In 1991 Stanley and Cattach patented Sub-Audio Magnetics, now a pre-eminent technology in both mineral exploration and UXO detection. The two jointly received the Grahame Sands award of the ASEG in 1988 and 1995 respectively for these developments. In 1997 Geophysical Technology acquired the GRI from the University, and G-tek was formed. He is now responsible for the development and application of new technologies to meet the requirements of the G-tek's markets and he is Manager of International Business Development.

EDWARD (NED) STOLZ obtained a BSc (Hons) in Geophysics from the University of Adelaide in 1985. For the following five years he was employed by CRA Exploration and worked on projects in Western Australia, Northwest Queensland and the Northern Territory. Between 1992 and 1997 he completed a PhD at the Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET), Macquarie University, on the topic of automatic interpretation of EM data. In 1997 he joined WMC at the Leinster nickel mine, and spent three and a half years exploring for nickel using surface and downhole TEM methods. Ned is currently a senior geophysicist for St Ives Gold Mining Company, and is involved in all aspects of gold exploration geophysics.

GREG STREET graduated with 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 began looking at the application of geophysics in shallow environmental problems. This interest led to the development, with Aerodata and the Department of Agriculture, of the application of airborne geophysical systems in land salinisation studies. From 1992 to 2000 he was Director of Environmental Services at World Geoscience Corporation where he was involved in the development of airborne geophysical methods for environmental applications. In 2000 he joined Sinclair Knight Merz 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 guest lecturer at Curtin University. Greg is a former President of the ASEG and the recipient of the inaugural Lindsay Ingall Memorial Award.

ROBERT STUART received a BSc (1st class Hons) in Geophysics from the University of Sydney in 1994. Following two years as geophysicist for Normandy Exploration in South Australia, he took a position with High-sense Geophysics (now Fugro Airborne Surveys) in Toronto, Canada, as an international field manager for airborne magnetic and radiometric surveys. Rob left High-Sense in mid 1999 to commence a PhD at the University of Western Australia.

JAMES SUN received a PhD (1980) in Physics from University of California, Riverside. He spent two years doing postdoctoral research in atomic scattering theory before joining ARCO in 1982. He was a Research Advisor in ARCO's exploration research group until ARCO merged with BP. He joined Veritas in 2000 and is currently a Senior Research Scientist at Veritas Research in Houston.

MICHAEL D. THOMAS's brief period in private industry, managing airborne geophysical surveys (international aid), has been followed by a career in the Canadian government at Natural Resources Canada (formerly Department of Energy, Mines and Resources). There, research interests have focused on the geological interpretation of regional gravity and magnetic data sets, firstly at the Earth Physics Branch, and then at the Geological Survey of Canada, when these two Branches were amalgamated. An early interest, at a time when Precambrian plate tectonics was a controversial subject, was interpretation of major gravity anomalies at structural province boundaries in terms of plate-driven continental collision. This interest in large-scale tectonics of the Canadian Shield continued, with topics including the Mid-Continent Rift. Current studies are directed towards the Trans-Hudson Orogen, and mapping of Precambrian basement beneath the Western Canada Sedimentary Basin. On a more local scale, investigations have been related to nuclear waste management and mineral exploration (massive sulphides, uranium, and platinum).

NICHOLAS VALLEAU is the Managing Director of Geosoft Australia. As well as managing the technical and business resources in the Perth office, Nick is responsible for working with Geosoft's major global clients in the mineral exploration industry, enabling their use of software technology to optimize efficiency and effectiveness, to improve their odds of finding mines. Geosoft provides comprehensive spatial data management, processing and analysis software for mineral and petroleum exploration, specialising in advanced geological, geochemical and geophysical tools. Nick has previously worked for geophysical survey contractors and equipment manufacturers, including Dighem Surveys and Processing Inc. and Geotech Ltd., two companies based in Canada. Nick has developed software and published papers on various aspects of PC-based data processing, imaging and enhancement as well as esoteric applications of HEM data. He graduated as a Geological Engineer from the University of Toronto in 1983.

LISA VELLA graduated from the University of Sydney with Honours in Geophysics in 1991. After two years with Newcrest Mining Ltd., working at the Telfer and Tuckabianna gold mines, Lisa commenced work with WMC Resources Ltd. She spent almost three years working at Hill 50 Gold Mine, prior to transferring to Melbourne to work in WMC's Africa/Eurasia Group, focusing on exploration in West and East Africa and Kazakhstan. Transferring to Perth in early 1998, Lisa spent two years working in WMC's global Project Generation team, with her main activities being reconnaissance exploration for nickel in southern Africa, iron-oxide Cu-Au in Brazil and gold in China, as well as providing geophysical support to Three Springs Talc Mine. Since early 2000, Lisa has been involved in managing reconnaissance Au and Ni exploration projects in China.

DARYN VOSS is an Applied Science (Hons) graduate in Geophysics and University of Queensland Medallist. He spent time with an international seismic contractor before joining Velseis in 2001. He is currently involved with a range of geophysical special projects and software development initiatives.

JULIAN VRBANCICH joined the Defence Science and Technology Organisation (DSTO) at Pyrmont (Sydney) in late 1984. His interests focus on studying EM emissions and DC electric fields arising from corrosion currents in ships and investigating the use of airborne EM methods to explore shallow water marine environments to measure sea depth and map seafloor resistivity.

DEREK WEBB completed his BSc at Wollongong University in 1977. He was awarded a Certificate of Equivalent Honours in Geophysics by the University of New England in 1981. From 1982 to 1994 Derek worked for Geopeko/North on their eastern Australian projects, including Goonumbla and Lake Cowal. During this period he was based in Parkes then Brisbane. In early 1995, he joined MIM Exploration (MIMEX) as a Senior Geophysicist working mainly on northeast Queensland projects, particularly Ravenswood. He is currently District Geoscientist - Eastern Australia, responsible for MIMEX' eastern Queensland and New South Wales projects.

STEVE WEBSTER is a Geology (B Sc, 1963) and Geophysics (MSc, 1970) graduate from Sydney University. He has been employed as a geophysicist for the NSW Geological Survey and in mining exploration throughout Australasia, the Middle East and elsewhere. Since 1997, he has consulted in geophysics by private practice. Steve has served on the ASEG Federal Executive in numerous roles and is currently President of the NSW Branch of ASEG. He is a Fellow of the Australian Institute of Geoscientists.

BOB WHITE graduated from Macquarie University with an MSc in 1974 and has since been working in all fields of mineral exploration, from the application of geophysics in regional interpretation down to mineral identification and definition. He has worked in project management, design and specification of exploration strategies and surveys, as well as the implementation, and interpretation of these projects. For the last 18 years he has worked as a consultant.

PETER MARK WHITING is Regional Processing Manager of Veritas DGC Asia Pacific Ltd. He obtained a BSc in Geophysics and Mathematics at the University of Sydney in 1983; in 1989 he was awarded an MSc in Geophysics at Macquarie University; and in 1994 he obtained his PhD in Applied Mathematics, from the University of Sydney. Peter worked from 1984-1993 with GSI/HGS, and from 1994-1996 with Digicon/Veritas DGC. He has been with Veritas DGC Asia Pacific Ltd. from 1996. Most of Peter's work experience has involved processing both land and marine 2D and 3D projects since 1984 and his main interests are in Seismic Tomography and Imaging. He is a member of SEG, ASEG and EAGE.

CHRIS WIJNS obtained a BSc (Hons) in Geophysics at McGill University in Montreal, Canada in 1993,and subsequently completed an MSc in Geophysics in 1996 at the University of British Columbia, in Vancouver, Canada. His research at UBC involved the development of a numerical code for modelling sulfur volcanism on Jupiter's moon Io. 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 is now 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.

PETER A. WOLFGRAM obtained his geophysical training at the Universities of Munich and Toronto and has specialised in electromagnetic exploration methods. He migrated to Australia in 1992 and joined the elusive round of airborne geophysicists. Presently product development manager at Fugro Airborne Surveys in Perth, he believes that we have just 'scratched the surface' with airborne EM. So - sit back, relax and stay tuned.

TOSHIYUKI YOKOTA received a BSc (1989) and an MSc (1991) in Exploration Geophysics at Kyoto University, Japan. From 1991 to 1997 he worked for Geological survey of Japan (GSJ) as an exploration geophysicist. In 1997, he moved to the Japan National Oil Corporation (JNOC) and returned back to GSJ in 1999. GSJ was re-organised into the National Institute of Advanced Industrial Science and Technology (AIST) in 2001. He is now working for GSJ, AIST. And his current research interests are borehole seismology and reservoir characterisation. Toshiyuki is working on seismic tomography inversion and time-lapse reservoir monitoring and their applications to geothermal and oil field explorations. He is a member of ASEG, SEG and SEG Japan.

FANMIN ZHANG received a BSc in Physics from Ningxia University, PRC in 1984 and an MSc in Geophysics from Seismological Institute of Lanzhou, PRC in 1992. He has been registered as a PhD student at the Department of Exploration Geophysics, Curtin University of Technology, Australia since 2000. From 1984 to 1989, he taught physics in high schools and between 1992 and 2000, he was a research fellow in geophysics at Seismological Institute of Lanzhou. Fanmin's research interests include seismic wave field decomposition, seismic signal processing using neural networks, shear wave splitting, numerical modelling of seismic wave propagation, inversion problems, seismic anisotropy and anisotropic seismic processing. He is a member of ASEG and SEG.

BING ZHOU received BSc (1982) and MSc (1989) degrees in Geophysics from Chengdu University of Technology (CDUT, formerly Chengdu College of Geology), China. From 1990 to 1995, he worked at the Institute of Geology and Geophysics for the Earth's Interior, CDUT. During this period he joined Seismology Groups at Flinders University of Southern Australia and the International Centre for Theoretical Physics in Trieste, Italy. He obtained his PhD in Geophysics at Adelaide University, Australia in 1998, then worked for two years. In 2000, he went to Sweden and worked at Department of Geotechnology, Lund University. He is currently a Senior Research Fellow of Department of Geology and Geophysics, Adelaide University. He has published over 20 papers in Chinese, Australian and international journals. He is a member of EAGE and ASEG. His research interests involve 2D/3D resistivity imaging, 2D/3D seismic wave modelling and inversion, geophysical inversion algorithms and the structure of the Earth's interior.

BINZHONG ZHOU joined CSIRO in 1995. He is now a Senior Research Scientist with the Geoscience Group in CSIRO Exploration and Mining, and a core member of the CMTE Geological Sensing Program in the School of Geosciences at Sydney University. He received his BSc (1983) and MSc (1986) in Geophysics from Chengdu University of Technology (CDUT), and his PhD in 1993 at The Flinders University of South Australia. From 1986 to 1989 he was a lecturer in Geophysics at CDUT. Between 1991 and 1993, he was a computer software engineer for Wiltshire Geological Services in Adelaide. After completing his PhD in 1993, he moved to the ARCO British geophysical imaging research group in Oxford as a Post-doctoral Fellow. During the time in Oxford (1993-1995), he was also an Elf Research Fellow in Geophysics at Lincoln College and a consulting research fellow at Elf Geoscience Research Centre in London. He was a key contributor to the ACARP project on the interpretation of small-scale geological features on seismic reflection data, which received the ACARP research award for excellence in the underground category in the year 2000. His current research interests include seismic data processing and interpretation for coal and petroleum industries and applying geophysical techniques to mining problems such as the delineation of deposits, the production of coal and metalliferous ore, mine planning and mining risk reduction. He is a member of ASEG, SEG and EAGE.