PREVIEW Issue 138 20th International Geophysical Conference and Exhibition 22–25 February 2009

PREVIEW

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS




ASEG 09

CONFERENCE HANDBOOK

20TH INTERNATIONAL GEOPHYSICAL CONFERENCE AND EXHIBITION

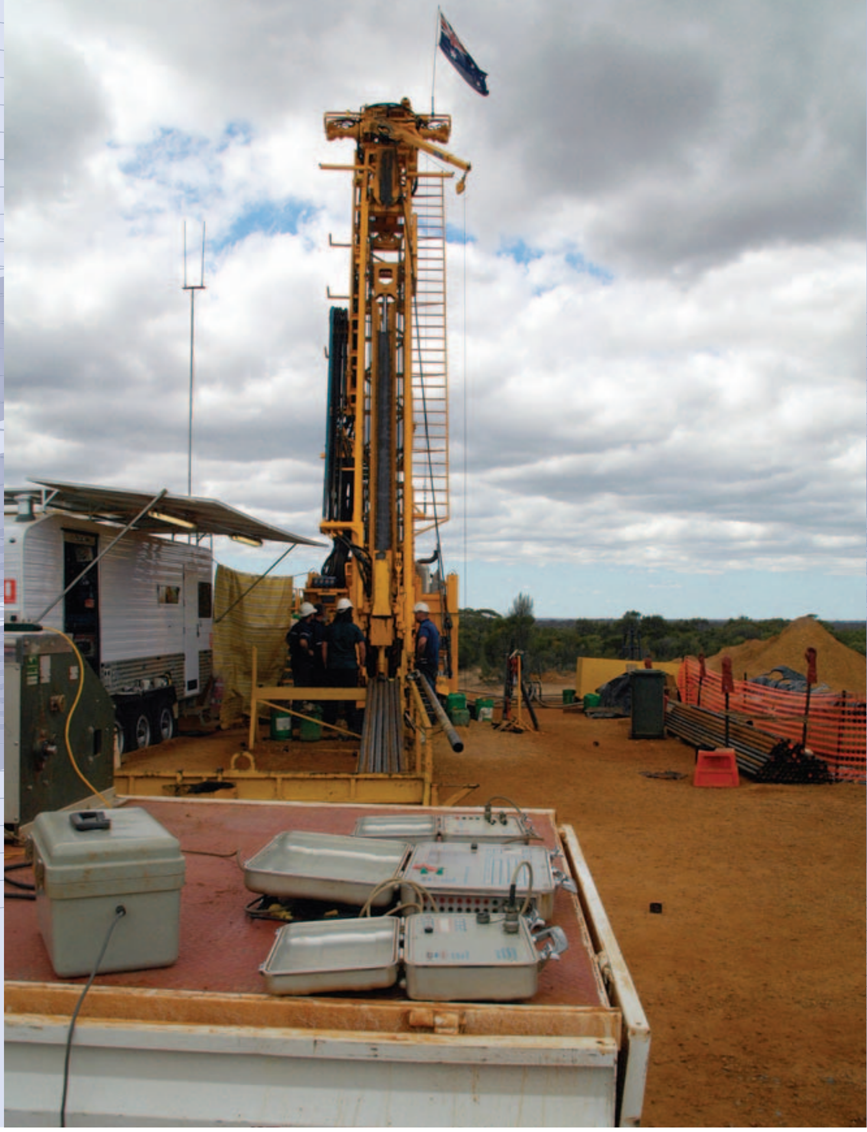
CO-HOSTED BY

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

PETROLEUM EXPLORATION SOCIETY OF AUSTRALIA

22–25 February 2009
Adelaide Convention Centre
South Australia

BRIGHTER • DEEPER • GREENER – GEOPHYSICS IN A CHANGING ENVIRONMENT



PREVIEW

ASEG 09

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From the Premier

The South Australian Government has long recognised that the resources sector offers significant opportunities for long-term, sustainable growth. That's why, since coming to office in 2002, we have made a concerted effort to expand our State's resources industries, and to take advantage of its unique resource base.

In particular, the Plan for Accelerated Exploration (PACE) program that we implemented in 2004 has delivered significant benefits through its partnership with industry. Our efforts to expand and diversify the sector through initiatives such as the PACE scheme have won international recognition. The *ResourceStocks* 2008 World Risk Survey ranked South Australia as the number one jurisdiction in Australia – and number two in the world – for investment in mining and exploration. As a result of this concerted investment and partnership, the number of operating mines in South Australia has risen from four in 2002 to 10 in 2009, with around 20 more in the planning or development stage.

Mineral exploration expenditure reached a new record of $355.2 million in the most recent financial year – representing a 10-fold increase in the past five years. There have also been a number of new oil and gas explorers drilling in the State's Cooper, Otway and Officer Basins, as well as developments in coal to liquid fuels in the Arckaringa Basin.

In addition to a sound outlook in the mining sector, South Australia has significant advantages in the development of emissions-free geothermal energy. Our comparative advantages in this naturally occurring "hot rock" resource, combined with our supportive investment framework have – to date – attracted more than 95 per cent of the nation's investment in geothermal exploration, appraisal and pilot development.

The first wave of mineral exploration generated by the PACE scheme has undoubtedly cemented South Australia's status as a mining investment destination, and created significant new activity in South Australia's resource sector. However, the recent global economic turmoil and dramatic falls in some key commodity prices contain significant ramifications for the resources industry worldwide. In South Australia, it is likely that it will result in some weakening of exploration activity in the short term. Despite this, the outlook for the South Australian resources sector remains positive as our known resources are long life and very competitive. The diversity of our resource base, coupled with the multitude of recent discoveries of world-class ore bodies and South Australia's global reputation as a secure place for investment in mining all bode well for the future of the resources sector in this State.

On behalf of the South Australian Government, I welcome you all to Adelaide for the 2009 International Geophysical Conference and Exhibition. I hope that you are able to enjoy some of the sights, tastes and experiences that our city and our State have to offer, and I wish all delegates a productive, enjoyable and successful Conference.

Mike Rann
Premier of South Australia
Minister for Economic Development

From the Organising Committee

Dear Convention Delegates, Sponsors and Exhibitors

Welcome to Adelaide and the 20th ASEG/PESA International Conference and Exhibition. On behalf of the Conference Organising Committee, the Australian Society for Exploration Geophysicists and the Petroleum Exploration Society of Australia we are proud to bring you one of the premier geophysical forums on the world stage.

As Co-Chairs we wish to thank the Organising Committee for their hard work and enthusiasm throughout the long lead up to the conference. We would like to thank the staff and principals of SAPRO, our Conference Organiser, for their valuable experience and guidance. The efforts of David Denham in editing Preview for not only this conference but also a number of years should also not go by unacknowledged. Also without the crucial support of the many presenters, sponsors and exhibitors the conference could not succeed.

The technical program will feature presentations from the minerals, petroleum and environmental fields. To complement the technical papers a series of workshops and field trips have been organised, also the SEG Distinguished Instructor Short Course (DISC) will be held in conjunction with the Conference.

In addition to enjoying the Conference we invite you to venture beyond the Convention Centre and sample many of the delights that Adelaide has to offer. Including the world leading wines and restaurants, all presented within the stunning backdrop of the Adelaide Hills or amazing beaches and to be enjoyed in a sophisticated cosmopolitan lifestyle that retains the big country town charm.

In these trying financial times the Conference Platinum Sponsor, Santos, is to be thanked for its support. In addition, we would like to express our appreciation for Gold Sponsors: RioTinto, Beach Petroleum, WesternGeco, Shell and Woodside Energy; the Silver Sponsors: Chevron Australia, CGGVeritas, Barrick and the Government of South Australia. The many Bronze Sponsors are also thanked for their support.

We look forward to enjoying the company of old friends and making new ones during your stay in Adelaide.

Co-Chairs

Andrew Shearer (*Taylor Collison*)
and Tony Hill (*PIRSA*)

The Committee

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Andrew Shearer

Tony Hill

From the Presidents

'Geophysics in a Changing Environment' is the theme of this 20th International Geophysical Conference and Exhibition. 'Brighter – Deeper – Greener' is a slogan that emphasises the changing environment, not only of our global community, but also the environment in which we work as geoscientists. Geoscience is one of the most important disciplines for sustainable development and conferences like this one are an opportunity to show that we can tackle many environmental challenges by thinking differently about the application of geology and geophysics. One of our challenges is to ensure that we have an adequate supply of geoscientists to be able to tackle resource and environmental issues. We should be looking for as many meanings as possible in the Brighter – Deeper – Greener slogan!

The ASEG and PESA are again collaborating to produce a world class conference and exhibition, during which 'Brighter' ideas will be presented to highlight better ways of applying our discipline. The 'resource boom' is now recent history as prices of most commodities have dropped over the last 12 months. However, we should now be focusing on the next boom, which is just around the corner. Now is the time to share ideas on how we can be more effective in finding new resources and at the same time preserve our environment. No doubt we will need to go 'Deeper' with our exploration to find new world class deposits of metals, coal, and oil and we will need to consider 'Greener' ways of doing this to protect the natural environment in which we work. We also need to go further and demonstrate the importance of geoscience and geophysics during both 'booms' and 'busts'.

This Conference, through the technical sessions, keynote addresses, exhibitions and informal gatherings, is going to provide an important forum to discuss philosophies, technologies and practices that will contribute to exploration and production success. It will not only offer a stimulating and enjoyable week to learn and to hear some new ideas, but provide an opportunity to catch up with old friends and to make new ones.

The Conference is being held in the Adelaide Convention Centre, which nestles on the edge of the Torrens River in one of Australia's famous cities. The City of Adelaide offers many delights. Beside the many attractions within the city itself, within one hour's drive are rolling hills covered in vineyards stretching from McLaren Vale in the south to the Barossa and Clare Valleys in the north. These are the production centres of the South Australian wine industry. Not to mention the charming town of Handorf situated in the Adelaide Hills, which is a historical German settlement. There are many attractions for delegates and their partners, when not engrossed in the excellent presentations at the conference and exhibition.

We sincerely thank the Convenors, Mike Hatch and Andrew Shearer, along with the Conference Organising Committee for their wonderful work in bringing this Conference to realisation.

It gives us great pleasure to welcome you all to the 20th International Geophysical Conference and particularly those delegates from overseas, our colleagues from ASEG and PESA, and representatives from our affiliated societies the SEG, EAGE, SEGJ, KSEG, HAGI and SAGA.

Enjoy your week.

Peter Elliott
President of the Australian Society of Exploration Geophysicists

Tom Loutit
President of the Petroleum Exploration Society of Australia

Platinum Sponsor

SANTOS

Santos

Santos Ltd is a major Australian oil and gas exploration and production company with interests and operations in every major Australian petroleum province and in Indonesia, Papua New Guinea, Vietnam, India, Bangladesh, Kyrgyzstan and Egypt.

We are one of Australia's largest producers of gas to the domestic market, supplying sales gas to all mainland Australian states and territories, ethane to Sydney, and oil and liquids to domestic and international customers. We also have the largest Australian exploration portfolio by area of any company – 192 000 square kilometres.

Santos is positioning itself to become the leading energy company for Australia and Asia. The Cooper Basin, which Santos and its joint venture partners have developed, is Australia's largest onshore resources project. Through our interest in the Darwin LNG project, we are a producer of LNG which is exported to customers in Japan. Santos has announced a $7.7 billion project to build an LNG facility in Gladstone, Queensland, that will process coal seam gas from eastern Queensland.

Santos has more than 1750 employees and produced 59.1 million barrels of oil equivalent in 2007.

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BEACH PETROLEUM

Beach Petroleum Ltd, founded in the early 1960s, is a publicly listed oil and gas Exploration and Production Company based in Adelaide, South Australia. The Company holds interests in more than 300 exploration and production tenements in Australia and overseas.

Beach has petroleum exploration interests in the Bass, Browse, Carnarvon, Cooper/Eromanga, Gippsland and Otway basins in Australia, the Canterbury and Taranaki basins in New Zealand, the Gulf of Suez in Egypt, the Ebro Basin in Spain and the Gulf of Papua, PNG (Pandora Project). The Company is also a participant in coal seam gas exploration in the Surat Basin and a geothermal energy project being conducted in the Arrowie Basin.

Beach holds interests in production joint ventures in the Cooper/Eromanga Basin, the Basker-Manta-Gummy Joint Venture in the offshore Gippsland Basin and the Tipton West CSG Joint Venture in the Surat Basin. As at June 2008, Beach's Proved plus Probable recoverable reserves were 145 million barrels of oil equivalent. During the financial year 2007/08, its share of production was 9.3 million barrels of oil equivalent.

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Web: www.beachpetroleum.com.au
Tel: +61 8 8338 2833

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Rio Tinto is a leading international mining group headquartered in the UK, combining Rio Tinto plc, a London and NYSE listed company, and Rio Tinto Limited, which is listed on the Australian Securities Exchange.

Rio Tinto's business is finding, mining and processing mineral resources. Major products are aluminium, copper, diamonds, energy (coal and uranium), gold, industrial minerals (borax, titanium dioxide, salt, talc) and iron ore. Activities span the world but are strongly represented in Australia and North America with significant businesses in South America, Asia, Europe and southern Africa.

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Email: mike.haederle@riotinto.com

SHELL DEVELOPMENT AUSTRALIA Pty Ltd

Shell Development Australia (SDA) is the exploration, production and gas commercialisation part of Shell's Australian business, holding an interest in about 20% of an estimated 136 trillion cubic feet of the gas resources in Australian waters.

As a gas growth centre for the Shell Group, SDA holds large reserves in the North West Shelf Venture (NWSV), Gorgon, Browse Basin and Timor Sea fields around Australia. SDA also maintains a substantial exploration portfolio in Australia with major representation in permits and reserves offshore Western Australia and the Northern Territory.

This is a business of very long-term plans and substantial investment. It involves acquiring and developing new exploration areas, making oil and gas discoveries and bringing them to market.

In Australia, SDA does this primarily through joint venture partnerships with other oil and gas businesses.

Shell Development Australia is also a founding member of the Australia LNG marketing consortium.

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250 St George's Terrace
Perth, Western Australia
Web: www.shell.com
Tel: +61 8 9338 6854
Contact: Kara Sloper
Email: kara.sloper@shell.com

WESTERNGECO

WesternGeco, a business unit of Schlumberger, is the world's leading geophysical services company, providing comprehensive worldwide reservoir imaging, monitoring, and development services, with the most extensive geophysical survey crews and data processing centres in the industry, as well as the world's largest multiclient data library. Services range from 3D and 4D (time-lapse) seismic surveys to multicomponent and electro-magnetic surveys, supplying our clients with accurate measurements of subsurface geology.

Level 5, 256 St Georges Terrace
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Web: www.westerngeco.com
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Contact: Elizabeth McFerran
Email: emcferran@perth.westerngeco.slb.com

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Woodside is Australia's leading independent energy company, with a 55-year history backed by one of the world's premier resource developments, the A$27 billion North West Shelf.

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Our position in the global energy market is growing, with an impressive portfolio of oil and gas developments including our Pluto liquefied natural gas project. With first sales by the end of 2010, the A$12 billion Pluto project will help triple our current equity production of liquefied natural gas.

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Tel: +61 8 9348 4000
Contact: Lesley Johnson
Email: lesley.johnson@woodside.com.au

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Level 10, 2 Mill Street
Perth, Western Australia
Web: www.barrick.com
Tel: +61 8 9212 5777
Email: aarbu@barrick.com

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CGGVeritas is a leading international pure-play geophysical company delivering a wide range of technologies, services and equipment to the oil and gas industry. Geophysical services cover offshore and onshore seismic acquisition, seismic data processing and imaging, as well as reservoir management. We offer an advanced suite of seabed seismic services. CGGVeritas also owns a recent vintage, well positioned library of multi-client land and marine seismic data. Hampson-Russell (A CGGVeritas company) provides its renowned geophysical software, training and technical services throughout the Asia-Pacific region.

38 Ord Street
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Web: www.cggveritas.com
Tel: +61 8 9214 6200
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CHEVRON AUSTRALIA

Chevron is one of the world's largest integrated energy companies, conducting business in more than 100 countries with a diverse and highly skilled workforce consisting of more than 59 000 employees. Chevron has been present in Australia for more than 50 years and is a significant investor in offshore north-western Australia exploration. The company is leading the development of the Gorgon Project, an LNG and domestic gas joint venture, and the wholly owned Wheatstone Project. Chevron operates the Barrow Island and Thevenard Island oil fields and is a participant in the North West Shelf Venture and Browse LNG development.

250 St Georges Terrace
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Contact: Erin May
Email: erin.may@chevron.com

GOVERNMENT OF SOUTH AUSTRALIA, PIRSA

Primary Industries and Resources SA (PIRSA) is a dynamic Government of South Australia agency committed to the economic development of the State and the sustainable use of the State's food, fibre and minerals industries.

The Division of Minerals and Energy Resources of PIRSA manages the state's mineral, petroleum and geothermal resources on behalf of the people of South Australia. It provides South Australian geoscientific information for resource industries to encourage minerals, petroleum and geothermal exploration. PIRSA also provides information for teachers, students, community groups and the general public.

Minerals and Energy Resources Division
Primary Industries and Resources South Australia (PIRSA)
7th Floor, 101 Grenfell Street
Adelaide, South Australia
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Tel: +61 8 8463 3000
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AngloGold Ashanti Ltd is one of the world's leading gold producers, with a varied portfolio of assets and orebody types in key gold-producing regions around the world. The company has 21 operations located in 10 countries (South Africa, Argentina, Australia, Brazil, Ghana, the Republic of Guinea, Mali, Namibia, Tanzania and the United States) on four continents, together with a substantial project pipeline and a focused, global exploration program. AngloGold Ashanti's in-house greenfields exploration is concentrated on advanced projects in Western Australia, Colombia and the Democratic Republic of Congo (DRC). The company also has exploration partnerships and joint ventures in Russia, China, Colombia, the Philippines and Laos. For future opportunities to join an organisation that will foster your career, and provide training, log on to: www.anglogold.com.au

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Tel: +61 8 9425 4600

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BHP Billiton is the world's largest diversified natural resources company. The company has approximately 41 000 employees working in more than 100 locations in 25 countries across the world. BHP Billiton Petroleum is a significant oil and gas exploration and production business with major producing assets in Australia, Algeria, Pakistan, Trinidad and Tobago, United Kingdom and the United States. BHP Billiton Petroleum conducts an international exploration and development program as well as marketing crude oil, condensate, liquefied petroleum gases, natural gas and liquefied natural gas to customers worldwide.

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Tel: +61 8 9338 4888

NEWMONT ASIA PACIFIC PTY LTD

Newmont Mining Corporation is a leading gold producer with operations on five continents and is also engaged in the exploration for and acquisition of gold properties in some of the world's best gold districts. It employs approximately 34 000 employees and contractors worldwide.

Newmont owns or has an interest in three Australian gold mining operations and is nearly finished with constructing the expanded Boddington gold mine 130 km southeast of Perth. The Kalgoorlie Consolidated Gold Mines (KCGM) Super-Pit at Kalgoorlie is 50 percent owned by Newmont, as part of a joint venture with Barrick Gold Corporation; Kalgoorlie Consolidated Gold Mines (KCGM) operates the mine. The Super Pit is the biggest gold open pit mine in the country and produces more than 25 tonnes of gold every year, far outweighing any other gold mining centre in Australia.

Level 1, 388 Hay Street
Subiaco, Western Australia
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Tel: +61 8 9423 6162

STUART PETROLEUM

Established in 1993 as a mineral exploration company, Stuart disposed of its mineral assets in 1999 and commenced activity as an oil and gas explorer in 2000 with its focus on the Cooper and Eromanga Basins in northern South Australia. Since then Stuart Petroleum has discovered and brought into production eight oilfields, reported profits in each year from 2003 to 2007, and in 2007 paid its third consecutive dividend.

The company has produced over 2.5 million barrels of oil and continues to add reserves through successful drilling. Production has generated cash for re-investment and payment of dividends while maintaining appropriate levels of liquidity. At present, apart from the Cooper and Eromanga Basins, it is exploring in the offshore Gippsland Basin in Victoria and the Vulcan Sub-Basin in the Timor Sea.

Level 7, 22 King William Street
Adelaide, South Australia
Tel: +61 8 8410 0611
Web: www.stuartpetroleum.com.au

OUTER-RIM EXPLORATION SERVICES PTY LTD

Outer-Rim Exploration Services has been providing reliable, professional, cost effective surface, underground and downhole EM surveys to the exploration and mining industry throughout Australia for more than thirteen years. ORE was the first to provide dependable three component DHEM surveys to Australia and the first to provide the new SQUID technology (using high temperature superconductors) to surface EM surveys, with the introduction of the CSIRO developed LANDTEM system. The LANDTEM now has an enviable record of exploration success in a relatively short time. For excellence in EM surveys, contact one of the ORE team at booth #52.

42 Vivian Street
Boulder, Western Australia
Tel: +61 8 9093 4400 (John More)
3 Katherine Street
Norman Park, Queensland
Tel: +61 7 3843 2922 (David Lemcke)
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Email: mail@outer-rim.com.au

VELSEIS PTY LTD

Velseis Pty Ltd is a highly experienced Australian seismic contractor, whose reputation is based upon 30 years of diverse operations throughout the Asia-Pacific region. Velseis offers fully integrated seismic services to the petroleum, coal and mineral industries.

The company's operations encompass seismic design, surveying, shot-hole drilling, data acquisition, processing and interpretation. The extensive experience of Velseis' key personnel ensures reliable and technically innovative solutions tailored to meet the needs of individual clients.

Velseis provides comprehensive seismic acquisition services, designed to accommodate geophysical, logistical, climatic, environmental and safety objectives. The company provides conventional 3D and 2D crews, utilising multi-component, heli-portable, and shallow marine recording.

In keeping with its full-service approach, Velseis provides a specialised shot-hole drilling service through its Seisdrill division and has recently purchased new Envirovibe units (light-weight Vibroseis buggies) which offer an alternative energy source for CSG and shallow petroleum targets. In addition, PT Velseis Indonesia provides comprehensive geophysical logging services in South East Asia.

Velseis is an industry leader in the processing of high-resolution seismic data, and is at the forefront of 3D seismic mine-planning imagery. Velseis also has an experienced oil and gas processing division, delivering high-quality 3D and 2D onshore, transition and marine seismic data processing services.

Velseis maintains its competitiveness with a proactive commitment to research and development. The R&D division engages in focussed research projects and provides technical support to production divisions.

Rob Wiens, Commercial Manager
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Tel: +61 7 3376 5544
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Other Sponsors

GEOFORCE

Geoforce Division of GroundProbe® provides high resolution subsurface information to reduce risk and maximise profit for our customers in the mining, infrastructure and environmental sectors.

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ORIGIN

Origin Energy is a major Australasian integrated energy company involved in gas and oil exploration and production, energy retailing and power generation. It holds significant producing assets, operates onshore processing facilities, and holds a portfolio of onshore and offshore exploration permits. Today Origin provides gas and electricity to more than 3 million homes and businesses across Australia, New Zealand and the Pacific.

John Oxley Centre
339 Coronation Drive
Milton, Queensland
Tel: +61 7 3858 0600
Web: www.originenergy.com.au

PETROSYS

Petrosys oil and gas mapping software gives you the power to create extraordinarily precise and meaningful maps by providing a unique combination of quality output, comprehensive mapping, 3D visualisation and surface modelling calculations so that you can effectively integrate data from the entire realm of seismic, well, engineering and economic systems involved in oil and gas exploration. There's simply nothing like it for speed, flexibility and accuracy.

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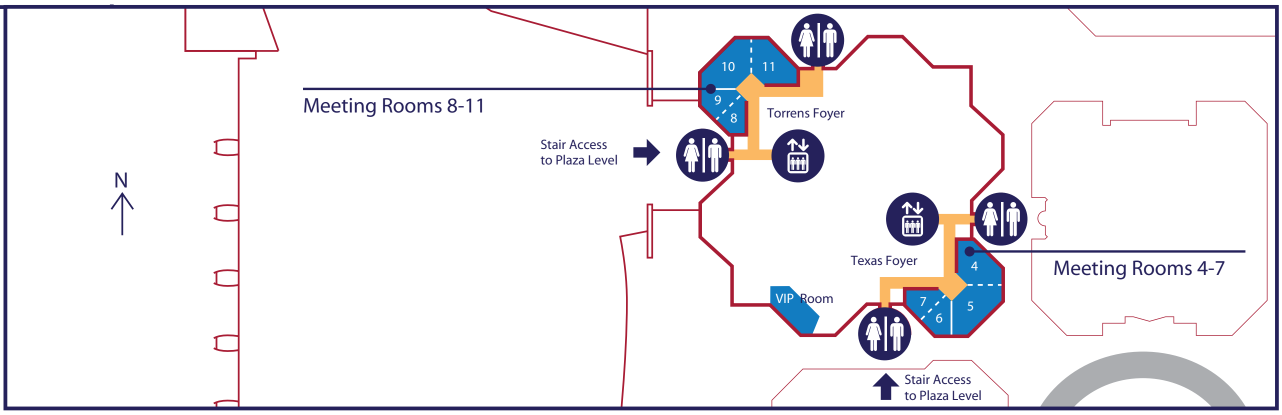
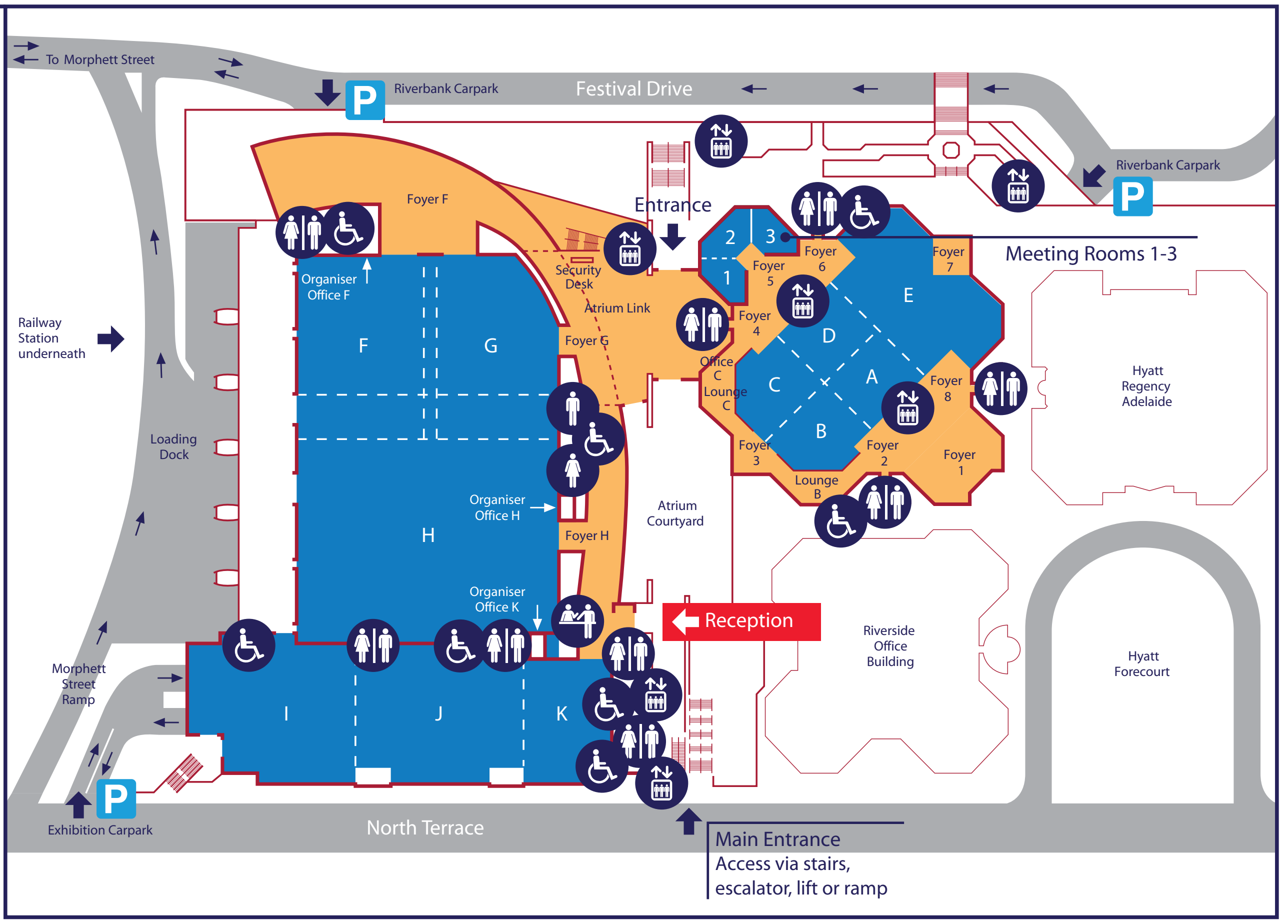
Perth, Western Australia
Web: www.petrosys.com.au
Tel: +61 8 9321 9299
Email: info@petrosys.com.au
Contact: Michael John Silva

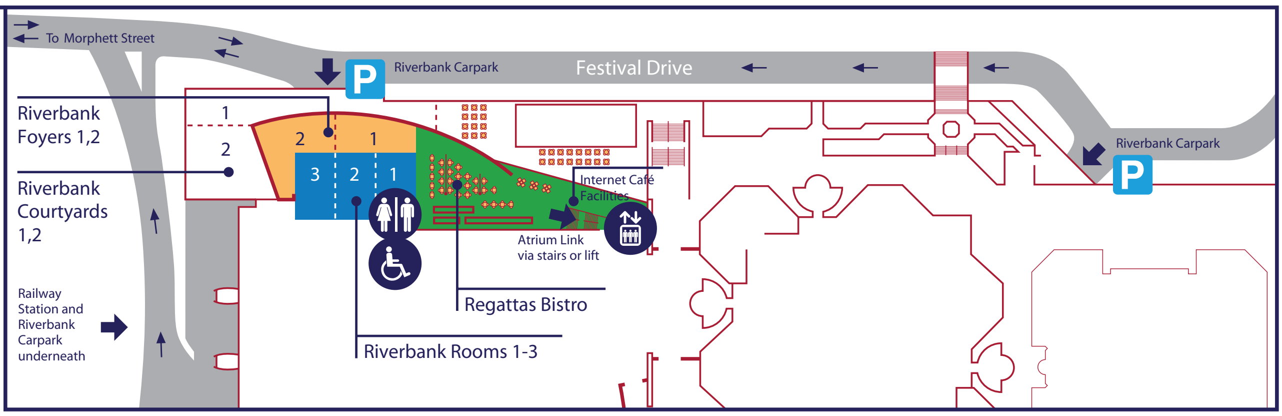
Level One



Plaza Level



Riverbank Level



Conference Venue

Adelaide Convention Centre
North Terrace
Adelaide 5000 Australia
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Fax: +61 (8) 8212 5101
Email: sales@adelaidecc.com.au
Website: http://www.adelaidecc.com.au/

Conference Secretariat

Sapro Conference Management
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Fax: +61 (8) 8352 7088
Email: admin@sapro.com.au
Website: www.sapro.com.au

Registration Desk

The registration desk will be located in the foyer of the Adelaide Convention Centre. The desk will open on Sunday 22 February 2009 from 2:30 pm to 6:30 pm. The desk will be open each day of the Conference from 8:15 am to 4:30 pm.

Conference Satchel

The Conference will offer a choice of two satchels for delegates. A quality vinyl bag suitable for laptops will be offered as standard. Delegates will have the option of upgrading to a larger satchel with wheels. It would be ideal as a "carry on" airline overnight case. The cost will be $25 per satchel. Please check out both options on the conference website in the 'Registration' section. Order your upgrade on the registration form.

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.

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.

Messages

Messages can be collected and left at the Conference Registration Desk. All messages will be posted on the message board adjacent to the desk. Please check the board regularly. No guarantee can be given to deliver messages personally. Please ensure your personal mail is sent to your accommodation address.

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 22 February 2009: 3:00 pm to 6:00 pm
Monday 23 February 2009: 7:30 am to 4:30 pm
Tuesday 24 February 2009: 7:30 am to 4:30 pm
Wednesday 25 February 2009: 8:00 am to 1:00 pm

Program Changes Board

All changes to the program will be displayed on the program changes board daily. The program changes board will be located near the conference registration desk.

Posters

Posters will be on display in the Exhibition Hall throughout Monday, Tuesday and Wednesday. The roster for poster presentations will be provided at the conference.

The Exhibition

The exhibition will be housed in Hall H. It will be open during the following times:

Sunday 22 February 2009: 6:00 pm to 7:30 pm
Monday 23 February 2009: 8:30 am to 6:00 pm
Tuesday 24 February 2009: 8:00 am to 6:00 pm
Wednesday 25 February 2009: 8:00 am to 3:00 pm

Delegates will be able to meet with exhibitors during the refreshment breaks provided.

Internet Café

A free Internet café for the convenience of delegates – proudly sponsored by Newmont – will be located in the Trade Exhibition Hall.

Catering

Morning & afternoon teas and lunches are included in the registration fees will be served in Hall G. Access is via the main entrance of the Trade Exhibition. Delegates with special dietary needs must advise the Conference Secretariat in writing via the registration form.

Car Parking

A number of car parks are located at or near the Adelaide Convention Centre. Earlybird fees are available although delegates should contact the individual car parks to confirm times and conditions.

Disclaimer

The 2009 International Geophysical Conference and Exhibition committee, including the conference organisers, accept no liability for injury of any nature sustained by delegates or partners, or for loss/damage to personal property as a result of the conference or associated events. The conference program is correct at the time of printing, though conference organisers hold the right to make necessary changes to programming. Receipt of delegate and partner registration acts as an acceptance of this disclaimer. Some scheduled events are subject to minimum numbers enrolling by a preset date, and we otherwise reserve the right to amend or cancel the proposed event.

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 Code

Conference Sessions: Smart casual
Evening Functions: Smart casual
Conference Dinner: Lounge suit/Cocktail dress

Climate

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

Airport

The Adelaide Airport is approximately 6 km from the Adelaide city centre. International and domestic passengers arrive and depart from the same terminal (T1). Skylink Airport shuttle provides a regular scheduled service between the Airport and the Adelaide CBD. The cost is A$8 each way: www.skylinkadelaide.com. Taxis and hire cars are also available.

Section 1

Conference Program

Pre-Conference Events

Workshops			
TBA	21–22 Feb. 2009	An Integrated Coalbed Methane Exploration Model: Defining Coal Seam Methane Sweetspots	Clare Room, Stamford Plaza Adelaide
09:00–17:00	21 Feb. 2009	Geophysics for Uranium Exploration	Terrace Room, Stamford Plaza Adelaide
09:00–16:00	22 Feb. 2009	Borehole Seismic Monitoring of Energy Reservoirs: Instrumentation, Installation, Interpretation, and Illustration	Mercure Grosvenor, Adelaide
08:00–17:00	22 Feb. 2009	EM in Africa Workshop	Sebel Playford Hotel
09:00–16:30	22 Feb. 2009	Developing Geophysical Skills in Australia – What are the Opportunities and Future Prospects?	Adelaide Convention Centre
Field Trip			
09:00–17:00	22 Feb. 2009	Geology of McLaren Vale	Depart Adelaide Convention Centre

Monday 23 February 2009

	TIME	STREAM 1		STREAM 2		STREAM 3		STREAM 4		STREAM 5	
Day 1 Session 1	8:45	Co–Chairs – **Andrew Shearer and Tony Hill**									
	8:55	ASEG Federal President, Peter Elliott									
	9:00	Premier of South Australia, Hon. Mike Rann									
	9:15	Plenary Session 1 Natural Gas: Australia's energy advantage – **David Knox, *Santos***									
	9:45	Plenary Session 2 The role of geophysics in mineral deposit discovery – a Rio Tinto perspective – **Stephen McIntosh, *Rio Tinto***									
	10:30	**Morning Tea**									
Day 1 Session 2		**Petroleum - Seismic imaging, depth migration & depth conversion**		**Minerals: Integrated Inversion**		**Geothermal Geophysics I**		**Minerals – Case Studies I**		**Minerals – Regional Scale Geophysics (New South Wales) Mike Dentith**	
	Venue: Chair:	Hall A Dennis Cooke		Hall C		Hall B Richard Hillis		Hall D David McInnes		Meeting Room 1	
	11:00	Using numerical models to aid in the seismic imaging of complex geological structures	John Bancroft, H. Moubarak & D. Lawton	Using a 3D geological mapping framework to integrate AEM, gravity and magnetic modelling – San Nicolas case history	Richard Lane, P. McInerney & R. Seikel	**Keynote Address Peter Malin *Joint geophysical imaging for fractured reservoirs***		Carrapateena: physical properties of a new iron-oxide copper-gold deposit	Lisa Vella & D Emerson	Carboniferous–Permian? Volcanic plugs in the Balranald region, NSW	Astrid Carlton
	11:30	Beam migration for imaging of complex geology	K. Schleicher, J. Sherwood, L. Comeaux & Mazin Farouki	Integrating geological and geophysical data through advanced constrained inversions	Peter Lelièvre, D. Oldenburg & N. Williams	Hot rocks in Australia - National overview	Barry Goldstein, A. Hill & A. Long	Review of the Jaguar Cu-Zn-Ag volcanogenic massive sulphide discovery and subsequent geophysical trials; a true blind geophysical discovery beneath a deep conductive overburden.	Nigel Cantwell, M. Cooper, J. Meyers, N. Martin & R. Sainty	Thomson Orogen – development of an integrated geological/ geophysical interpretation	David Robson, D. Glen, N. Vickery, J. Watkins & M. Faunde
	12:00	Velocity-less imaging of linearly inhomogeneous media in 3D	Andrej Bona & D. Cooke	Joint inversion of gravity and magnetotelluric data	Rachel Maier, G. Heinson, M. Tingay and S. Greenhalgh	In search of hot buried granites: a 3D map of sub-sediment granitic bodies in the Cooper Basin region of Australia, generated from inversions of gravity data.	Tony Meixner & F. Holgate	Towards direct detection of gold bearing rock formations from seismic data, St. Ives gold camp, Western Australia	Milovan Urosevic & C. Harrison	Geophysical evidence for 'blind' magmatism associated with Devonian rifting, Lachlan Orogen, New South Wales	Yvette Poudjom Djomani & R.A. Glen
	12:30	**Lunch**									

Monday 23 February 2009

Day 1 Session 3

TIME	STREAM 1		STREAM 2		STREAM 3		STREAM 4		STREAM 5	
	Petroleum – Seismic Acquisition and the Environment		**Petroleum – Seismic Processing & Modelling**		**Geothermal Geophysics II**		**Minerals – Comparisons of AEM Systems**		**Minerals – Potential Fields Inversion**	
Venue: Chair:	Hall A Doug Roberts		Hall C John Bourne		Hall B Tony Hill		Hall D Richard Lane		Meeting Room 1 Phil Heath	
13:30	**Keynote Address** **John Hughes** ***Seismic surveys and marine life: why is it so difficult to let the science speak?***		Shallow water 3D surface-related multiple modelling an Australian waters case study	Pierre Plasterie, M. Gayne, M. Lange, I. Sarjono, A. Pica, R. Bril, C. Faulkner & C. Mosher	Imaging a potential geothermal target using Mt Isa regional seismic reflection and potential field geophysics, Queensland, Australia	Josef Holzschuh	An overview of Helicopter Time-Domain EM systems	Daniel Sattel	Pareto optimal 2D joint inversion of gravity and magnetic data	Indrajit Roy
14:00	Lower impact seismic reflection– trialling envirovibes in the Surat Basin	Mathew Dorling, R. Taylor & S. Hearn	Transient solution for viscoacoustic wave propagation in a double porosity medium, and its limitations	Xu Liu, S. Greenhalgh & B. Zhou	Forward prediction of spatial temperature variation from 3D geology models	Ray Siekel, K. Stuwe, H. Gibson, B. Bendall, L. McAllister, P.Reid & A. Budd	Examples showing characteristics of the MEGATEM airborne electromagnetic system	Richard Smith & J. Lemieux	Maximising geological information recovery from different magnetic instruments through the application of joint inversion	David Pratt & B. McKenzie
14:30	Minimal-impact seismic acquisition: successful imaging using an accelerated weight drop system	Natasha Hendrick, N. Yassi & T. Visser	Time series prediction using iterative phase estimation	James Leven	Innovative geophysics and the green revolution	Tim Pugh	Results of various airborne EM systems over a target of high conductance	Ken Witherly	An automated sparse constraint model builder for UBC–GIF gravity and magnetic inversions	Nicholas Williams
15:00	**Afternoon Tea**									

Monday 23 February 2009

Day 1 Session 4

TIME	STREAM 1		STREAM 2		STREAM 3		STREAM 4		STREAM 5	
	Petroleum - Interpretation/Case Histories		Minerals - Case Studies II		Environmental - AEM		Minerals - Advances in EM Technology		Minerals - Airborne Geophysical Techniques (non electrical)	
Venue: Chair:	Hall A Luke Gardiner		Hall C Andrew Thompson		Hall B Ken Lawrie		Hall D Kim Frankcombe		Meeting Room 1 Terry Crabb	
15:30	5 popular pitfalls in seismic amplitude interpretation	Jarrod Dunne	Application of geophysics to gold exploration in Ghana: examples from Newmont projects.	Thomas Tsiboah & T. Grant	From little things, big things grow…. or do they? a one-eyed view on airborne EM in environmental management over the last 20 years.	Tim Munday	Monitoring current waveform of the SeaTEM system	A. Davis, James. Macnae, J. Vrbancich & R. Smith	Interpreting gamma radiometrics in the NT	Roger Clifton
16:00	Integrated dip data, seismic and potential field data interpretation for fault analysis of the Elk/Antelope gas field.	Adrian Goldberg	3D IP and resistivity for nickel exploration: case study from Western Australia	Eric Battig, R. Mortimerm & R. Porter	Spatial modelling incorporating AEM data to show the effects of manipulating flow regimes and groundwater lowering options over the Chowilla floodplain, SA	Tim Munday, I. Overton, A. Fitzpatrick, K.P. Tan & Z. Marsden	Extracting more information from on-time data	Sean Walker & J. Rudd	VK-1 – a new generation airborne gravity gradiometer	J. Anstie, T. Aravanis, M. Haederle, A. Mann, Stephen. McIntosh, R. Smith, F. Van Kann, G. Wells & J. Winterflood
16:30	Geophysical studies of Australia's remote eastern deep-water frontier: results from the Capel and Faust Basins	Ron Hackney, P. Petkovic, R. Hashimoto, K. Higgins, G. Logan, G. Bernardel, J. Colwell, N. Rollet & M. Morse	Deep exploration technologies for illuminating highly prospective ground in the shadow of headframes	Greg Hollyer & R. Gordon	Investigation on the groundwater resources of the South Eyre Peninsula, South Australia, determined from spatially constrained inversion of tempest data.	Esben Auken, A. Christiansen, A. Viezzoli, A. Fitzpatrick, K. Cahill, T. Munday & V. Berens	Z-TEM (airborne AFMAG) tests over unconformity uranium deposits	Bob Lo, J. Legault & P. Kuzmin	Further developments with full tensor gradiometry datasets	Desmond Fitzgerald, D. Argast & H. Holstein
17:00			Results from the first field trial of a borehole gravity meter for mining applications	H. O. Seigel, Chris Nind, J. MacQueen, M. Chouteau & B. Giroux	Utilizing airborne electromagnetic (EM) data, high resolution DEM and hydrogeological information to derive customised products for natural resource management along the River Murray corridor	KokPiang Tan, L. Halas, C. Pain, K. Lawrie, J. Clarke, H. Apps, K. Cullen & D. Gibson	Significantly increasing TEM survey performance by modifying frequency content of transmitter waveform	Andrew Duncan & N. Dorn		
17:30	Happy Hour – Sponsored by Woodside									

Tuesday 24 February 2009

	TIME	STREAM 1		STREAM 2		STREAM 3		STREAM 4	
Day 2 Session 1		**Petroleum – Modelling and Inversion**		**Petroleum - Reservoir stress paths/fracture characterisation**		**Minerals - AEM Modelling and Inversion**		**Minerals - Continent Scale Geophysics**	
	Venue: Chair:	Hall A Danny Burns		Hall C Terry Barr		Hall B John Paine		Hall D David Denham	
	8:30	Extracting detailed lithology from seismic data	Kevin Jarvis & D. Saussus	Reducing structural uncertainty in seismic interpretation by mapping wall-rock strains to get a plausible geological model - the strain minimisation approach	Peter Boult, B. Freeman, G. Yielding & S. Menpes	**Keynote Address** **Max A. Meju** **Joint 3D interpretation of electromagnetic and seismic data: Challenges and the way forward**		The radiometric map of Australia	Brian Minty, R. Franklin, P. Milligan, M. Richardson & J. Wilford
	9:00	Understanding near-surface velocity effects using physical models	Brian Evans & R. Greaves	Spectral decomposition of 3D megasurvey for definition of hydrocarbon remigration systems and prediction of traps integrity	Laurent Langhi	Base level (drift) estimation for frequency domain HEM data using causality	James Macnae & R. Springall	The Australia-wide airborne geophysical survey – accurate continental magnetic coverage	Peter Milligan, B. Minty, M. Richardson & R. Franklin
	9:30	3D traveltime inversion of induced micro-seismic events to construct a detailed velocity model	Abdullah Al Ramadhan & B. Hartley	State and origin of present-day stress fields in sedimentary basins	Mark Tingay	Fast approximate inversion of SkyTem airborne electromagnetic data	Niels Christensen, J. Reid & M. Halkjaar	Acquiring high resolution airborne geophysical data and recognition of new mineral exploration potential as part of a development program launched by the South African government	Detlef Eberle, P. Cole & P Nyabeze
	10:00			Mechanostratigraphic control on carbonate fractured reservoir evaluation: a PNG case study	O'Karo Yogi & A. Goldberg	Fast approximate inversion of FDHEM data	Niels Christensen, A. Fitzpatrick & T. Munday	Airborne geophysics as a tool to promote mineral investment in Africa	Stephen Reford, K. Kwan, J. Nyakaana, A. Katumwehe & O. Wane
	10:30	**Morning Tea**							
Day 2 Session 2		**Petroleum - Seismic Acquisition**		**Petroleum - EM**		**Minerals - EM Case Studies**		**Minerals - Geophysical Concepts and Applications**	
	Venue: Chair:	Hall A Malcolm Horton		Hall C Jenni Clifford		Hall B Kim Frankcombe		Hall D Terry Crabb	
	11:00	Assessing the repeatability of reflection seismic data in the presence of complex near-surface conditions CO_2CRC Otway Project, Victoria, Australia	Youseuf Al Jabri, M. Urposevic, A. Kepic & B. Evans	**Keynote Address** **Lucy MacGregor** **Integration of Geophysical data: Wells, Seismic and Electromagnetics**		A case study of deep electromagnetic exploration in conductive cover	Michael Webb & B. Corscadden	New data and ideas for energy exploration in Australia	Ned Stolz
	11:30	Signal resolution and penetration from dual-sensor streamer data on the NW shelf of Australia	Andrew Long, D. Mellors, T. Allen & A. McIntyre	Airborne - EM hydrocarbon mapping in Mozambique	Andreas Pfaffling, S. Monstad, R. Groom & J. Rudd	Greenfield nickel exploration using airborne and ground EM techniques in the Eastern Arunta Region, NT	Andrew Thompson & J. McKinnon-Matthews	Geological mapping and target definition to depth through the application of distributed electrical deep earth imaging and the integration of geological information	Rob Gordon
	12:00	Geoscience Australia's southwest margin geophysical surveys	Edward Bowen & B. Bradshaw	The effect of resistivity anisotropy on earth impulse responses	Bruce Hobbs, D. Werthmüller & F. Engelmark				
	12:30	**Lunch – Sponsored by CGGVeritas**							

Tuesday 24 February 2009

Session	TIME	STREAM 1		STREAM 2		STREAM 3		STREAM 4	
Day 2 Session 3		**Petroleum - Seismic Acquisition**		**Minerals and Coal Seismic**		**Minerals - AEM Inversion**		**Environmental - Groundwater**	
	Venue: Chair:	Hall A Dave Cockshell		Hall C Greg Turner		Hall B John Paine		Hall D Andrew Fitzpatrick	
	13:30	**Keynote Address** **Craig Beasley** **New Developments in Seismic Acquisition**		Feasibility of the application of borehole seismology for hard rock exploration	Andrew Greenwood, M. Urosevic & A. Kepic	Application of a holistic inversion method in salinity risk and groundwater resource mapping in the River Murray corridor, SE Australia	Ken Lawrie, R. Brodie, K.P. Tan, L. Halas, D. Gibson, J. Clarke, C. Apps & K. Cullen	Groundwater recharge investigation using towed imaging devices	David Allen
	14:00	Bookabourdie Q-land* 3D proof of concept study; mapping sand thickness and sand quality in the Cooper Basin	Tim Bunting, M. Bayly, M. Tham, P. McBride, M. Daly & F. Barclay	Sub-basalt coal seam structure imaging – results from numerical modelling	Weijia Sun & B. Zhou	Holistic inversion of time domain AEM data	Ross Brodie & M. Sambridge	Improvements in mapping of floodplain dynamics by integrating drilling information with airborne EM, ground penetrating radar and ground based, high resolution EM	Michael Hatch, J. Clarke, K. Lawrie& P. Mill
	14:30	Results of a 3D hi-resolution vibroseis acquisition trial in the Cooper Basin	Stuart Brew, K. Driml, P. Gatley, F. Nicholson & S. Tobin	Azimuthal imaging challenges in coal-scale 3D multi-component seismic reflection	Shaun Strong & S. Hearn	A single software for processing, inversion, and presentation of AEM data of different systems: the Aarhus Workbench	Esben Auken, A. Viezzoli & A. Christensen	An integrated geostrategy for mapping of structures favourable to ground water occurrence – a case study	Narasimman Sundararajan, Mubarak Ali & M. N. Chary
	15:00	**Afternoon Tea**							
Day 2 Session 4		**Petroleum - Reservoir Characterisation & Rock Properties**		**Hydrogeophysics - AEM**		**General Interest - Big Picture Geophysics**		**Near Surface - Engineering Geophysics**	
	Venue: Chair:	Hall A Peter Boult		Hall C James Macnae		Hall B Shanti Rajagopalan		Hall D Michael Asten	
	15:30	Successful fluid discrimination in tight, overpressured reservoirs using AVO inversion	Jan Rindschwentner & K. Jarvis	Mineral and groundwater exploration with the SkyTEM system	Niels Christensen, M. Halkjaer & K. Sorensen	Modelling the effects of ocean and sediments on electromagnetic fields, example from the Gawler Craton, South Australia	Stephen Thiel & G. Heinson	Application of geophysics to underground space development for improvement of urban environments	Robert Whiteley
	16:00	Velocity-saturation relation transition during rocks saturation: direct laboratory observation by computer tomography and ultrasonic technique	Maxim Lebedev, B. Gurevich, B. Clenell, M. Pervukhina, V. Shulakova & T. Müller	Utilizing airborne electromagnetic data to map groundwater salinity and salt store at Chowilla, SA	KokPiang Tan, T. Munday, L. Halas & K. Cahill	Geophysical modelling of the Gawler Craton, SA - interpreting geophysics with geology	Philip Heath, T. Dhu, G. Reed & M. Fairclough	3D treatment of MASW data for monitoring ground improvement at an uncontrolled fill site	Koya Suto & B. Scott
	16:30	Quantitative characterization of hydrocarbon reservoir by means of seismic rock physics analysis: an integrated approach among seismic data, seismic rock physics of well-log and core measurement	Bagus Nurhandoko, M. Choliq, K. Triyoso, I. Soemantri, S. Praptono & M. Nurcahyo	Constrained inversion of AEM data for mapping of bathymetry, seabed sediments and aquifers	Andrea Viezzoli, E. Auken & A. Christiansen	Some issues and insights for gravity and magnetic modelling at the region to continent scale	Richard Lane	Multichannel analysis of surface waves for bedrock depth estimation over granites, Hyderabad, India	Narasimman Sundararajan, Ali Al Lazki & Seshunarayana
	17:00	3D Microanalysis of geological samples with nanofocus computed tomography	Thomas Paul, G. Zacher & O. Brunke	Development of a helicopter time domain system for bathymetric mapping and seafloor characterisation in shallow water	Julian Vrbancich & R. Smith	An extension of the closed-form solution for the gravity curvature (Bullard B) correction in the marine and airborne cases	Dominik Argast, M. Bacchin & R. Tracey	Shaft sinking risk analysis through the integration of borehole radar and acoustic televiewer data in deep geotechnical boreholes	Kazek Trofimczy, Petro Du Pisani & S. Coomber
	17:30	**Happy Hour – Sponsored by Rio Tinto**							

Wednesday 25 February 2009

	TIME	STREAM 1		STREAM 2		STREAM 3		STREAM 4	
Day 3 Session 1		Petroleum - Seismic acquisition		Minerals - Crustal & Solid Earth Geophysics		Minerals - Case Studies, AEM		Minerals - Potential Fields, Mineral Exploration	
	Venue: Chair:	Hall A Rod Lovibond		Hall C Graham Heinson		Hall B Michael Asten		Hall D Lisa Vella	
	9:00			Geophysical dataset integration of the vredefort dome, South Africa	Duncan Cowan & G. Cooper	Comparison of ground TEM and VTEM responses over kimberlites in the Kalahari of Botswana	Ed Cunion	Querying potential field inversions for signatures of chemical alteration: an example from Cobar, NSW	Richard Chopping & S. van der Wielen
	9:30	The role of in-field seismic processing in early evaluation in under-explored areas of the Darling Basin	Leonie Jones	Coherence between teleseismic tomography and long-wavelength features of the gravity and magnetic fields of southeastern Australia	Robert Musgrave & N. Rawlinson	Base metal discoveries in Africa and Australia from VTEM data	Magdel Combrinck, R. Mortimer & B. Peters	Constrained potential field inversions in areas under cover: examples from Gawler Craton IOCG prospects	Brendan Howe
	10:00	Towards cost-effective permanent seismic reservoir monitoring	Natasha Hendrick, M. Farouki, S. Mass & B. Bunn	Geophysically imaging Paleoproterozoic terrane boundaries in the unexposed northern Gawler Craton, Marla region	Graham Baines, D. Giles, P. Betts & G. Backe	Case histories illustrating the characteristics of the HeliGEOTEM system	Richard Smith, J. Lemieux & G. Hodges	Constraining gravity and magnetics inversions for mineral exploration using limited geological data	Nicholas Williams, D. Oldenberg & P. Lelievre
	10:30	Morning Tea							
Day 3 Session 2		Petroleum - Seismic Anisotropy		Minerals - Hyperspectral Mapping		Minerals - African Geophysics, AEM		Minerals - Potential Fields, Advances In Processing	
	Venue: Chair:	Hall A Mark Tingay		Hall C		Hall B Lisa Vella		Hall D	
	11:00	An Equivalent Offset time migration for anisotropic data	John Bancroft & P. Elapavuluri	Mineral and compositional mapping using airborne hyperspectral and geophysical products, North Queensland	Rob Hewson, T. Cudahy, M. Jones, M. Thomas, C. Laukamp & F. Agustin	VTEM response of the Tusker gold deposit, Tanzania	Karen Pittard & B. Bourne	Terracing potential field data	Gordon Cooper & D. Cowan
	11:30	Improving seismic anisotropy estimation by multi directional residual curvature analysis.	Sergey Birdus & L. Li	Mapping regional alteration patterns in the Curnamona Province using hyperspectral core scanning technology	Alan Mauger	Geophysical response of the Munali Ni-Cu deposit, Zambia	Ken Witherly	Enhancement of lamproite magnetic signatures	Duncan Cowan & G. Cooper
	12:00	Nonlinear estimation of Thomsen anisotropy parameters in TI media	Dariush Nadri, A. Bona & M. Urosevic	Acid sulphate soil mapping with hyperspectral imagery at South Yunderup, Western Australia	Ian Lau & M. Verrall	the application of airborne geophysics in the exploration for iron ore in the Zouerat area of Mauritania	Willem Botha & Mohamed Elhacen Ould Med Yeslem	Strategies to invert a suite of magnetic field anomalies due to remanent magnetization: an example from the Georgetown area of Queensland	Clive Foss & B. McKenzie
	12:30	Lunch							

Wednesday 25 February 2009

	Time	STREAM 1		STREAM 2		STREAM 3		STREAM 4	
Day 3 Session 3		Petroleum - Seismic processing		Minerals - Electrical Geophysics Concepts		Minerals - AEM Mapping		Minerals - Electrical and EM Geophysics	
	Venue: Chair:	Hall A Stuart Brew		Hall C Todd Grant		Hall B David McInnes		Hall D Michael Hatch	
	13:30	Revisiting the Vibroseis wavelet	Shaun Strong & S. Hearn	SPM and airborne EM	Paul Mutton & R. Mortimer	Airborne electromagnetic survey results from the Paterson Province, WA	Camilla Sorensen, A. Fisher & M. Costelloe	DC resistivity Frechet derivatives for a uniform anisotropic medium with a tilted axis of symmetry	Tim Wiese, S. Greenhalgh, B. Zhou, L. Marescot & M. Greenhalgh
	14:00	Using modern processing technology to improve signal to noise ratio, a Perth basin 3D land case study.	Pierre Plasterie & N. Mudge	Use of principal component images for classification of the EM response of unexploded ordnance	Michael Asten	Structural mapping under cover with airborne EM	Chris Wijns	Fast approximate 3D inversion of ground TEM data utilising the concept of magnetic moments.	Ralf Schaa & P. Fullager
	14:30	Practical issues of reverse time migration: true amplitude gathers, noise removal and harmonic-source encoding	James Sun & Y. Zhang	A revised mathematical formulation for induced polarization	Andrea Viezzoli	The AeroTEM system in Africa	Jonathan Rudd & S. Walker	DC resistivity modelling in anisotropic media with Gaussian quadrature grids	Mark Greenhalgh, B. Zhou & S. Greenhalgh
	15:00	Afternoon Tea							
Day 3 Session 4		Petroleum - Seismic processing		Petroleum - Gravity & Magnetics		Near Surface - Micro Earthquakes			
	Venue: Chair:	Hall A Phil McBride		Hall C Said Amri-Besheli		Hall B Koya Suto			
	15:30	Interpolating a 2D acquisition into a 3D using a Fourier reconstruction method	Pierre Plasterie, Y. Jacquot, S. Irvine, G. Poole, T. Martin, V. Lendzionowski & A. Davies	Basement constraints on offshore basin architecture as determined by new aeromagnetic data acquired over Bass Strait and western margin of Tasmania	Michael Morse, G. Gibson & C. Mitchell	An elastic properties computation to predict 4D seismic effects for CO2 sequestration – a methodology	Putri Wisman & Milovan Urosevic		
	16:00	3D tomographic amplitude inversion for compensating amplitude attenuation	Kefeng Xin, B. Hung, S. Birdus & J. Sun			Microtremor observations in Tamar Valley, Launceston, Tasmania: evidence of 2D resonance from observed microtremor and numerical modelling	Maxime Claprood & M. Asten		
	16:30	Conference Close							
	17:00	Happy Hour and Closing Drinks – Sponsored by Shell							

Post-Conference Events

Workshops			
09:00–17:00	26 Feb. 2009	A Short Course in Magnetotelluric (MT) Methodology	University Club, Adelaide University
09:00–17:00	26 Feb. 2009	Alteration Mapping in the Virtual Core Library – Semi-quantitative Mineralogy for Geophysicists using HyLogging	PIRSA, Grenfell Street
09:00–16:00	26 Feb. 2009	Constrained Inversion and Presentation of AEM Data of Different System with the Aarhus Workbench	Holiday Inn Adelaide
09:00–17:00	26 Feb. 2009	2009 SEG Distinguished Instructor Short Course Petroleum Engineering: Integration of Static and Dynamic Models – Dr Patrick Corbett, Heriot-Watt University	Mawson Lecture Theatre, Mawson Bldg (Geology Dept), University of Adelaide Campus
Field Trip			
TBA	26 Feb. – 4 Mar. 2009	Australian Uranium Deposits	TBA

Committee	Date	Time	Catering	Room	Contact	Email
Membership Committee	Sunday 22/02/2009	12:30–13:30	Light lunch	Meeting Room 3 – Ground Floor	Emma Brand & Cameron Hamilton	emma.brand@mun.ca; cameron.hamilton@origonenergy.com.au
ASEG Council Meeting	Sunday 22/02/2009	14:00–17:00	Tea & Coffee Light afternoon tea	Meeting Room 3 – Ground Floor	Louise Middleton	louise@casm.com.au
Technical Standards Committee	Monday 23/02/2009	12:30–13:30	Light lunch	Meeting Room 3 – Ground Floor	Dave Robson	david.robson@dpi.nsw.gov.au
Website Training Session	Monday 23/02/2009	12:30–13:30	Light lunch	Meeting Room 10 – Level 1	Wayne Stasinowsky	wayne.stasinowsky@encom.com.au
International Affairs Committee	Monday 23/02/09	12:30–13:30	Light lunch	Meeting Room 7 Level 1	Koya Suto	koyasuto@optusnet.com.au
International Affairs – Inter-Society Luncheon	Tuesday 24/02/2009	12:30–13:30	Light lunch	Meeting Room 3 – Ground Floor	Koya Suto	koyasuto@optusnet.com.au
COC Sponsors/Exhibitors meeting	Tuesday 24/02/2009	07:30–08:30	Breakfast	Meeting Room 3 – Ground Floor	Doug Roberts	doug.roberts@beachpetroleum.com.au
Research Foundation	Tuesday 24/02/2009	12:30–13:30	Light Lunch	Meeting Room 10 – Level 1	Phil Harman	phil.harman@gravitydiamonds.com.au
Education Committee	Wednesday 25/02/09	12:30–13:30	Light lunch	Meeting Room 4 Level 1	Milovan Urosevich	m.urosevic@curtin.edu.au
Publication Committee	Wednesday 25/02/2009	12:30–13:30	Light lunch	Meeting Room 3 – Ground Floor	Phil Schmidt	phil.schmidt.@csiro.au
Conference Advisory Committee	Wednesday 25/02/2009	12:30–13:30	Light lunch	Meeting Room 10 – Level 1	Mike Hatch	michael.hatch@adelaide.edu.au

Sunday 22 February 2009

6–8 pm **Ice-breaker Reception**
Proudly sponsored by Santos
Adelaide Convention Centre (Hall H)
Please join us for a unique opportunity to renew old acquaintances and develop some new business relationships in a relaxing environment.
Cost included with full registration
Additional tickets $44 per person

Monday 23 February 2009

5–6 pm **Happy Hour**
Sponsored by Woodside
After completing the first day of sessions, unwind with a drink in the exhibition area to complete the day.
Cost included with full registration
Additional tickets $25 per person

5.45 pm **Geology of North Terrace**
Join a couple of local geoscientists for a self-funded walk with a difference. The late afternoon walk (and pub-crawl) along North Terrace provides the chance to discuss a little geology, visit a couple of hotels and chat with friends and new acquaintances. Many of the public and commercial buildings along the Terrace are constructed from a range of local, Australian and overseas dimension stones. Nick Lemon, with the assistance of local organising committee members, will lead the tour.
Those interested should assemble at the registration desk at 5.45 pm.
Approx. time 1.5 hours

Tuesday 24 February 2009

5–6 pm **Happy Hour**
Sponsored by Rio Tinto
Adelaide Convention Centre (Hall H)
Cost included with full registration
Additional tickets $25 per person

7 pm **Conference Gala Dinner**
Sponsored by Beach Petroleum
Stamford Grand Hotel, Glenelg
After a drink at Happy Hour, we invite you to join us for an unforgettable evening at The Stamford Grand Hotel, Glenelg. Situated on one of Adelaide's most famous beaches, The Stamford Grand stands out not only for its location, but also its hospitality. Enjoy the complete experience and travel to and from Glenelg on one of Adelaide's famous trams, specially chartered for ASEG delegates. An exquisite three course dinner including local beverages will be complimented by entertainment from Rod Quantock, one of Australia's best comedians.
Tickets $99 per person (limited numbers apply)

Wednesday 25 February 2009

5–6 pm **Closing Drinks**
Sponsored by Shell
To conclude the 20th International Geophysical Conference & Exhibition, attend the farewell reception in the foyer, with stunning views of the River Torrens and city lights.
Cost included with full registration
Additional tickets $25 per person

Friday 27 February 2009

10 am onwards **PESA/SPE Golf Day at Flagstaff Hill Golf Course**
An all day event starting at 10 am for check in and shotgun start at 11 am. The golf is followed by an evening dinner.
Entry fee covers green fees, on-course lunch and refreshments, pre-dinner drinks and dinner.
Please note that these charges apply to all participants regardless of membership affiliation. $75 for SPE/PESA/ASEG members. $100 for non-members.
$40 for attendance at the dinner only. Limited numbers. Bookings only via the SPE website: http://southaustralia.spe.org.

WOODSIDE

As Australia's largest liquefied natural gas producer, **Woodside** is playing a significant role in meeting the world's growing clean energy needs.

Woodside is an Australian oil and gas company with a global perspective on energy supply.

Based in Perth, we have major operational assets and exploration and development interests in Australia and overseas.

We are Australia's largest publicly traded oil and gas exploration and production company, traded on the Australian Securities Exchange.

With an impressive portfolio of LNG projects and planned developments, Woodside is poised to help meet growing global demand for clean energy.

Our goal is to be a global leader in LNG production, with demand for LNG exceeding supply until at least 2020.

We operate the North West Shelf Venture, the fourth biggest LNG producer in the world.

Our LNG production capacity will increase significantly from the end of 2010 with first gas from our $12 billion Pluto LNG Project.

We offer a dynamic and challenging work environment, extending from our world-class Australian LNG operations, to major oil producing facilities and international exploration, development and construction projects.

Woodside is committed to excellence in health and safety, reducing its environmental footprint, and sustainable development which benefits the communities in which we operate.



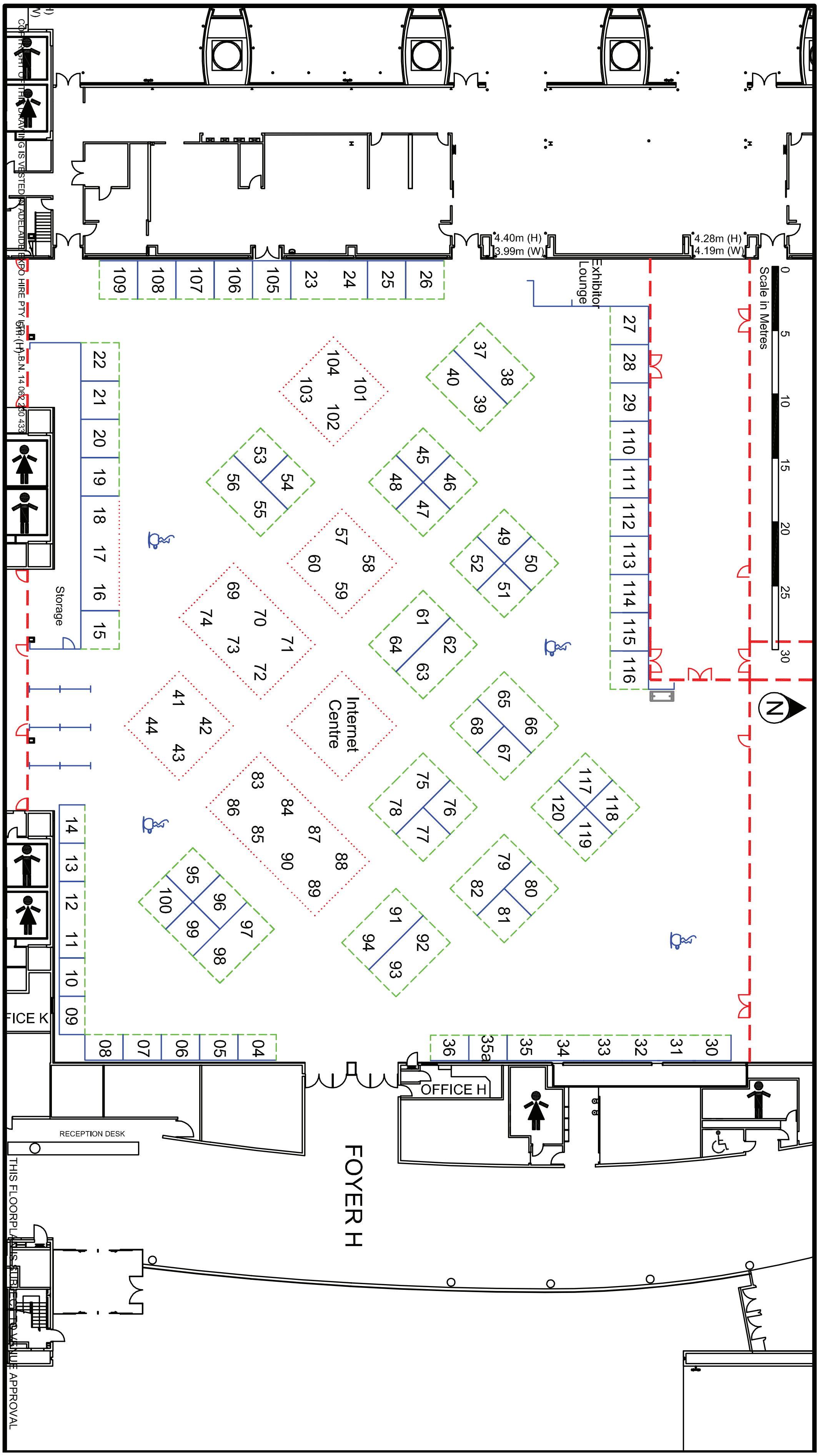




www.woodside.com.au

SECTION 2

EXHIBITION



FOYER H
OFFICE H
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Exhibitor Lounge
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Internet Centre
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4.28m (H) 4.19m (W)
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Advanced Logic Technology	105
Alpha Geoscience	27
Archimedes Financial Planning Pty Ltd	77
ASEG	110
Australian School of Petroleum	19
Barrick Gold (Silver Sponsor)	**26**
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Company	Stand
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Wavefield Inseis Australia Pty Ltd	6
WesternGeco (Gold Sponsor)	**83–87**
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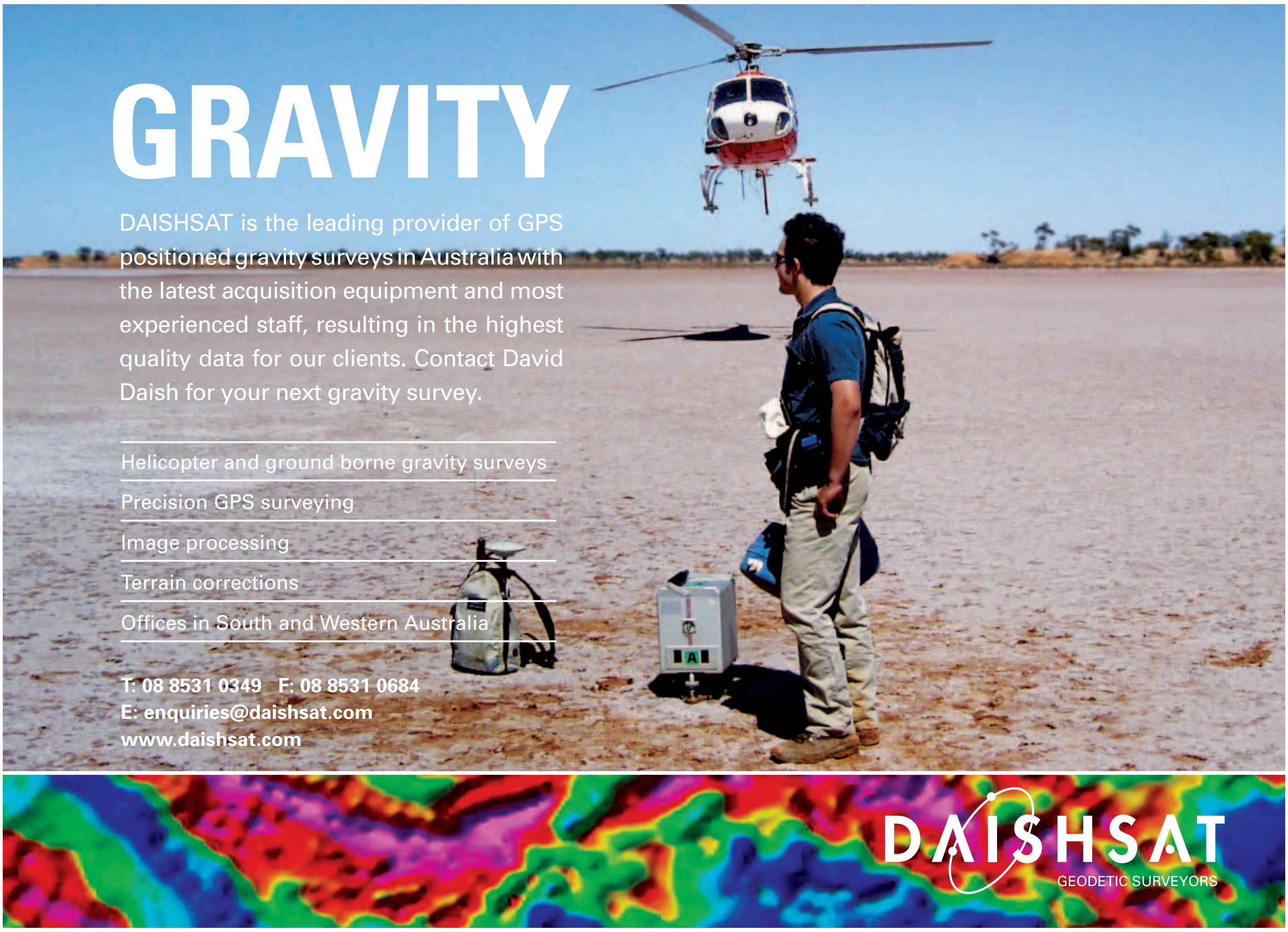
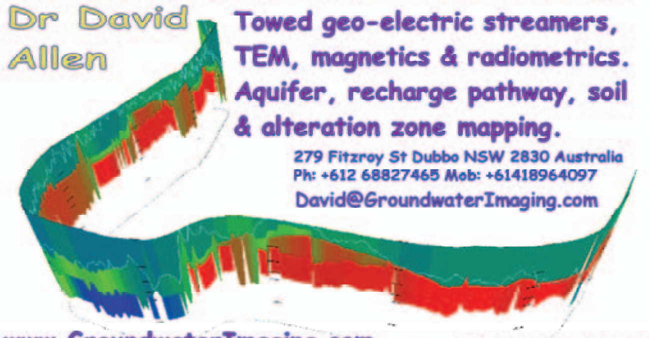



The Crone PEM System


LANDTEM "Squid" Survey



AARHUS GEOPHYSICS Stand 99

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Email: info@aarhusgeo.com
Website: www.aarhusgeo.com
Contact: Andrea Viezzoli, Manager

Aarhus Geophysics provides software and know-how for large scale AEM, EM and DC surveys. Our GIS integrated software, the Aarhus Workbench, is the state of the art for the processing and inversion of large scale AEM datasets for groundwater/hydrogeophysical applications. It is used worldwide by organisations such as CSIRO, USGS, BGS, GGA, and others to process data from different systems, both time and frequency domain. If you just want the results, we can process your AEM data, from virtually any system. We can also help you plan the survey before writing the tender. We also offer courses and training.

ABSOLUTE GEOPHYSICS Stand 13

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Email: aduncan@absolutegeo.com.au
Website: www.absolutegeo.com.au
Contact: Andrew Duncan

Absolute Geophysics Pty Ltd is a business formed in 2008 to offer a unique service in total field electromagnetic surveys. Absolute Geophysics is a joint venture between Electromagnetic Imaging Technology Pty Ltd and Gap Geophysics Pty Ltd. Absolute Geophysics operates the SAMSON B-field ground TEM system which can be deployed in fixed or moving loop modes. SAMSON offers very low noise data acquisition at low base frequencies and is often operated at base frequencies as low as 0.125 Hz. It is an excellent tool for the detection of highly conductive targets and/or the discrimination of highly conductive targets from host responses. Short station occupation times and logistical simplicity mean that high production rates can be achieved in addition to high data quality.

ADVANCED LOGIC TECHNOLOGY Stand 105

Bâtiment A – Route de Niederpallen
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Grand Duché du Luxembourg
Tel: +352 23 649 289
Email: info@alt.lu
Website: www.alt.lu
Contact: Timo Korth
Mobile: +352 621 150 558
Email: timo.korth@alt.lu

For over 13 years ALT – Advanced Logic Technology has manufactured high quality borehole logging systems in Luxemburg, Europe. ALT supplies worldwide sales and services in the following areas:

- Acoustic Imaging Tools – product line includes slim hole and high temperature/high pressure systems for open and cased hole applications
- Slimhole Optical Imaging Tools
- Geophysical Borehole Tools (FWS, GR, FDS, MagSus, Induction, …)
- New stackable probe line using high end quick link technology
- High end data acquisition systems (MATRIX and ALT Logger with real time data upload capabilities)
- WellCAD – Well data management, presentation, processing and interpretation software
- CoreCAD – Digital core description software
- Rental of Logging Systems.

ALPHA GEOSCIENCE Stand 27

1/43 Stanley Street
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Email: info@alpha-geo.com
Contact: Grant Rosewarne
Email: grosewarne@alpha-geo.com

Alpha Geoinstruments undertake the sales, service and rental of geophysical instrumentation in the Australian and New Zealand markets. Alpha Geoinstruments represent a wide variety of instrument manufacturers from around the work providing the latest and greatest geophysical tools, both hardware and software available. The equipment includes magnetics, ground penetrating radar, seismic, resistivity, time and frequency domain electro-magnetics, well logging, magnetic susceptibility and radiometrics. Geometrics, Mala Geoscience and Radiation Solutions Inc. are among the major instrument manufacturers that Alpha Geoinstruments represent. Alpha Geoinstruments have been appointed the exclusive worldwide distributors for the *terraTEM* Transient EM System from Monash Geoscope in Melbourne. Alpha Geoscience also undertakes specialised geophysical survey for environmental and exploration targets.

ARCHIMEDES FINANCIAL PLANNING Pty Ltd Stand 77

3/1315 Gympie Rd
Aspley, Queensland 4034
Tel: +61 7 3863 1846 or 1300 387 351
Website: www.archimedesfinancial.com.au
Contact: Noll Moriarty
Email: noll.moriarty@archimedesfinancial.com.au

Archimedes Financial Planning undertakes extremely thorough and personalised analyses of people's financial status, needs and objectives. It specialises in resource industry clients who live throughout Australia and internationally, providing highly advanced risk management techniques such as Efficient Frontier investment portfolios.

Specialist expertise areas include:

- Wealth creation planning
- Debt management
- Do-it-yourself superannuation
- Retirement Planning
- Securities & Derivatives
- Personal insurances
- Tax planning strategies
- Corporate superannuation
- Mortgage broking & finance (*through Aust. Loan Company*)

The advisers of Archimedes Financial Planning Pty Ltd provide financial services as Authorised Representatives of Professional Investment Services Pty Ltd, ABN 11 074 608 558, AFSL 234951

ASEG – AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS — Stand 110

PO Box 8463
Perth Business Centre, WA 6849
Tel: +61 8 9427 0838
Email: secretary@aseg.org.au
Website: www.aseg.org.au
Contact: Louise Middleton

The ASEG is a learned society of approximately 1400 members, embracing professional earth scientists specialising in the practical application of the principles of physics and mathematics to solve problems in a broad range of geological situations.

Its aims are to:

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

AUSTRALIAN SCHOOL OF PETROLEUM — Stand 19

The University of Adelaide
Level 2, Santos Petroleum Engineering Building
Frome Road, Adelaide, SA 5000
Tel: +61 8 8303 8000
Website: www.asp.adelaide.edu.au
Contact: Richard Hillis
Email: richard.hillis@adelaide.edu.au

The School was created at the University of Adelaide in July 2003 by the merger of the National Centre for Petroleum Geology and Geophysics and the School of Petroleum Engineering and Management. It comprises two disciplines: Petroleum Geoscience and Petroleum Engineering and Management. It is part of the Faculty of Engineering, Computing and Mathematical Sciences at the University of Adelaide. It is the largest petroleum-focused university program in the Southern Hemisphere, with about 30 full-time staff, 150 undergraduate students and 50 postgraduate students and is one of only a few institutions in the world offering integrated teaching and research programs covering petroleum geoscience, engineering and management.

BARRICK — Stand 26

Silver Sponsor

Level 10, 2 Mill Street
Perth, Western Australia
Tel: +61 8 9212 5777
Web: www.barrick.com/
Contact: Barry Bourne
Email: bbourne@barrickgold.com

Barrick is the world's pre-eminent gold producer, with a portfolio of 27 operating mines, many advanced exploration and development projects located across five continents, and large land positions on the most prolific and prospective mineral trends. Barrick's Australia Pacific region is headquartered in Perth, Western Australia and comprises 10 operating mines: its 50% interest in the Kalgoorlie mine; the Kanowna, Granny Smith, Plutonic, Darlot and Lawlers gold mines in Western Australia; the Cowal gold mine in New South Wales; the Henty gold mine in Tasmania; the Osborne copper-gold mine in Queensland; and the Porgera gold mine in Papua New Guinea.

BAYSIDE PERSONNEL INTERNATIONAL — Stand 45

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Tel: +61 3 9864 6080
Website: www.baysidegrp.com.au/
Contact: Dennis Anderson
Email: danderson@baysidegrp.com.au

Saudi Aramco, currently celebrating its 75th Anniversary, is the largest integrated oil company in the World; continually seeking to employ top professionals. Bayside Personnel International, established in 1975 is currently celebrating its 18th anniversary as Saudi Aramco's sole recruitment agent for the Australia and New Zealand region.

BELL GEOSPACE — Stand 81

Unit 5A, Crombie Lodge
ASTP Bridge of Don
Aberdeen, AB22 8GU
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Mob. +44(0)7831 149396
Tel: +44(0)1 224 227711
Contact: Michael Douglas

Bell Geospace uses state of the art technology to provide the most sophisticated and highest resolution gravity data available from both airborne (Air-FTG®) and shipborne (Marine-FTG®) platforms. With over ten years of experience, Bell Geospace has the expertise to acquire the best quality gravity data, to apply the most advanced data processing, and to provide the most reliable interpretations. Bell Geospace acquires Full Tensor Gravity Gradiometry (FTG) worldwide for petroleum, mining, and groundwater exploration. With over ten years experience, Bell Geospace provides assistance and service for all stages of the FTG exploration program. FTG Applications – Diamond, Base Metal and Precious Metal and Petroleum Exploration. Prospect Level Geological Mapping and Regional Gravity and Fault Studies.

BERGEN OILFIELD SERVICES — Stand 119

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5035 Bergen, Norway
Tel: +47 9502 5056
Singapore Office
103 Beach Road # 03-02
Premier Centre
Singapore 189704
Tel: +65 6334 2267
Website: http://www.bergenofs.no
Email: ann.lim@bergenofs.no

Bergen Oilfield Services AS (BOS) is a Norwegian offshore seismic survey company with a focus on subsea technology commercialisation. We manage the whole value chain from vessel ownership, data acquisition through to processing; ensuring a high quality, on time response. The organisation is driven by the quality of its services, the continuous pursuit for innovative solutions and the expertise of its employees. At all stages of our operations safety, quality and environmental preservation are paramount.

BOREHOLE WIRELINE Pty Ltd — Stand 29

2 Wilfrid St (PO Box 439)
Edwardstown, SA, 5039
Tel: +61 8 83513255
Website: www.borehole-wireline.com.au
Contact: Duncan Cogswell or Paul Starling
Email: dcogswell@borehole-wireline.com.au

Operating Australia wide, Borehole Wireline provides BH geophysical logging services for Uranium, Coal, CBM, Iron Ore, Geothermal, Geotechnical & Groundwater projects. Using modern digital, 'best in class' logging systems, we aim to provide timely and cost effective services. Our probes are 'stackable' allowing less run time in the BHs and less rig standing time. We have a wide range of slimhole logging probes including dual laterolog, dual induction, dual & triple spaced density, fullwave sonic, acoustic & optical BH imagers. Our probes are calibrated and we verify our probe responses between calibrations.

CGGVERITAS — Stands 69–73

Silver Sponsor

38 Ord Street
West Perth Western Australia
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Tel: +61 8 9214 6200
Contact: Suzanne Del Rosso
Email: suzanne.delrosso@cggveritas.com

CGGVeritas is a leading international pure-play geophysical company delivering a wide range of technologies, services and equipment to the oil and gas industry. Geophysical services cover offshore and onshore seismic acquisition, seismic data processing and imaging, as well as reservoir management. We offer an advanced suite of seabed seismic services. CGGVeritas also owns a recent vintage, well positioned library of multi-client land and marine seismic data. Hampson-Russell (A CGGVeritas company) provides its renowned geophysical software, training and technical services throughout the Asia-Pacific region.

CHEVRON — Stand 115

Silver Sponsor

250 St Georges Terrace
Perth, Western Australia
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Tel: +61 8 9216 4000
Contact: Erin May
Email: erin.may@chevron.com

Chevron is one of the world's largest integrated energy companies, conducting business in more than 100 countries with a diverse and highly skilled workforce consisting of more than 59 000 employees. Chevron has been present in Australia for more than 50 years and is a significant investor in offshore north-western Australia exploration. The company is leading the development of the Gorgon Project, an LNG and domestic gas joint venture, and the wholly owned Wheatstone Project. Chevron operates the Barrow Island and Thevenard Island oil fields and is a participant in the North West Shelf Venture and Browse LNG development.

COFFEY GEOTECHNICS — Stand 116

8/12 Mars Rd, Lane Cove West
NSW 2066
Tel: +61 2 9911 1000
Email: geophysics@coffey.com
Website: www.coffey.com
Contact: mina_hayashi@coffey.com

Coffey Geotechnics' geophysics team delivers solution-oriented geophysical consulting to the civil infrastructure, mining and exploration, environmental and groundwater markets with a vested interest in identifying the risks and finding the most effective solution for our clients. We offer sub-surface imaging solutions in the land, marine and near-shore environments, specialising in the integration of land and nearshore information. Coffey Geotechnics has been managing the earth for 50 years and has offices in Australia, New Zealand, Canada and the United Kingdom. This means we can draw on specialists from around the world, participating in providing solutions on complex engineering projects.

CSIRO — Stand 49

Bag 10, Clayton South
Victoria, 3169
Tel: 1300 363 400
Email: enquiries@csiro.au
Website: www.csiro.au
Contact: Jeanne Young
Email: jeanne.young@csiro.au

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves business, industries, governments and communities across the nation. CSIRO has a long history in geophysical research and partnering with the resources industry to develop practical and effective tools and technologies. These include innovative magnetometer and magnetic tensor gradiometry systems such as LANDTEM (ground-based TEM), GETMAG (detecting magnetic minerals from the air and mapping deposits in three dimensions) and OCEANMAG (allowing traditional oil and gas exploration techniques to be extended to shallow water).

DAISHSAT — Stand 7

4 Carter Road
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Tel: +61 8 85310349
Mob: 0418 800122
Website: www.daishsat.com
Contact: David Daish
Email: david.daish@daishsat.com

Daishsat began in 1992 as a precision GPS surveying company. Technical excellence, innovation, data quality and reliability of service to its clients have been its hallmarks since inception. The company has developed an impeccable reputation for ground and helicopter borne gravity surveys and is now the leading provider of gravity surveys within Australia, surveying well over 1 000 000 GPS positioned gravity stations over the last 17 years. The company has offices in South and Western Australia and is offering gravity and precision GPS surveying services to clients around the globe who value experience, quality of service and a proven track record.

DEPARTMENT OF PRIMARY INDUSTRIES VICTORIA – GEOSCIENCE VICTORIA Stands 61 & 64

GPO Box 4440
Melbourne Vic 3001
Tel: +61 3 9658 4562
Website: www.dpi.vic.gov.au/dpi
Contact: Kathy Hill
Email: kathy.hill@dpi.vic.gov.au

Victoria's Department of Primary Industries' (DPI) Minerals and Petroleum Division (M&P) is responsible for the promotion and regulation of the extractive, oil and gas, pipelines, geothermal energy, minerals exploration and mining industries in Victoria. Industry specific facilitation and development marketing services are provided, along with the maintenance of the State's historical geological database and the development of additional state-of-the-art regional geological and geophysical data. M&P maintains an efficient licensing and permitting administration system to provide secure title for exploration, production and pipeline activities. We also ensure that industry environmental management standards meet community needs.

DOWNUNDER GEOSOLUTIONS Pty Ltd Stands 55 & 56

80 Churchill Avenue
Subiaco, WA 6008
Tel: +61 8 9287 4100
Website: www.dugeo.com
Contact: Joy Turvey/Alina Ariffin
Emails: joyt@dugeo.com; alinaa@dugeo.com

DownUnder GeoSolutions is an innovative geosciences company, offering services to the global oil and gas industry across three main areas:

- Seismic Processing and Depth Imaging – DownUnder offers a complete seismic processing and depth imaging capability starting with field tapes or data at any stage of the processing/ imaging flow.
- Quantitative Interpretation (QI) Products & Services – DownUnder has developed a comprehensive QI flow which begins with depth dependent rock physics model building and stochastic forward modelling. A Bayesian based classification scheme is used to predict lithology and fluid content using the rock property volumes from seismic inversion and the modelled distributions.
- Full Range of Integrated Petrophysical Services – including well log editing, synthesis and interpretation.

We have successfully completed projects from all over the globe working out of our offices in Australia, Malaysia and Indonesia. Visit our website at www.dugeo.com.

ELECTROMAGNETIC IMAGING TECHNOLOGY Stands 11 & 12

6/9 The Avenue
Midland, WA 6056
Tel: +61 8 92951 456
Website: www.emit.iinet.net.au
Contact: Andrew Duncan
Email: aduncan@electromag.com.au

ElectroMagnetic Imaging Technology Pty Ltd (EMIT) is a geophysical technology business based in Perth, Western Australia, established in 1994. EMIT develops geophysical instrumentation and software and undertakes contract technology development. EMIT's main products are the SMARTem Receiver System, Maxwell EM Software and Atlantis Borehole Magnetometer for EM. SMARTem is an 8-channel PC-based receiver system that has powerful signal processing, VGA display and full time-series recording. Maxwell software is industry standard in presentation, processing and interpretation of EM geophysical data. Atlantis is a unique magnetometer system for borehole TEM, especially powerful for discriminating massive nickel sulphides from weaker conductors.

ENCOM TECHNOLOGY Stands 97 & 98

Level 1, 123 Walker Street
North Sydney, NSW 2060
Tel: +61 2 9957 4117
Website: www.encom.com.au
Email: info@encom.com.au
Contact: Jacqueline Leech
Email: jacqueline.leech@encom.com.au

Encom develops GIS and geophysical software applications, provides advanced consulting services and operates the GPinfo petroleum tenement exploration information service. Encom's software applications have been integrated with the Compass Enterprise geospatial data management solution enabling provision of experienced GIS and data management services.

FUGRO GEOSCIENCES Stands 30–35

PO Box 1847, Osborne Park, DC
Western Australia 6916
Tel: +61 8 9273 6400
Website: www.fugroground.com
Email: perth@fugroground.com
Contact: Kathlene Oliver/Ben Oostermeyer

Fugro Ground Geophysics are world leaders in acquiring and processing high quality ground geophysical data for mineral, oil, gas, and water exploration, for engineering studies and for environmental monitoring, throughout the world. We acquire quality electromagnetic, magnetic, radiometric, induced polarisation and gravity data using a wide range of instruments selected for superior performance in particular areas. The company offers turnkey solutions on request, and provides all data acquisition, processing, interpretation and final reporting.

GAP GEOPHYSICS AUSTRALIA Stand 14

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South Brisbane, Queensland 4101
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Website: www.gapgeo.com
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Email: mcattach@gapgeo.com

Gap Geophysics Australia is a Brisbane-based technology company specialising in leading edge geophysical survey technologies and instrumentation for the mining exploration, environmental mapping and UXO remediation industries. Our services include proprietary field techniques such as Sub-Audio Magnetics (SAM), Total Field Electromagnetics (SAMSON) and Ultra High Definition Magnetics (ground and airborne). The company develops very sophisticated, fast sampling, total field magnetometers and high powered (up to 350 amps) EM transmitters.

GBG AUSTRALIA — Stand 107

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GBG Australia are specialists in Non Destructive Techniques (NDT) applying advanced test and inspection methods to buildings, structures, pavements and rail infrastructure as well as undertaking specialised shallow geophysical investigation of contaminated sites. We offer our clients innovative methods of revealing condition and construction information whilst minimising damage or disturbance.

GEOFORCE Pty Ltd — Stands 65 & 66

1/288 Victoria Rd
Malaga, WA 6090
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Website: www.geoforce.com.au
Contact: Kira Madaschi
Email: kira@geoforce.com.au

Geoforce Division of GroundProbe® provides high resolution subsurface information to reduce risk and maximise profit for our customers in the mining, infrastructure and environmental sectors. The company provides turn-key geophysical solutions with the ability to:

- Reduce risk during design and execution of infrastructure projects
- Optimise engineering designs
- Monitor condition of assets
- Find and define mineral and water resources

Geoforce prides itself on technical excellence and strong client focus. With a team of highly qualified consultants, field staff and operations support we have the proven capacity to service major projects throughout Australia.

GEOIMAGE Pty Ltd — Stand 67

13/180 Moggill Road
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Website: www.geoimage.com.au
Contact: Sylvia Michael
Email: sylvia@geoimage.com.au

Geoimage Pty Ltd is a privately owned Australian remote sensing company specialising in image processing, the production and sales of satellite and geophysical imagery, and the spatial analysis and interpretation of remotely sensed imagery for the natural resource sector. With offices in Brisbane, Sydney and Perth, Geoimage services a client base which extends throughout Australia, Asia, Africa, the USA and South America, and spans a number of industry sectors. Geoimage has been the leading commercial Australian satellite remote sensing data supplier since 1990 and is an authorised value-added reseller for a number of satellite operators with access to both Australian and overseas archives.

GEOKINETICS Inc — Stands 79 & 82

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Website: www.geokinetics.com
Mobile: +61 418 758114
Contact: Greg Dunlop Regional Manager Australasia
Email: greg.dunlop@geokinetics.com

Geokinetics is a leading geophysical service company offering a broad range of specialised geophysical services to the petroleum and mining industries, worldwide. Services include, land, shallow water OBC (ocean bottom cable) and TZ (transition zone) seismic data acquisition and advanced processing and interpretation services. The company offers 2D, 3D, 3C and 4C seismic survey design, conventional and multi-component acquisition, leasing/permitting, survey and site preparation, dynamite, Vibroseis, airgun and low impact impulsive sources. Geokinetics has comprehensive global resources with in-depth expertise and experience operating in the US, Canada, Latin America, Europe, Africa, Middle East, Eastern Hemisphere and Asia Pacific regions.

GEOSCIENCE AUSTRALIA — Stands 39 & 40

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Freecall: 1800 800 173
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Email: sales@ga.gov.au
Contact: Ned Stolz
Email: ned.stolz@ga.gov.au

Geoscience Australia is the Australian Government's geoscientific and geospatial information agency. Within the portfolio of Resources, Energy and Tourism, Geoscience Australia enables the government and the community to make informed decisions about resource exploration, environmental management and critical infrastructure protection. Our display showcases Geoscience Australia's national coverage of geophysics, including the Gravity Anomaly Map, the Magnetic Anomaly Map and the newly released Radiometric Map of Australia. These images are compiled by merging hundreds of geophysical datasets acquired over many decades. Australia is the only continent in the world where such consistent data coverage exists. The booth also displays recently acquired onshore and offshore seismic images, and results from earthquake risk assessment projects.

GEOSOFT AUSTRALIA — Stands 75 & 78

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Email: tanya.brown@geosoft.com

Geosoft empowers geophysicists, geologists and geochemists with a complete solution for earth mapping and processing. Worldwide geoscientists utilise Geosoft software for effective surface, subsurface and hydrologic characterisation in engineering, environmental, mining, UXO, archaeological, and oil and gas investigations. Geosoft Oasis montaj is the most robust and comprehensive mapping, interpretation and modelling solution that provides optimal environment for integrating, viewing and comparing large-volume geophysical, geochemical and geological data. Geosoft has grown to be a global leader in innovative solutions for geoscientists, accelerating data processing and ensuring data quality, effectively supporting decision making in today's competitive marketplace.

GEOTECH AIRBORNE Pty Ltd — Stand 21

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Geotech has been an innovator in the design, development and application of EM instrumentation and related geophysical surveys for over 25 years. We specialise in advanced digital helicopter-borne EM systems and offer full-service airborne geophysical surveys. Our proprietary, large dipole-moment, **VTEM** (Versatile Time-Domain ElectroMagnetics) system is the cornerstone of our business and is one of the most advanced systems available today. This technology has demonstrated depth penetration of 800 metres while allowing high horizontal discrimination of conductors. Due to the success of VTEM, 2006 was Geotech's most productive year yet, with surveys spanning five continents. Currently, sixteen systems are fully operational with an additional two in development. Geotech now offers a new next-generation system incorporating AFMAG (**A**udio **F**requency electro **MAG**netics), Magnetics and Gravity. This combination is ideal for large regional surveys, whether for deeply seated ore bodies or hydrocarbon exploration.

GF INSTRUMENTS — Stand 50

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GF Instruments is a company developing and manufacturing a wide range of measuring instruments for geophysical, geological, engineering-geological, environmental, archaeological and similar use:

- gamma-ray spectrometers and radiometers (Gamma Surveyor, SGR)
- electromagnetic conductivity meters CMD series
- DC resistivity systems (ARES, GEPS-2000)
- magnetic susceptibility meters (SM-20)
- metal detectors (TM-93 and TM-D)
- laboratory instruments based on the above mentioned methods.

The company also provides near-surface geophysical measurements and authorised services in the field of geology, engineering geology and UXO survey.

GPX SURVEYS — Stand 95

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GPX Surveys is based in Perth, Western Australia and is an internationally recognised service company specialising in the collection, processing and interpretation of airborne and ground remotely sensed data. GPX offers a suite of airborne systems, both fixed wing and helicopter collecting Magnetics, Radiometerics, Electromagnetics, Altimetry and Gravity. To complement this GPX also provides ground geophysical systems specialising in the collection of Induced Polarisation, Electromagnetics and Magnetics. The company is staffed and managed by people with hands on experience in all aspects of the geophysical service industry and has a number of highly experienced engineers who specialise in the installation and setup of this equipment in various aircraft provided by accredited suppliers of choice located near key areas of operations. Our management, operations and data processing team have accumulated many years of experience and have operated in many countries throughout South East Asia, Micronesia, India, Africa, Europe and the Americas.

HAINES SURVEYS Pty Ltd — Stand 36

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Haines Surveys are specialists in the acquisition of high quality gravity data using the latest GPS technology. They have offices in Perth and Adelaide to provide a cost effective service Australia wide. The company has been operating since 1991 and was one of the first to introduce GPS surveying to the industry. Haines Surveys have completed gravity projects in all states of Australia and several regions overseas including North America, Europe, Scandinavia, South East Asia and Africa. Their clients are provided with a highly automated, reliable and economical gravity service through the use of experienced staff, the latest Trimble GPS equipment and Scintrex CG-5 gravity meters.

HAWKER RICHARDSON (Phoenix|x-ray) — Stand 8

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National Hot Line: 1300 360 031
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With its phoenix|x-ray product line, GE Sensing and Inspection Technologies is a technology leader in microfocus and nanofocus® X-ray microspcopy and computed tomography (CT). High resolution nanoCT® is the perfect tool for non-destructive 3D evaluations of the spatial distribution of pores and pore-connections as well as cementation properties which are of utmost importance in the evaluation of reservoir properties. The phoenix|x-ray nanotom® is the first 180 kV nanofocus® CT system tailored specifically for highest-resolution scans with exceptional voxel-resolutions down to <0.5 microns. For many applications, it can even compete with high cost and rare available synchrotron facilities. Production, research and development of phoenix|x-ray x-ray tubes and systems are located in Germany, with 6 additional support and service centres around the world. In Australia, phoenix|x-ray systems are distributed and supported by Hawker Richardson.

IKON SCIENCE Ltd — Stand 28

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Ikon specialises in combining log, seismic and pressure data to create Quantitative Interpretation modelling workflows. Such workflows are mandatory for understanding the rocks, deciding which type of inversion to use and creating truly meaningful inversions, adding real value to the interpretation. With RokDoc® software used globally and Ikon technical services teams in London, Houston, Durham, KL and Perth WA, we are ready to help you whatever your E&P challenge may be. Whether through a consulting service or as a RokDoc® software solution, Ikon has an unrivalled record of finding Oil & Gas with our customers.

INSTITUTE OF EARTH SCIENCE & ENGINEERING — Stand 53

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IESE acts as a single point of contact within The University of Auckland for earth science research and projects with industry, government, and other universities.

IESE core commercial services are:

- Geothermal exploration and monitoring
- Microseismic.z monitoring networks
- Custom borehole instrumentation
- Consulting.

The Institute builds on existing multi-dimensional research strengths from across the University and engages in basic research, commercial research and consulting on a broad range of topics with specific interests in geo-resources, geo-hazards and the environment.

INSTRUMENTATION GDD Inc — Stand 9

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Website: www.gddinstrumentation.com
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Email: pgaucher@gddinstrumentation.com

Since 1976, Instrumentation GDD Inc. manufactures, sells and develops to user's needs innovative leading edge rugged and reliable geophysical instruments for mining (Dilution Control Probe for iron and nickel mines) and mineral exploration (Upgradeable 8, 16, 24 and 32 channels 3D – Full Wave IP Receiver, 3600W, 5000W and 10kW – 4800V IP Transmitter, Surface EM, Hand Held Magnetic Susceptibility Meter, etc.). GDD is renowned for its worldwide customer service. Take a minute and test GDD latest MPP-EM2S+ probe and the 3D 32 channels IP Receiver at GDD booth #09 during the ASEG convention.

INTREPID GEOPHYSICS — Stand 48

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Websites: www.intrepid-geophysics.com; www.geomodeller.com
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Desmond FitzGerald & Associates Pty Ltd (trading as Intrepid Geophysics since 2001) has operated for thirty years and since 1992, has developed software and services for potential field geophysics. The primary software developed is Intrepid, GeoModeller and Jetstream. Since 2002, 3D geological modelling and integration with Geophysics has played an important role in the company. This is an industy/Government partnership with the company having close links to BRGM (France) and Geoscience Australia. Our associated company GeoIntrepid provides processing and interpretation services including a special ability to solve high end, very large data volumes and difficult issues. Substantial quality control and airborne processing expertise exists. We have offices in Perth, Melbourne and Namibia.

MERCURY COMPUTER SYSTEMS — Stand 22

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Contact: Aude Robertet

Mercury Computer Systems is serving the Oil & Gas industry worldwide. Products range from high-end visualisation software and systems to seismic computing optimisation (GPGPU and Cell). Mercury's 3D software components (Open Inventor™, VolumeViz™ LDM, ScaleViz™) provide innovative solutions in the fields of 3D visualisation, visualisation servers and immersive VR. These toolkits (C++/.NET and Java) provide application developers with revolutionary solutions for understanding massive seismic data volumes (> several 100 GB) or huge reservoir models. Mercury also provides Avizo™, an application framework for visualising and managing oil & gas data including seismic, horizons, reservoir, as well as core sample analysis.

MIRA GEOSCIENCE ASIA PACIFIC — Stand 15

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Mira Geoscience offer software and consulting services in 3D earth modelling to the global mining industry for mineral exploration, resource assessment, mine planning, geotechnical hazard and environmental monitoring. Our work is focused on applications of the Gocad 3D-GIS software which offers the most advanced technology available today for 3D surface and volume modelling, visualisation, geophysical forward modelling and inversion, and multi-disciplinary decision support. Mira Geoscience provides software sales, support, and training, the development and sale of Gocad modular plug-ins for mining applications, as well as earth modelling and exploration targeting consulting services. Our Advanced Geophysical Interpretation Centre (AGIC) provides industry-leading modelling, inversion, and interpretation services across the range of geophysical methods.

NAMIBIAN GEOLOGICAL SURVEY — Stand 20

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The Geological Survey of Namibia, as custodian of Namibia's rich endowment of geological resources, facilitates the responsible development and sustainable utilisation of these resources for the benefit of all Namibians.

- It provides Geoscientific information through research to promote sustainable development and investment in Namibia.
- Guides land-use decisions to ensure the availability and sustainability of resources for the current and future welfare of our society.
- Stimulates investment in Namibia's Mining Sector in order to contribute to the development of Namibia's economy.
- Creates awareness of the earth sciences in order to enhance the understanding of the geoenvironment and its interaction with the life-supporting system of the Namibian people.

NEW SOUTH WALES DEPARTMENT OF PRIMARY INDUSTRIES — Stand 96

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Website: www.dpi.nsw.gov.au
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Email: david.robson@dpi.nsw.gov.au

The Geological Survey of NSW provides information and advice to government, the exploration and mining industry and the community on the state's geology, mineral resources and their impact on land use planning. The Survey programs have been augmented by a three year (2008–11), $16.5M extension to the New Frontiers initiative, to fast-track the provision of new geoscience data and promote petroleum and mineral exploration investment into underexplored parts of the state. The extended program will include acquisition of deep seismic, teleseismic, gravity, airborne magnetic and radiometric data supported with 3D mapping, mineral systems studies and with a new Hylogger program.

OUTER-RIM EXPLORATION SERVICES — Stand 52

Bronze Sponsor

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Mob: 0428 30 0134; 0412 54 9980
Website: www.outer-rim.com.au
Email: mail@outer-rim.com.au
Contacts: John More, Operations Manager; David Lemcke, Manager

Outer-Rim Exploration Services has been providing reliable, professional, cost effective surface, underground and downhole EM surveys to the exploration and mining industry throughout Australia for more than thirteen years. ORE was the first to provide dependable three component DHEM surveys to Australia and the first to provide the new SQUID technology (using high temperature superconductors) to surface EM surveys, with the introduction of the CSIRO developed LANDTEM system. The LANDTEM now has an enviable record of exploration success in a relatively short time. For excellence in EM surveys, contact one of the ORE team at booth #52.

PARADIGM — Stands 16–18

Level 8, 256 St Georges Terrace
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Contact: Dee Elliot
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Paradigm software enables customers to locate oil and natural gas reservoirs and optimise production from existing reservoirs by creating and analysing dynamic digital models of the earth's subsurface. These models of oil and natural gas reservoirs are used to identify prospects and optimise reservoir fluid and natural gas extraction. Paradigm software solutions include Seismic Data Processing and Imaging, Visualisation, Interpretation, Modelling, Reservoir Characterisation, Petrophysical Analysis, Well Planning, and Drilling. Paradigm also provides strategic consulting services to enhance customer workflows and assist in realising greater returns on exploration and production activities. Our solutions provide unconflicted vision for decision makers in subsurface disciplines to reduce uncertainty, improve confidence, minimise risk, and optimise responsible management of assets.

PETROLEUM GEO-SERVICES — Stands 57–60

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Australian Office
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Website: http://www.pgs.com
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Petroleum Geo-Services (PGS) is a technology focused oilfield service company principally involved in providing geophysical services worldwide. The company provides a broad range of geophysical and reservoir services, including seismic data acquisition, processing and interpretation plus field evaluation.

Since the start of the company in 1991, PGS has:

- Pioneered the development of multi-streamer seismic acquisition, producing increasingly efficient, high-quality 3D seismic data for the oil industry;
- Developed in-house expertise in geology, geophysics, reservoir and production; and
- Introduced high-density 3D seismic (HD3D) in all environments: streamer, seafloor (4C) and land seismic.

With its headquarters in Oslo, Norway, the company has offices in 22 different countries with larger regional offices in London, Houston and Singapore. PGS' main competitive advantages are a strong technology base, a comprehensive knowledge base and a culture for innovation and new ideas.

PICO ENVIROTEC Inc — Stand 47

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Email: kh@picoenvirotec.com
Contact: Matt Edmonds
Email: matt@geosensor.com.au

Pico Envirotec Inc. (PEI) is involved in advanced data acquisition techniques related to instrumentation used with moving platforms. Precise data positioning and time synchronisation of data acquisition together with substantially increased sensor resolution and data sampling rates is based on GPS – PPS (Global Positioning Systems and accurate Pulse per Second) timing. Utilisation of high-density electronics with increased calculation allows building independent and intelligent high resolution geophysical sensors. Connection of sensors to the data acquisition system are user friendly. Precise GPS time and position synchronisation and standardisation of data formats for all instrumentation provide simplified data processing.

PRIMARY INDUSTRIES AND RESOURCES SOUTH AUSTRALIA — Stands 37 & 38

Silver Sponsor

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Primary Industries and Resources South Australia
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Primary Industries and Resources SA (PIRSA) is a dynamic Government of South Australia agency committed to the economic development of the State and the sustainable use of the State's food, fibre and minerals industries. The Division of Minerals and Energy Resources of PIRSA manages the state's mineral, petroleum and energy resources on behalf of the people of South Australia.

It provides South Australian geoscientific information for resource industries to encourage minerals, petroleum and geothermal exploration. PIRSA also provides information for teachers, students, community groups and the general public.

QUANTEC GEOSCIENCE Pty Ltd — Stand 51

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Quantec Geoscience provides geophysical services to the mining industry with a focus on data acquisition, interpretation and survey execution. With over twenty years of operations and more than 2000 projects completed globally, Quantec is an established leader in providing exploration solutions. Committed to employing innovative processes and advanced technology, Quantec continues to build its reputation of being a pioneer in the geophysics industry.

- Global operations since 1986
- Offices in eight countries: Canada, USA, Chile, Argentina, Peru, Mexico, Australia and Botswana
- Projects completed in over 30 countries – geophysical data acquisition, processing, inversion and interpretation
- Team of over 100 geophysicists, geophysical technologists and project based field assistants

QUEENSLAND DEPT OF MINES & ENERGY — Stand 46

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Geological Survey of Queensland
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Emails: info@dme.qld.gov.au; geophysics@dme.qld.gov.au
Contact: Chris Xavier (Senior Geophysicist)
Tel: 61 7 3362 9357
Email: chris.xavier@dme.qld.gov.au

The Department of Mines and Energy seeks to deliver a world-class mining industry and a sustainable energy market to support economic growth and improved welfare for all Queenslanders. The department draws together and seeks to maximise the synergies that exist in Queensland's valuable mining and energy sectors. The department is responsible for policies and processes to facilitate exploration and development and delivers services to protect the health and safety of people involved in Queensland's mining, quarrying, petroleum, gas and explosives industries, a sector that contributes over $16 billion to Queensland's Gross State Product.

EXHIBITION

RADIATION SOLUTIONS — Stand 106

Radiation Solutions Inc
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Radiation Solutions is a designer and manufacturer of advanced radiation detection systems. These detection systems are directed towards the geophysical exploration market with models for airborne, carborne and handheld spectrometers. For additional information, visit our stand or our website.

RIO TINTO EXPLORATION — Stands 23 & 24

Gold Sponsor

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Rio Tinto is a leading international mining group headquartered in the UK, combining Rio Tinto plc, a London and NYSE listed company, and Rio Tinto Limited, which is listed on the Australian Securities Exchange. Rio Tinto's business is finding, mining, and processing mineral resources. Major products are aluminium, copper, diamonds, energy (coal and uranium), gold, industrial minerals (borax, titanium dioxide, salt, talc) and iron ore. Activities span the world but are strongly represented in Australia and North America with significant businesses in South America, Asia, Europe and southern Africa.

ROBERTSON GEOLOGGING Ltd — Stand 68

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RG Regional Contact Details (Hong Kong):
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Contact: Steve Parry
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Our slimline borehole logging equipment is currently used for civil engineering, geotechnical, water-well management, environmental, mining and oil/gas surveys in 145 countries. Also (and uniquely in this industry), we started as a borehole logging contract-service company and continue to operate our own contract borehole logging services as an important part of our business. Our customers range from major international oil and mining companies and government institutions to the one-man consultant. Our regional sales centres provide direct RG sales and support, worldwide. RG-UK, our North Wales headquarters, covers Europe and Africa and global oilfield sales. RG-ASIA, our sales representative based in Hong Kong, covers Asia, the Middle East and the Pacific while RG-USA, our Houston-based subsidiary company, provides support for North America and South America in both English and Spanish languages. Elsewhere, RG is represented by more than 45 local agents. RG also has a JV Contract Logging company 'RGGA' based in Queensland, for those customers who prefer to outsource their logging requirements.

RPS — Stand 120

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RPS Energy is a multi-disciplinary consultancy, providing technical, commercial and project management support services in the fields of operations, geoscience, engineering and health, safety and environment to the energy sector worldwide. RPS Energy focuses primarily on the upstream oil and gas, the renewable energy and nuclear sectors from operating bases in the Australia, Singapore and Malaysia, UK, USA, and Canada.

RPS Energy has an enviable track record in providing specialist consultancy services to clients with a broad-based technical and project management service that can be accessed to provide support to client projects at all stages of an asset life cycle.

SANTOS — Stands 101–104

Platinum Sponsor

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Santos Ltd is a major Australian oil and gas exploration and production company with interests and operations in every major Australian petroleum province and in Indonesia, Papua New Guinea, Vietnam, India, Bangladesh, Kyrgyzstan and Egypt. We are one of Australia's largest producers of gas to the domestic market, supplying sales gas to all mainland Australian states and territories, ethane to Sydney, and oil and liquids to domestic and international customers. We also have the largest Australian exploration portfolio by area of any company – 192 000 square kilometres. Santos is positioning itself to become the leading energy company for Australia and Asia. The Cooper Basin, which Santos and its joint venture partners have developed, is Australia's largest onshore resources project. Through our interest in the Darwin LNG project, we are a producer of LNG which is exported to customers in Japan. Santos has announced a $7.7 billion project to build an LNG facility in Gladstone, Queensland, that will process coal seam gas from eastern Queensland. Santos has more than 1750 employees and produced 59.1 million barrels of oil equivalent in 2007.

SCINTREX Ltd — Stand 80

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Scintrex Limited is a leader in geophysical instrumentation, providing sales for ground and airborne applications. Scintrex products are used in mineral, petroleum, groundwater, environmental, academic and scientific applications. Scintrex Limited is a globally recognised brand name around the world with a world-wide agent network. We are proud to have led the way and set the standards for geophysical instrumentation for the past 40 years. Geosensor Pty Ltd is the Australian Sales Agent. For any enquiries please contact Matt Edmonds (see above).

SEG – SOCIETY OF EXPLORATION GEOPHYSICISTS — Stand 111

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The Society of Exploration Geophysicists is a not-for-profit organisation that promotes the science of geophysics and the education of applied geophysicists. SEG, founded in 1930, fosters the expert and ethical practice of geophysics in the exploration and development of natural resources, in characterising the near surface, and in mitigating earth hazards. The Society, which has more than 25 000 members in 129 countries, fulfils its mission through its publications, conferences, forums, websites and educational opportunities. SEG encourages its members to learn about the newest technologies by sponsoring speakers, publishing new theories in periodicals and other formats, and organising continuing education classes around the world. Through SEG, members can network and learn from other professionals.

SOCIETY OF EXPLORATION GEOPHYSICISTS JAPAN (SEGJ) — Stand 112

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No further details supplied.

SEISMIC AUSTRALIA — Stand 76

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SEISMIC MICRO-TECHNOLOGY ASIA Pty Ltd — Stand 109

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Since 1984, Seismic Micro-Technology, Inc. (SMT) has provided the upstream E&P industry with innovative software solutions that have changed the game for ease of use, cost-effectiveness and total integration. We developed the first geoscience interpretation tools for the Windows® environment to help fast-track interpretation, collaboration and decision-making while delivering exceptional accuracy and consistency. Today, SMT is the global leader in Windows-based exploration and production software – now used by geoscientists in over 80 countries. In January 2006, SMT opened its first office in Asia in Singapore. With this office SMT now has facilities in Houston, Croydon, UK, and Singapore. All offices provide training and support to SMT customers. SMT's success is based upon total software integration. The entire cohort of SMT geoscience interpretation tools functions off of one single executable. This means that with the click of just one application the interpreter can instantly operate each of SMT's geoscience modules. The benefit of truly integrated software, that is logical to learn and to use, is significantly improved interpreter productivity.

SHELL DEVELOPMENT AUSTRALIA Pty Ltd — Stands 41–44

Gold Sponsor

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Shell Development Australia (SDA) is the exploration, production and gas commercialisation part of Shell's Australian business, holding an interest in about 20% of an estimated 136 trillion cubic feet of the gas resources in Australian waters. As a gas growth centre for the Shell Group, SDA holds large reserves in the North West Shelf Venture (NWSV), Gorgon, Browse Basin and Timor Sea fields around Australia. SDA also maintains a substantial exploration portfolio in Australia with major representation in permits and reserves offshore Western Australia and the Northern Territory. This is a business of very long-term plans and substantial investment. It involves acquiring and developing new exploration areas, making oil and gas discoveries and bringing them to market. In Australia, SDA does this primarily through joint venture partnerships with other oil and gas businesses. Shell Development Australia is also a founding member of the Australia LNG marketing consortium.

SKYTEM — Stand 108

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SkyTEM Aps is a private company established in 2003 to provide SkyTEM surveys, including data acquisition, interpretation and documentation. SkyTEM Aps provides services to Government Agencies, Environmental and Geological Engineering and Mining Industries worldwide. SkyTEM is a time domain transient electromagnetic method used for environmental investigations, mineral exploration and other resistivity studies. Contact us for more information

SOUTH AFRICAN GEOPHYSICAL SOCIETY (SAGA) Stand 113

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Contact: Yolande Oosthuizen/Jann Otto or Stefaans du Plessis
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SAGA was founded in 1977 to foster and encourage the development of Geophysics in South Africa and has since grown to over 350 members worldwide. SAGA hosts regular monthly talks, produces a topical newsletter, presents short courses annually, and runs biennial technical meetings. The SAGA2009 biennial conference will be held in the Royal Kingdom of Swaziland, located near the Barberton Mountainland (one of the best exposed greenstone belts in the world) and the Kruger National Park. Field trips into the Barberton Mountainland are offered.

SOCIETY OF PETROLEUM GEOPHYSICISTS SPG INDIA Stand 114

1 Old CSD Building, KDMIPE Campus
Kaulagarh Road
Dehradun 248195, Uttarakhand, India
Tel: + 91 135 2795536
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SPG India aims to:

1. Provide a forum for technical excellence and technological advancement in the profession of Geophysics for Exploration and Exploitation of Petroleum deposits; and exchange of views and ideas amongst the Geoscientists.
2. Formulate, monitor and promote norms of professional ethics for practicing Geophysicists.
3. Contribute to the cause of continuing education and technical advancement of geophysical professionals and students.
4. Promote and foster research into important aspects of the geophysical technologies.
5. Exchange knowledge with fellow geophysicists and professional from various universities, sister disciplines and through other similar societies in India and abroad.

SUPERSONIC GEOPHYSICAL Stand 5

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Email: jeff.williams@acousticpulse.com

SuperSonic Geophysical provides quality processing of full waveform acoustic logs (wireline and LWD) for:

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SuperSonic Geophysical also writes and sells licenses to Sonicware, a full wave acoustic log processing program. SuperSonic Geophysical, LLC also engages in Consulting, Special Projects, and Sonic Tool Modelling on request. Endorsed by theoreticians and practitioners the world over, the SuperSonic Geophysical can provide you with consistent expert processing of your sonic logs.

TERREX SEISMIC Stand 4

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Terrex Seismic (TS) is Australia's largest onshore seismic acquisition contractor operating 2 × 3D and 2 × 2D Seismic Crews. Terrex Contracting (TC) provides line preparation services to TS and operates 2 × Earthmoving Crews. TS and TC are 100% Australian owned, employ 220 personnel and have recorded over 600 2D and 3D seismic programs in Australia since 1981. Terrex's Core Businesses are the provision of onshore 2D/3D seismic acquisition subsurface imaging services for:

1. Conventional Oil & Gas,
2. Coal Seam Gas (CSG),
3. Minerals Exploration,
4. High Resolution Underground Coal Imaging,
5. Underground CO2 Carbon Storage,
6. Research – Deep Crustal and Regional Seismic Studies, and
7. Equipment Rental for VSPs, Microseismic Monitoring.

THE EASYCOPY COMPANY Stand 54

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Essentially, the design philosophy in the creation of the EasyCopy product suite is to provide an intuitive collection of tools across the Windows and Linux (32 & 64 bit) platforms and UNIX. With support for CGM+, CGM PIP, EMF, SVG, PDF, TIFF, JPEG etc., the EasyCopy product suite handles conversion, editing, screen-capture, animation, montage, stitch-PDF and plotting. The EasyCopy Company offers the series of tools that becomes an indispensable part of daily work processes for geophysicists, geologists and geo techs all over the world. Individually the tools are excellent, but joined they mesh in the perfect system for everything you need.

THOMSON AVIATION Pty Ltd Stand 100

Thomson Aviation Geophysical Survey
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Contact: Paul Rogerson
Email: paul@thomsonaviation.com.au

Thomson Aviation Geophysical Survey can offer the highest resolution airborne magnetic, radiometric and digital terrain data available. Our advanced acquisition techniques, combined with the latest instruments and systems ensure the best value for money data sets in the industry. Thomson Aviation have over 18 years experience in low level operations and can offer fixed wing and helicopter systems for both domestic and international projects. Data processing and QC is performed independently by Baigent Geosciences, thus providing our clientele a transparent survey operation – again unique in the industry. Please come and have a chat – you can find us at stand 100.

TOTAL DEPTH PTY LTD — Stand 118

21 Churchill Avenue,
Subiaco, WA 6008
Tel: +61 8 9382 4307
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Total Depth Pty Ltd (Exploration Services) is a Geophysical Consultancy, which has provided services within Australia and overseas since 1993. Our clientele include companies from the Petroleum and Minerals sector as well as those involved with R&D and software development. Our objective is to help address specific technical challenges using hybrid workflows created from existing and newly developed technology. The aim is to use these workflows to independently validate existing models and to help address elements of non-uniqueness. One of the new technologies we will be showcasing at this year's ASEG is Seisnetic's Automated pre-interpretation of 3D seismic data.

UTS GEOPHYSICS PTY LTD — Stands 92–93

PO Box 126
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UTS Geophysics (UTS) forms part of the Aeroquest Group of Companies. Since 1992, UTS has been successful in the development of many new airborne geophysical techniques and have acquired and processed more than 9.0 million line kilometres of high resolution airborne geophysical data. UTS has an ongoing commitment to safety, innovation and system development, ensuring that the services provided to its clients will always be of the most technologically advanced, and acquired following strict safety guidelines.

Survey capabilities currently include:

• Fixed wing & helicopter magnetics and radiometrics;
• Helicopter-borne TEM and FEM (AeroTEM & Impulse);
• Fixed wing gravity; and
• High quality data processing, presentation and interpretation.

VELSEIS Pty Ltd — Stands 62 & 63

Bronze Sponsor

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Contact: Rob Wiens Commercial Manager
Email: rwiens@velseis.com.au

Velseis Pty Ltd is a highly experienced Australian seismic contractor, whose reputation is based upon 30 years of diverse operations throughout the Asia-Pacific region. Velseis offers fully integrated seismic services to the petroleum, coal and mineral industries. The company's operations encompass seismic design, surveying, shot-hole drilling, data acquisition, processing and interpretation. The extensive experience of Velseis' key personnel ensures reliable and technically-innovative solutions tailored to meet the needs of individual clients. Velseis provides comprehensive seismic acquisition services, designed to accommodate geophysical, logistical, climatic, environmental and safety objectives. The company provides conventional 3D and 2D crews, utilising multi-component, heli-portable, and shallow marine recording. In keeping with its full-service approach, Velseis provides a specialised shot-hole drilling service through its Seisdrill division and has recently purchased new Envirovibe units (light-weight Vibroseis buggies) which offer an alternative energy source for CSG and shallow petroleum targets. In addition, PT Velseis Indonesia provides comprehensive geophysical logging services in South East Asia. Velseis is an industry leader in the processing of high-resolution seismic data, and is at the forefront of 3D seismic mine-planning imagery. Velseis also has an experienced oil and gas processing division, delivering high-quality 3D and 2D onshore, transition and marine seismic data processing services. Velseis maintains its competitiveness with a proactive commitment to research and development. The R&D division engages in focussed research projects and provides technical support to production divisions.

VORTEX GEOPHYSICS Pty Ltd — Stand 10

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Vortex Geophysics provide contract electrical geophysical services including down hole electromagnetic (DHEM) and magnetometric resistivity (DHMMR) surveys using the Atlantis probe, surface EM and MMR surveys and consulting. Vortex Geophysics sets a high standard in safety, protection of the environment and data quality. We are based in Perth, Western Australia and provide services throughout Australia.

WAVEFIELD INSEIS AUSTRALIA Pty Ltd — Stand 6

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Wavefield Inseis provides proprietary and non-exclusive. Multi-client marine geophysical services which includes long offset 2D, high capacity 3D, 4D, Multi/Wide-azimuth data acquired with highly specified vessels and the latest seismic equipment. We are also a full service permanent 4D acquisition provider and will, through a number of strategic alliances, introduce new technologies to accelerate and de-risk the replenishment of our clients' reserves. One such technology is OPTOWAVE™ which has provided the world's first fibre optic Life of Field Seismic (LoFS) Implementation in the Ekofisk field(North Sea). We are also currently acquiring the world's largest 3D acquisition and processing contracts in Libya.

WESTERNGECO — Stands 83–87

Gold Sponsor

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WesternGeco, a business unit of Schlumberger, is the world's leading geophysical services company, providing comprehensive worldwide reservoir imaging, monitoring, and development services, with the most extensive geophysical survey crews and data processing centres in the industry, as well as the world's largest multiclient data library. Services range from 3D and 4D (time-lapse) seismic surveys to multicomponent and electromagnetic surveys, supplying our clients with accurate measurements of subsurface geology.

ZONGE ENGINEERING & RESEARCH ORGANISATION — Stands 91 & 94

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Zonge Engineering and Research Organisation is a recognised leader and innovator in the development of electromagnetic and induced polarisation survey technology. We have been providing field services in Australia for mining, petroleum, and environmental investigations since 1984. A combination of experienced trained crews, Zonge instruments, together with an emphasis on safety and data quality permits our crews to successfully acquire data in difficult environments. Field experience, gained worldwide, together with a skilled technical staff enables us to provide comprehensive services including survey design, data collection, geosciences personnel, data processing and analysis, and interpretation for a broad spectrum of geophysical applications.

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

- IP techniques
- MT/AMT
- CSAMT
- TEM
- NanoTEM
- Downhole MMR, TEM and IP.

Equipment can also be repaired and upgraded as requested. Some of the applications Zonge Australia are contracted for are mineral exploration, structural mapping, landfill mapping, environmental studies, salinity mapping as well as solving certain engineering problems such as locating cavities. Zonge Australia can field up to ten crews within Australia and overseas at any one time and have over 25 years experience in working in the remotest areas and under the most extreme conditions. Come and see us at Stand 91 to discuss your next survey.

Elliott Geophysics is an Australian based company and started operating in Australia in 1987, first as a Partnership and later as a Corporation. It incorporated as Elliott Geophysics Ltd. in 1990, and then as Elliott Geophysics International Ltd. in 1996. The company's principal expertise lies in mining geophysics as applied to metaliferrous deposits, coal, and oil, but the company also has experience in geophysical surveys over toxic waste dumps, construction sites, pipeline routes, tunnels, and other geotechnical projects. Methods most often used by EGI include aeromagnetics, electrical methods, downhole surveys, gravity, and high resolution shallow seismic (marine and land). The company also offers GPR surveys for special applications.

Elliott Geophysics International Ltd. is the parent company for PT. Elliott Geophysics Indonesia. The President Director is Dr. Peter J. Elliott who is a graduate of the University of Melbourne and Macquarie University in Australia. Dr. Elliott has had some 30 years experience in mining geophysics.

PT. Elliott Geophysics Indonesia provides logistical and technical support to other contract companies with specialized expertise in areas not immediately covered by EGI's own in-house expertise.

In December 2001, Elliott Geophysics opened a branch office in Manila, Philippines. The Philippine Company trade under the name of Independent Exploration Services Inc. Elliott Geophysics has been operating in the Philippines over the last six years.

During the past 20 years Elliott Geophysics has completed over 300 contracts, for more than 100 clients, throughout the world; including countries such as: Australia, Indonesia, India, Papua New Guinea, USA, New Zealand, Philippines, Myanmar, etc..

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ELLIOTT GEOPHYSICS AIRBORNE DIVISION

SECTION 3

ABSTRACTS

Day 1: Monday 23 February 2009

8:45–10:30
Session 1

Hon. Mike Rann
Premier of South Australia

PLENARY SPEAKERS

NATURAL GAS: SOUTH AUSTRALIA'S ENERGY ADVANTAGE

David Knox
CEO and Managing Director, Santos Limited

David Knox was appointed CEO of Santos on 29 July 2008 and is

originally from Edinburgh, Scotland. He joined Santos in September 2007 as Executive Vice President, Growth Businesses, responsible for Santos' emerging new businesses including LNG, Geoscience and New Ventures, Indonesia and other strategic projects. He holds a first class honours degree in Mechanical Engineering from Edinburgh University and a Masters of Business Administration from the University of Strathclyde. David has 25 years of experience in the petroleum industry, and was previously Managing Director for BP Developments in Australasia from 2003 to 2007. He has previously held senior positions with BP in Australia, the United Kingdom and Pakistan. He has worked for ARCO and Shell in the United States, Netherlands, the United Kingdom and Norway.

THE ROLE OF GEOPHYSICS IN MINERAL DEPOSIT DISCOVERY – A RIO TINTO PERSPECTIVE

Stephen McIntosh
Rio Tinto Exploration

Stephen McIntosh is Managing Director of Rio Tinto Explorations' global Project Generation Group (PGG) and is based in Melbourne. PGG houses a team of senior commodity, technical and commercial specialists that have global accountabilities in their respective areas of expertise. This team is also responsible for all R&D activities undertaken by the exploration group. Stephen has MSc (Hons) degrees in Geology and Physics from the University of Auckland. He has over 22 years of service with the Rio Tinto group of companies. Since joining Rio Tinto, Stephen has worked on projects in over forty countries and has been actively involved in the direct assessment or discovery of a number of the groups' exploration discoveries including Simberi Gold, PNG; Lihir gold, PNG; Las Cruces copper, Spain; Murowa diamonds, Zimbabwe; Simandou iron ore, Guinea and the Chapudi coal project, South Africa. More recently PGG has been credited with the discovery of the Mutamba ilmenite deposit located in Mozambique and the Jadar lithium/borate deposit located in Serbia.

11:00–12:30
Day 1 Session 2 Stream 1

PETROLEUM

Seismic imaging, depth migration and depth conversion

USING NUMERICAL MODELS TO AID IN THE SEISMIC IMAGING OF COMPLEX GEOLOGICAL STRUCTURES

John Bancroft, Hesham Moubarak and Don Lawton*
University of Calgary, Canada
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Seismic data, surface geology, and well-logs were used to create a two dimensional numerical model that represents a complex geologic structure. The model contains box folds, faulting and overthrusts. Synthetic seismic data was created from the model and processed in an attempt to image steep dips of the structure. Poor imaging of these dips resulted in redefining the 'field' parameters that were used to create the synthetic data, which eventually led to improved imaging.

The modelling package produced wavefront images every two milliseconds for each source location. The wavefronts were used to track energy to and from a reflection area that was difficult to image. The energy at the geological surface was then mapped at the corresponding time to the source record. This energy was then followed through the migration process to ensure its inclusion in the final migrated image.

A number of lessons were learned from this project. The acquisition parameters required modification to actually record the data, and to prevent aliasing. Care was also required when applying a mute to the migrated source records to preserve tracked energy. Numerous migration algorithms were tested on the data.

BEAM MIGRATION FOR IMAGING OF COMPLEX GEOLOGY

*Karl Schleicher, John Sherwood, Lynn Comeaux and Mazin Farouki**
Petroleum Geo-Services Asia-Pacific, Kuala Lumpur
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Kirchoff migration has traditionally been the leading implementation for depth migration of seismic data, and in most geological regimes produces images that are as good as, or better than, more expensive implementations using downward continuation algorithms. However,

ABSTRACTS

Kirchhoff migration has a significant limitation in its inability to image more than a single arrival. By contrast downward continuation algorithms handle all arrivals but are unable to image steep dips.

An alternative implementation is beam migration which relaxes the single arrival limitation of Kirchhoff while retaining its steep dip capability. Several different types of beam migration implementations exist; our implementation is unique in the industry and involves a decomposition of the data into dip components using the Radon transform and a back-propagation of the dip components into the earth. The dip components can be enhanced based on various criteria before the back-propagation, thereby giving a more coherent image. The methodology inherently allows the attenuation of multiple energy, and coherent as well as non coherent noise.

We give a description of our beam migration and show improved imaging results from different, challenging geological regimes. Our implementation has merits of simplicity, economy, flexibility and future development possibilities. Migrated images have excellent accuracy and quality, especially in areas of poor signal to noise ratio and steep dip. The relative economy makes it an excellent velocity estimation tool to use prior to other, more compute intensive, depth migration methods.

VELOCITY-LESS IMAGING OF LINEARLY INHOMOGENEOUS MEDIA IN 3D

Andrej Bóna[1] and Dennis Cooke[2]*
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We introduce a method for obtaining the precise 3D location of a reflector for a given source-receiver pair in a layer with a linear velocity gradient. Since the presented method provides also exact velocity function for each source-receiver pair, it belongs to the category of velocity-less imaging. The three coordinates of the reflector and the two velocity parameters of the layer are obtained from the reflected travel-time and the two horizontal components of the slowness at each source and receiver. The resulting five equations for five unknowns are solved for each source-receiver pair. The method is well suited for non-planar and non-smooth reflectors. The imaging of multilayer media can be done by layer stripping. Alternatively, the method can be adapted for velocity-less migration.

We demonstrate the potential of the method on synthetic data. In the discussion of the technical aspects of the method, we include comparison of several methods for determination of the horizontal slownesses. The practical application of the method for 3D surveys is discussed.

Day 1 Session 2 Stream 2

MINERALS

Integrated Inversion

USING A 3D GEOLOGICAL MAPPING FRAMEWORK TO INTEGRATE AEM, GRAVITY AND MAGNETIC MODELLING – SAN NICOLAS CASE HISTORY

Richard Lane[1], Phil McInerney[2] and Ray Seikel[2]*
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Geoscience Australia has a strategic vision of an information management and technology framework that allows us to integrate complimentary but diverse sources of information into consistent products. Several groups have made progress on a core element of this vision by combining 3D geological mapping and geophysical modelling software tools. We describe the approach implemented in GeoModeller software and illustrate a typical workflow with a case study involving the San Nicolas VMS deposit and surrounding region. An initial 3D geological map, based on sparse surface geological observations, was progressively refined using AEM and potential field modelling results. At each stage, the geological map was used to capture and communicate the inferred distribution of map units. During the latter stages of interpretation, the geological map was also used to provide constraints for potential field modelling. In addition to the opportunity for direct detection of highly conductive basement-hosted sulphide mineralisation, the availability of AEM data proved crucial in the San Nicolas example by allowing variations in the thickness of a moderately conductive transported cover unit to be determined. This significantly reduced the ambiguity of subsequent potential field interpretations. The AEM data that are being acquired for Geoscience Australia during 2006–2011 as part of the Onshore Energy Security Program are expected to provide similar insights when unravelling the geology of the survey areas. The approach that is described in this paper is relevant to a wide range of applications from regional geological mapping, groundwater studies, through to mineral or geothermal prospecting.

INTEGRATING GEOLOGICAL AND GEOPHYSICAL DATA THROUGH ADVANCED CONSTRAINED INVERSIONS

Peter Lelievre, Douglas Oldenburg and Nicholas Williams*
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To be reliable, Earth models used for mineral exploration should be consistent with all available information. Our research addresses that goal by advancing the integration of geologic and geophysical data through appropriate inversion methodologies. In this paper we discuss new methods for integrating both located and non-located geologic knowledge and geophysical data and provide illustrative synthetic and real-data examples.

When not constrained by geologic information, default UBC-GIF inversions of geophysical data can generate reasonable results, recovering spatially simple physical property distributions that honour the survey data. However, such first-pass results may not honour the geologic information available, the inclusion of which can dramatically improve the recovered Earth models. The geologic information may include, for example, observations of rock types, expected physical property distributions, structural trends, contact orientations, information regarding the relative positions of rock units, and expected aspect ratios of causative bodies.

Combining several complimentary types of geophysical data collected over the same Earth region can further reduce ambiguity and enhance inversion results. The different physical property models recovered independently from different geophysical data sets can be inconsistent with each other; that is, they may not show the expected correlation indicated by the existing geologic knowledge. We have developed iterative cooperative inversion strategies that exploit the functionality of the UBC-GIF inversion codes and allow incorporation of multiple geophysical data types while ensuring consistency between the different physical property models.

JOINT INVERSION OF GRAVITY AND MAGNETOTELLURIC DATA

Rachel Maier, Graham Heinson, Mark Tingay and Stewart Greenhalgh*
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We have developed a joint inversion methodology that simultaneously inverts gravity and magnetotelluric (MT) data to yield a unified density and conductivity model. Individual inversions of gravity or MT data can produce highly varied models that fit the data equally well. Joint inversion helps to reduce this ambiguity without having to introduce external constraints. The integrated models also allows for more rigorous interpretations.

The difficulty with joint inversion is how to link the different data sets. A petrophysical approach can be used which links density and conductivity through a connecting formula. Often there is no physical basis for the relationship to link these parameters and empirical formulas typically only apply to limited environments or over a limited range of the model. We used the structural approach, which is based on the premise that the geological conditions that control changes in density also effect conductivity. This means changes in density should coincide with changes in conductivity. The benefit of this approach is that it can be extended to all compatible techniques and multiple datasets.

There are many applications for simultaneously inverting gravity and MT data. In particular, MT is being increasingly used in geothermal exploration as a cost effective way to determine the depth to 'hot' rocks, and it can be easily combined with widely available gravity datasets to give an improved understanding of subsurface structure. Furthermore, joint inversion of gravity and MT data is widely applicable to deep crustal investigations and in the determination of basin structure in petroleum exploration.

Day 1 Session 2 Stream 3

Geothermal Geophysics 1

KEYNOTE ADDRESS: JOINT GEOPHYSICAL IMAGING FOR FRACTURED RESERVOIRS

Peter E. Malin
Institute of Earth Science and Engineering, University of Auckland, New Zealand
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Seismic and electromagnetic wave fields in the accessible (drillable) earth both respond to changes in rock properties and structure, yet are not usually combined into a single subsurface map that reflect these common changes. Variations in layer thicknesses, folds, faults, fault-related offsets, porosity, fluids, and saturation create anomalies in both fields. The presence of oriented fractures and fabric adds anisotropic responses to both as well. Ideally, both fields would be used to create a map that combines their responses to a sought after property, say porosity, in a single 'joint geophysical image'. The members of the Institute of Earth Science and Engineering are working toward such JGI maps, progress in which is reported on in this presentation.

A simple example of JGI is the inversion of high-resolution seismic refraction and magnetotelluric data collected over a simple layer-over-basement structure. Here the common factor is the layer thickness, the value of which is most accurately found forcing the seismic velocity and apparent resistivity models to give the same number. A less simple example is the combined use of seismic travel times and MT resistivity converted to seismic velocity to locate microearthquakes. An even more complicated example is the inversion of shared S-wave-splitting and MT-polarisation effects from zones of oriented and fluid-filled fractures.

Some of theoretical and practical aspects of these three cases will be discussed, including: (a) data gathering techniques, (b) physical models of the shared properties, especially in the case of fractures and anisotropy, and (c) quantitative methods for combining measurements.

HOT ROCKS IN AUSTRALIA – NATIONAL OVERVIEW

Barry A. Goldstein[1,3], A. J. Hill[2,3] and A. D. Long[3]*
[1]Australia's Executive Committee Member to the IEA'S Geothermal Implementing Agreement
[2]Australia's Alternate Committee Member to the IEA'S Geothermal Implementing Agreement
[3]Petroleum and Geothermal Group, PIRSA, Adelaide, Australia
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Australia's hot rock and hydrothermal resources have the potential to fuel competitively-priced, emission free, renewable baseload power for centuries to come.

Expenditures for studies, geophysical surveys and drilling that comprise the work programs required to sustain tenure in these 366 geothermal licences areas in the term 2000–2008 total ~AUS$200 million. The forecast expenditure for 2009–2013 is an additional AUS$800 million), taking expectations for investment for proof-of-concept geothermal projects to more than AUS$1 billion. This figure excludes up-scaling and deployment projects assumed in the Energy Supply Association of Australia's scenario for 6.8% (~ 5.5 GWe) of Australia's base-load power coming from geothermal resources by 2030.

This astounding level of investment in pre-competitive geothermal projects is driving sector-wide cooperation to support high priority and complementary research that can speed the pace and lower the cost of commercialising Australia's vast Hot Rock (HR) and Hot Sedimentary Aquifer (HSA) geothermal plays.

Companies are targeting resources that fall into two categories: (1) hydrothermal resources in relatively hot sedimentary basins; and (2) hot rocks. Most exploration efforts are currently focused on hot rocks to develop Enhanced Geothermal Systems (EGS) to fuel binary power plants. Roughly 80 percent of these projects are located in South Australia.

This paper summarises research priorities and studies undertaken under the umbrella of the Australian Geothermal Energy Group's 10 Technical Interest Groups and proof-of-concept projects co-funded by investors and government. It also describes the geology, challenges, investment risk assessment and promising future for hot rock geothermal energy projects in Australia.

IN SEARCH OF HOT BURIED GRANITES: A 3D MAP OF SUB-SEDIMENT GRANITIC BODIES IN THE COOPER BASIN REGION OF AUSTRALIA, GENERATED FROM INVERSIONS OF GRAVITY DATA

Tony Meixner and Fiona Holgate*
Geoscience Australia, Canberra, Australia
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The Cooper Basin region, straddling the border between South Australia and Queensland, consists of Carboniferous and older basement, blanketed by younger Cooper Basin and Eromanga Basin sediments. High geothermal gradients and the discovery by Geodynamics Limited of the Habanero geothermal play, has resulted in an increase in exploration for geothermal resources in the region. This study uses the Habanero play, consisting of a high heat producing, low density granite, buried beneath thermally insulating sediments, as an exploration model to identify other potentially high heat producing buried granites. The study, covering a 300×450 km area, was conducted as part of the Onshore Energy Security Program's Geothermal Energy Project, of Geoscience Australia.

The known basement granites are typically of lower density than the surrounding basement and may, therefore, be delineated by inversion of gravity data. The inversion model was geologically constrained using existing 3D surfaces constructed from seismic reflection surveys and well data, which define the spatial extent of the overlying sediments. Densities for the sediments were estimated from a seismic refraction survey. The resulting inversion, consisting of a 3D mesh of density values that satisfy the observed gravity data, produced regions of lower densities within the basement, some of which were predicted from well intersections of known granites. Assigning typical densities for known granites for the newly identified low density regions provided further model constraints in subsequent inversions that allowed the delineation of the depth extent, and therefore, the volume of the newly interpreted granites. This granite model will form the basis for future thermal modelling.

Day 1 Session 2 Stream 4

MINERALS

Case Studies 1

CARRAPATEENA: PHYSICAL PROPERTIES OF A NEW IRON-OXIDE COPPER-GOLD DEPOSIT

Lisa Vella[1] and Don Emerson[2]*
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Carrapateena is a new, Olympic Dam–style, iron-oxide copper-gold deposit, located approximately 160 km north of Port Augusta, within the eastern margin of the Gawler Craton, South Australia. Discovery of Carrapateena, in 2005, by RMG Services Pty. Ltd. and subsequent exploration by joint venture partner, Teck Cominco Australia Pty. Ltd., has demonstrated strong similarities with Olympic Dam, albeit at a smaller scale. It is now known that significant copper-gold mineralisation exists at Carrapateena (for example, drill hole CAR050 intersected 905 m @ 2.1% Cu and 1 g/t Au), but the overlying 470 m thickness of moderately conductive Stuart Shelf sediments presents significant technical challenges to exploration. Therefore, a solid understanding of the physical properties of both cover sequences and basement rocks is critical.

To this end, extensive laboratory petrophysical testing has been carried out on drill core samples, with measurements comprising mass properties (density, porosity), inductive properties (magnetic susceptibility, inductive conductivity), galvanic electrical measurements (resistivity, IP effect), natural remanent magnetisation and P-wave velocity. Electrical anisotropy of the cover sequences has also been investigated.

Results have demonstrated the petrophysical characteristics of basement samples from Carrapateena are dominated by the presence of iron-oxide, mainly hematite, with magnetite and sulphides playing a lesser part. Separation of the responses from the iron-oxides, iron-sulphides and copper-sulphides, in a practical sense, will be difficult and this has implications for the interpretation of geophysical survey results, particularly gravity and electrical techniques. Significant electrical anisotropy within the cover sequences represents a further complicating factor.

REVIEW OF THE JAGUAR CU-ZN-AG VOLCANOGENIC MASSIVE SULPHIDE DISCOVERY AND SUBSEQUENT GEOPHYSICAL TRAILS: A TRUE BLIND GEOPHYSICAL DISCOVERY BENEATH DEEP CONDUCTIVE OVERBURDEN

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Jaguar is a Cu-Zn-Ag volcanogenic massive sulphide (VMS) deposit approximately 300 m below surface, located approximately 5 km south of the historic Teutonic Bore VMS deposit in Western Australia.

Jaguar was discovered in 2001 by the Canadian exploration company INMET Mining in joint venture with Pilbara Mines of Australia. INMET Mining sought out the Teutonic Bore tenements in their search for a world class massive sulphide deposit and proceeded with an aggressive exploration program which included extensive fixed-loop EM (FLEM) surveys using the surface Crone PEM system developed in Canada.

The first drillhole directed into a long strike length FLEM anomaly (TBD202) intersected massive sulphides, and became the Jaguar discovery hole. Subsequent drilling and downhole EM (DHEM) surveys further refined the target and aided resource drilling. The mineralisation starts 300 m below surface but surrounding the mineralised zone are several shale and sediment horizons, which are also strong electromagnetic conductors and add to the complexity that need to be considered when assessing the effectiveness of the different geophysical techniques that have now been applied.

FLEM, MLEM, DHEM, DDIP and airborne magnetic and EM surveys have now been completed over the Jaguar deposit and within the Jaguar to Teutonic Bore mine corridor.

This paper reviews and evaluates the results from each survey and highlights issues that are apparent when exploring for deep VMS deposits under cover.

TOWARDS DIRECT DETECTION OF GOLD BEARING ROCK FORMATIONS FROM SEISMIC DATA, ST. IVES GOLD CAMP, WESTERN AUSTRALIA

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The utilisation of seismic methods for mineral exploration in Western Australia has become widespread in the last few years. The use of seismic data has been primarily structural interpretations only. Lithological interpretations require introduction and testing of new methodologies such as inversion and attributes analysis. While these techniques are considered mature by hydrocarbon standards, their application in hard-rock environments still requires extensive study to verify results.

Challenges to hard-rock seismic methods begin with acquisition where factors such as remoteness, inaccessibility and environmental restrictions, result in seismic lines being misaligned with dip of the dominant structures. Massive shear zones, faulting, folding and dyke intrusions, common for these areas, result in complex subsurface structures which compound seismic images. The regolith, a near surface zone up to 150 metres thick comprised of altered, transported and weathered material causes energy dissipation and time delays in seismic mapping of hard rock environments. The lack of borehole data with sonic logs further contributes to the difficulty of seismic data calibration.

Preservation of amplitude, frequency and phase of original signal is a prerequisite for inversion and attribute analysis. The complex structure seen in mineral exploration in Western Australia makes this task cumbersome. Inherently low signal to noise ratio and variable receiver and source ground coupling, presents a problem for true amplitude processing of hard rock seismic data. Each of the challenges facing hard-rock seismic however has a systematic solution. Lithological interpretation by directly relating seismic impedance and attributes to various rock formations in contact is possible with rigorous research.

Day 1 Session 2 Stream 5

MINERALS

Regional Studies (New South Wales)

CARBONIFEROUS–PERMIAN? VOLCANIC PLUGS IN THE BALRANALD REGION, NSW

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The New Frontiers exploration initiative of the NSW government has commenced the interpretation of regional geophysical datasets for the Ana Branch, Pooncarie, Booligal, Balranald, Hay and Deniliquin 1:250 000 map sheet areas. The aim is to encourage exploration to frontier areas of NSW by extrapolating the geology beneath covered areas using regional aeromagnetic, gravity, radiometric, Landsat7, seismic and borehole stratigraphy datasets.

The Balranald 1:250 000 map sheet area, which was predominantly interpreted using Total Magnetic Intensity (TMI) data and 1VD TMI data, is the second area to be interpreted over the Murray Basin. Outcomes of this interpretation are:

- Magnetic volcanic plugs intrude the basement and are possibly Carboniferous–Permian in age. The cover thickness over these modelled plugs ranges from 200 to 500 m, but this needs to be confirmed with drilling. Similar plugs occur on the Hay 1:250 000 map sheet area.
- Silurian–Devonian basement of the Hay–Booligal Zone contains numerous interpreted, deep, NNW–SSE trending, weakly magnetic dykes.
- Remarkably elongated, Silurian–Devonian granites with metamorphic aureoles occur at the termination of the Bendigo Zone.
- 300–700 m of cover consisting of poorly consolidated alluvial sands, including the Pliocene Loxton–Parilla Sands, contains economic heavy minerals placers that are currently under extraction.
- That the gold-rich Stawell Zone in Victoria extends into NSW

Results of this study are expected to increase exploration interest in the extension of the Stawell Zone into NSW. The volcanic plugs in the Balranald and Hay areas may have some potential for gemstones.

THOMSON OROGEN – DEVELOPMENT OF AN INTEGRATED GEOLOGICAL/GEOPHYSICAL INTERPRETATION

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The Thomson Orogen, which underlies the Channel Country in far northwest New South Wales and is a major, largely unknown orogen that is overlain by the Mesozoic–Tertiary Eromanga Basin. The orogen has potential for arc- and ocean-crust-related gold and base metal deposits while the northern part of the Lachlan Orogen, immediately the south of the orogen, may have potential for Mississippi Valley style zinc and lead deposits. The prospective targets are obscured by variable thicknesses of Mesozoic and Cainozoic sedimentary units.

The objective of this project is to develop a better understanding of the tectonic setting and mineral potential of the Thomson Orogen. An integrated geoscience program has included acquisition of 170 000 km of high resolution aeromagnetic and radioelement data; 300 km of deep seismic data; 5000 new gravity stations; regolith mapping through classification of satellite data; review of past and present company data; baseline geochemistry; stratigraphic drilling; and studies of lithofacies, age data, geochemistry and petrology from selected drill core acquired by exploration companies. The data are the basis for the new Thomson Orogen GIS.

The first stage of this integrated study has been completed and indicates that the Thomson Orogen formed in a convergent margin setting that has many similarities to the mineral-rich Lachlan Orogen.

In conjunction with CRCLEME, an Explorers' Guide has been developed to assist mineral exploration in this regolith dominated terrane.

GEOPHYSICAL EVIDENCE FOR 'BLIND' MAGMATISM ASSOCIATED WITH DEVONIAN RIFTING, LACHLAN OROGEN, NEW SOUTH WALES

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The Silurian–Middle Devonian history of the Lachlan Orogen is characterised by the formation of rift basins and the emplacement of large amounts of granite. Many rift basins contain felsic or mixed felsic and mafic volcanic rocks, indicative of crustal as well as mantle melting being involved in lithospheric extension. However, there are several large rift basins that are filled by siliciclastic sedimentary rocks in which volcanics occupy << 1% of the basin fill and may be buried. For the latter basins the question is: was rifting amagmatic, or are products of melting present at depth below the surface, either in deep basin sediments or in basement below the basin.

We attempt to address this question for sedimentary basins in the Cobar–Louth region of western New South Wales. For the Late Silurian–Early Devonian Cobar Basin, we use 1989 explosion–generated seismic reflection data that have been reprocessed using a new semblance filtering technique to improve the data quality. For the Nelyambo Trough, part of the Devonian Darling Basin in western NSW, we used Vibroseis deep seismic reflection data recently acquired in cooperation with Geoscience Australia and the Predictive Mineral Discovery Cooperative Research Centre. Gravity profiles were acquired along the Cobar lines. For the Nelyambo Basin, data were extracted from a statewide dataset to match the seismic lines. The combined seismic and gravity data sets suggest that bright reflectors in the seismic sections represent mafic volcanics. These reflectors lie within inferred rift fill near the base of the Nelyambo Trough, but also occur in basement under the southwestern margin of the Cobar Basin.

13:30–15:00
Day 1 Session 3 Stream 1

PETROLEUM

Seismic Acquisition and the Environment

KEYNOTE ADDRESS: SEISMIC SURVEYS AND MARINE LIFE: WHY IS IT SO DIFFICULT TO LET THE SCIENCE SPEAK?

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The offshore oil and gas exploration industry in Australia (and worldwide) has conducted extensive research and monitoring programs which have provided valuable insights into the nature of seismic signals in different water depths and the behaviour of marine animals such as whales, dolphins and fish in the vicinity of seismic surveys. Despite this, we in Australia still have to operate marine seismic surveys under a set of protocols covering the interaction between seismic surveys and whales that are the most stringent (over-precautionary?) in the world.

Why can this be so? If all regulators and all interested parties are looking at the same body of science:

(i) Why are the protocols for interaction between seismic surveys and whales not consistent throughout the world and
(ii) Why is the seismic industry accused of adversely impacting marine life when, after 40 years of marine exploration using airgun arrays, there is no real evidence of this?

This presentation briefly describes the results achieved from using such techniques as towed PAM (passive acoustic monitoring), seabed acoustic loggers, shipboard observations (synthesis of MMO data), aerial surveys, etc.

It then explores the main reasons why the industry finds it so difficult to get its message across. These include the lack of awareness of many geophysicists, asset managers and companies about the challenges involved in acquiring seismic data in the first place, the complexity of the science, the difficulties involved in collating it into a meaningful result, the fact that the science is often interpreted or portions of it selected by those who have a biased opinion (as opposed to panels that provide a balanced view) and the reluctance of many companies in the industry to challenge the often emotive and inaccurate accusations by some environmental groups and the media.

LOWER IMPACT SEISMIC REFLECTION – TRIALLING ENVIROVIBES IN THE SURAT BASIN

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Reducing the social and environmental footprint of land seismic operations continues to drive a demand for lower impact recording methods and equipment. We demonstrate that lightweight vibrators offer several advantages in this regard and are a viable seismic source for imaging both coal seam gas (CSG), and moderate-depth conventional targets in the Surat-Bowen Basin, Queensland.

In early 2008, Origin Energy Ltd acquired several 2D trial seismic lines using two IVI Envirovibes, each with a 15 000 lb maximum peak force, mounted on a 17 000 lb, six metre long articulated 'minibuggy'. These trials confirm that the Envirovibe source is capable of imaging targets at depths from less than 300 m to over 3000 m. Processing of the first 2D line produced a section with signal-to-noise ratio and bandwidth similar to that from an intersecting line acquired in 2005 using two 44 000 lb vibrators and much higher sweep effort.

Various sweep tests were conducted prior to the acquisition of each trial line, in order to optimise source effort and examine the potential benefits and limitations associated with these smaller vibrators. In each instance, a single 6 to 8 second sweep, using both vibrators, provided adequate record quality. A trial using a single vibrator produced an almost equivalent stack. Similarly, a reduction in vibrator peak force (e.g. from 70% to 30%) also caused surprisingly little degradation of record or stack quality. First breaks appeared cleaner and sharper than those obtained using the heavier vibrators, increasing confidence in the computed static corrections.

The results of these experiments suggest that the ratio of signal to coherent noise in this case is largely independent of source effort, and that the use of lightweight vibrators and short- duration, single-sweep recording is unlikely to degrade stack quality.

MINIMAL-IMPACT SEISMIC ACQUISITION: SUCCESSFUL IMAGING USING AN ACCELERATED WEIGHT DROP SYSTEM

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The first onshore seismic survey in the Kingdom of Cambodia commenced in 2008. In addition to this reconnaissance 2D seismic program surrounding a region of global environmental significance, it lies within an area of significant risk due to mines and unexploded ordinance (UXO), and passes through a number of local communities. An accelerated weight drop system was deemed the most appropriate seismic source to handle the logistics of working through village areas and around UXO whilst minimising the footprint of the survey on the local ecosystem.

Comprehensive infield testing has helped optimise seismic acquisition parameters and satisfy the geophysical objectives of the survey. Contrary to previous accelerated weight drop studies, little difference is observed in data records from the first and subsequent thumps of the source. The well-compacted road surface along which most of the survey is being conducted is believed to provide excellent coupling for the base plate. However, traffic on roads is also a source of non-seismic noise. Consequently multiple thumps are required at each source location to maintain acceptable signal-to-noise ratios. Four drops at each source location are deemed a good compromise between data quality and daily production. A high fold also contributes to the reduction of random and other non-seismic noise.

The 2D seismic profiles derived from this survey are serving as constraints for the interpretation of locally-available gravity data, and will help to prioritise subsequent hydrocarbon exploration initiatives.

Day 1 Session 3 Stream 2

PETROLEUM

Seismic Processing and Modelling

SHALLOW WATER 3D SURFACE-RELATED MULTIPLE MODELLING: AN AUSTRALIAN WATERS CASE STUDY

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The efficiency of multiple attenuation techniques depends on how shallow and how structurally complex the sea floor is. In shallow water environment comes a point where the sea floor is theoretically too shallow for Surface Related Multiple Elimination (SRME) techniques to efficiently model all multiples.

In this Bonaparte basin case study we look at a range of multiple attenuation techniques. 3D surface related model-based modeling technique (3D SRMM), 2D SRME and predictive deconvolution are applied to water depths ranging from 100 ms to 500 ms. Attempts at identifying the reasons for successes or failures at different water depths are made and conclusions drawn on to which of the three or combination of the three methods was the most efficient for a given water depth.

Through this Australian case study, are SRME/SRMM methods still efficient in shallow water depths compared to predictive deconvolution, is the first aspect we analyse. The second aspect looks at the relative efficiency of fully data driven 2D SRME versus 3D surface related model-based modeling technique (3D SRMM) in this shallow and structurally non-complex water bottom environment.

TRANSIENT SOLUTION FOR VISCOACOUSTIC WAVE PROPAGATION IN A DOUBLE POROSITY MEDIUM AND ITS LIMITATIONS

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The double porosity model was developed by Pride and Berryman to model acoustic wave propagation through heterogeneous porous structures. In this theory, an internal fluid transfer model accounts for the wave attenuation caused by mesoscopic heterogeneities. However, it is very difficult to analytically solve the governing equations for a macroscopic heterogeneous double porosity medium. We have applied a poro-viscoacoustic model to numerically approximate the solution, since in such a model wave propagation can be simulated in the time domain through the introduction of memory variables. The constitutive equations are approximated by the standard linear solid. By comparing the analytical transient solution and dispersion characteristics of the double-porosity model with those of the poro-viscoaoustic model for a homogeneous medium, we found that the dissipation mechanism of local fluid flow of the double porosity model is very hard to be fit over the entire frequency range by a single

Zener element. However, in seismic exploration we are normally restricted to a fairly narrow frequency band. This means that for frequency-dependent material properties, such as attenuation, the values around the centre frequency of the source will primarily determine the wave propagation characteristics. Therefore, we can choose the relaxation function which just approximates the dispersion behaviour of the double porosity model around the source centre frequency. When the frequency is much lower than the peak attenuation frequency of the double porosity model, wave propagation can be well described by the poro-viscoaoustic model. For most water-filled sandstones having a double porosity structure, this holds true across the seismic frequency range. As an illustrative example, we compute the wave field in a two layer, water-saturated double porosity sandstone model.

TIME SERIES PREDICTION USING ITERATIVE PHASE ESTIMATION

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For prediction, and particularly in predictive deconvolution, Weiner's approach has been used extensively in the seismic industry. In spite of the importance of phase in the prediction process (Urlych, 2008), approaches explicitly utilising phase have received scant attention, due to the non-intuitive nature of phase.

An approach to seismic prediction has been developed which explicitly focuses on the phase of the predicted time series, without having to unwrap this phase. This technique assumes a slow temporal variation in the amplitude spectrum as a sampling window is advanced forward over the time series. By explicitly separating the amplitude and the phase, the non-linearity of the problem to predict phase component can be linearised using iterative least squares analysis.

Having calculated the phase, the amplitude component can be estimated - giving the predicted time series of the advanced window. Subtracting the predicted values from the observed data removes those components within this time series that are predictable, such as multiples.

Day 1 Session 3 Stream 3

Geothermal Geophysics 2

IMAGING A POTENTIAL GEOTHERMAL TARGET USING MT ISA REGIONAL SEISMIC REFLECTION AND POTENTIAL FIELD GEOPHYSICS, QUEENSLAND, AUSTRALIA

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Geoscience Australia acquires seismic reflection data across major crustal boundaries in key areas of Australia to provide an increased understanding of crustal structure. Approximately 820 km of 2D regional seismic reflection data over 6 transects were collected in the Mt Isa region of Queensland, in 2006. One of these transects was located approximately 190 km to the south-west of Mt Isa, with a general SW to NE orientation and line length of approximately 156 km. The northern end of the transect lies in gravity and magnetic lows of regional gravity and magnetic maps. The seismic data shows three distinct sedimentary reflection packages from 0 to 1 s. The lowermost sedimentary section consists of fragmented reflections that displayed numerous reflection hyperbola pre-migration, indicating a potentially highly fractured zone. A highly fractured carbonate sequence is expected to be present in the area, with an age that places it below the two upper more continuous sedimentary packages. The depth to the base of the sediments is approximately 2.5 km. Below the sediments, the seismic reflections end abruptly and there exists an area where only a few scattered reflections could be imaged. This extends mainly from 1 to 4 s, approximately 2.5 to 12 km depth. The abrupt end to seismic reflections and the gravity and magnetic lows suggest this may be a large granite body, a potential geothermal target, situated beneath sediments. The extent of the granite body can be inferred from the regional gravity map.

FORWARD PREDICTION OF SPATIAL TEMPERATURE VARIATION FROM 3D GEOLOGY MODELS

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Collaborative work is under way to develop an accessible method for rapid calculation of the spatial variation of temperature directly from a 3D geology model. The need for a tool of this nature stems from Australia's emerging geothermal energy exploration and production industry. The prohibitive cost and huge task involved in acquiring comprehensive sets of heat flow data, means that the ability to accurately model heat flow at surface, and/or predict 3D temperature distribution for a modelled part of the crust, will be key to supporting this industry, and possibly others. Here we explain the approach we have taken. The Mt Painter region in South Australia is used as a case study to showcase the developments.

This paper presents: (1) a summary of the relevant theory of heat flow, (2) an explanation of how it was implemented, (3) justifications for the assumptions and simplifications we currently make for the Australian geological setting, (4) a unit test report from the proto-type code, and (5) a brief overview of the Paralana geothermal energy exploration project (South Australia) – the subject of a 3D geology model built to validate the technique. Providing a sophisticated way to forward model temperatures from 3D geology models is possible via the marriage of the new geothermal software module, with an existing 3D model building application: GeoModeller (developed by Intrepid Geophysics and BRGM). While other software packages currently have thermal modelling capacity, the strengths of using GeoModeller as the platform are that it rapidly builds fully 3D geology models constrained by diverse datasets and observations. Starting from such a comprehensive 3D geology model (in which the geological units may be attributed), means higher accuracy will be possible when predicting the final temperature distributions. The temperature calculations can be made on generic 3D voxet models as well as those built in GeoModeller.

INNOVATIVE GEOPHYSICS AND THE GREEN REVOLUTION

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With the increasing pressure on the world's hydrocarbon resources, alternative sources of energy are being investigated and established. At the forefront is wind power and more specifically offshore wind. Many developers investing in this new technology are land based utility companies and to many the concept of installing structures at sea is quite alien. They have therefore turned to the oil sector for advice, resulting in not only a transfer of technology but an acceptance of alternatives which also embraces the realms of geophysics. As the offshore wind industry evolves, developers are being faced with more stringent requirements to achieve development consents, specifically those of an environmental and archaeological nature. These new demands have to be taken into serious consideration when designing a site investigation survey and innovative methodologies have to be applied. By presenting data from the United Kingdom and Irish Round 1 and 2 wind farm sites, this paper will provide a brief overview of the European offshore wind industry and how well designed geophysical surveys, utilising the latest technology is aiding the developers in their geotechnical investigations, foundation design, archaeological and UXO investigations resulting in the establishment of safe, and fit for purpose sites.

Day 1 Session 3 Stream 4

MINERALS

Comparisons of AEM Systems

AN OVERVIEW OF HELICOPTER TIME-DOMAIN EM SYSTEMS

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A number of helicopter time-domain EM (heli-TDEM) systems have been introduced to the exploration industry over the last decade. This paper gives an update on these systems including AeroTEM, HeliGEOTEM, SkyTEM and VTEM. RepTEM and a new system. The optimum application of these AEM systems is determined by their geometries, data bandwidths and dipole moments.

AeroTEM is a rigid and relatively heavy system measuring x- and z-component data at the centre of the transmitter loop. The transmitted waveform is triangular in shape, which, combined with an induction coil receiver, results in a pseudo B-field square-wave response being recorded. AeroTEM's on-time data allow for the detection of highly conductive bodies undetectable with off-time data, which is demonstrated by field data from the Shabogamo prospect, Labrador, Canada.

HeliGEOTEM measures the 3-component EM response excited by a transmitted half-sine waveform. Due to the receiver being offset from the transmitter centre, the x- and z-component data can be inverted independently for a layered-earth model.

RepTEM is a medium power system, operated by GPX and very similar in design to HoisTEM, the system it replaced. It measures the off-time z-response due to a square pulse at the centre of the transmitter loop. Modelling results of the shown RepTEM data successfully outline the location of palaeochannels in an exploration area in South Australia.

SkyTEM records the x- and z-component EM responses due to high- and low-moment pulses, that are transmitted sequentially. This allows good resolution of the near-surface as well as good depth penetration. Field data acquired for a land-management survey in South Australia compare well with other high resolution ground and airborne EM data.

The VTEM has the highest moment of the available helicopter EM systems. It measures the z-component at the centre of the transmitter loop and the latest upgrade allows for the derivation of B-field data from the recorded full-waveform dB/dt data. VTEM data has reportedly indicated mineralisation at depths of more than 500 m below the surface. The shown field data from the Caber deposit, Quebec, Canada indicates the mineralisation at a depth of 150 m.

EXAMPLES SHOWING CHARACTERISTICS OF THE MEGATEM AIRBORNE ELECTROMAGNETIC SYSTEM

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The power of the MEGATEM system has doubled to approximately 2 000 000 Am^2. A comparison of systems with different power at the Reid-Mahaffy test site clearly demonstrates how a larger power improves the shape and amplitude of the anomaly.

A height attenuation test over the Iso ore body has been used to estimate the signal and noise levels of the system. Subsequent modeling indicates that the same relatively small body would be identified when buried 250 m deep. A test survey over a much larger body buried 700 m deep at Shea Creek illustrates that this body is clearly visible in a highly resistive environment. A nearby comparison with the TEMPEST system shows that MEGATEM can see significantly deeper.

Tests at Gallen were conducted with both the transmitter on and off. The test with the transmitter off show that the signals radiated from a nearby power line can be a significant source of noise. Recent improvements to the algorithms for rejecting power-line noise show a significant reduction in the amplitude and width of the noisy zone, making it easier to identify true anomalies close to the power line.

A comparison of a MEGATEM survey with an older survey in an area near the Chibougamau district indicated that the MEGATEM system was able to see 25% more anomalies than the older system. Many of these anomalies were from smaller or shallow bodies, but about 500 were estimated to come from sources well beyond the depth of exploration of the older systems.

RESULTS OF VARIOUS AIRBORNE EM SYSTEMS OVER A TARGET OF HIGH CONDUCTANCE

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The ability to detect and characterise targets of high conductance (>1000 S) has become a primary technical criteria for airborne

EM surveys being flown in the course of the exploration of sulfide nickel-copper deposits. A variety of commercial airborne EM systems have flown over the same high conductance target as well as prototype dual aircraft system called Gemini. These results show what the current capabilities are of the various systems and as well, what type of future technology is required to significantly improve the high-end conductance aperture of airborne EM technology.

Day 1 Session 3 Stream 5

MINERALS

Potential Field Inversion

PARETO OPTIMAL 2D JOINT INVERSION OF GRAVITY AND MAGNETIC DATA

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Inverse modelling of gravity/or magnetic data is an essential component in geoscience research, to help determine the distribution of physical properties within the earth. Various numerical techniques for solving potential field inverse problems have evolved over many years. However, solving the non-uniqueness in inversion and the uncertainty in subsequent model building still remain elusive. The use of additional independent information as soft constraints should help with the non-uniqueness. Does the joint inversion of gravity and magnetic data help this situation? Unfortunately, it often turns out that the constraints of joint inversion of gravity and magnetic data are no longer soft. It becomes more difficult to obtain optimal solutions that honour both data sets, which are two mutually competitive members. To help resolve this problem, the Pareto optimal solution from the solution space is chosen. Between two competitive members such a solution guarantees making one member better off without making other member worse off. The L_2-norm measure of fit between observed and computed data is considered in the use of particle swarm optimisation (PSO). This is a global optimisation technique to minimise the misfit between observed and computed data. The Pareto front is determined, and hence the Pareto optimal solution from the cluster solutions in the solution space. The method is applied in delineating architectural settings of Dunmarra sedimentary basin of Northern Territory.

MAXIMISING GEOLOGICAL INFORMATION RECOVERY FROM DIFFERENT MAGNETIC INSTRUMENTS THROUGH THE APPLICATION OF JOINT INVERSION

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The introduction of new magnetic instruments such as cross-wing gradiometers, vertical gradiometers and full tensor SQUID magnetometers has presented new challenges for interpretation and geophysical inversion. In particular, the full tensor magnetometer presents many new challenges for an interpreter where only the vertical derivative of the vertical magnetic component presents a useful geological analogue for visual interpretation. With six channels of information how do we make practical use of the other five channels which implicitly contain useful information about the 3D distribution of magnetic properties?

Joint inversion of all six channels is the logical solution whereby the data is inverted directly to a 3D magnetic susceptibility model. When compared with the scalar amplitude of the total magnetic intensity measurement, the magnetic tensor has valuable 3D information. For example just a few samples can provide sufficient information to immediately determine if an igneous pipe is on the left or right side of the flight line. A few more samples can locate the position and depth of a pipe that is off to the side of a flight line.

Joint inversion can be used with various combinations of sensors and derived parameters. For example a cross-wing total magnetic field gradiometer can be used with the centre point total field value to derive important off-line geological information. The first vertical derivative derived from gridded data can be combined with total magnetic intensity measurement for two channel joint inversion to optimise the quality of depth, width, dip and depth extent inversions.

Examples are provided to illustrate the improvement in geological information extraction when compared with single channel inversion of total magnetic intensity data. The methods provide new opportunities to look at the latest generation of instruments and new ways to look at old surveys.

AN AUTOMATED SPARSE CONSTRAINT MODEL BUILDER FOR UBC–GIF GRAVITY AND MAGNETIC INVERSIONS

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Inversion of geophysical data seeks to extract a model, or suite of models, representing the subsurface physical property contrasts that can explain an observed geophysical dataset. The most desirable solutions are those that can also reproduce known geological features; a goal that can only be achieved by including any available geological information into the inversions as constraints.

A new procedure has been developed to quickly and automatically generate geological constraints for UBC–GIF gravity and magnetic inversions based only on the available geological observations where those observations occur. With known geology imposed in some areas, inversions are applied to fill in intervening areas with a prediction of the physical properties required to explain the observed geophysical response. This sparse data approach is particularly suited to problems where geological information is limited, sparsely distributed or concentrated within restricted areas such as known ore bodies or along the ground surface.

The technique outlined here builds constraints from sampling, surface geology maps, drilling geology logs and physical property logs. It can also include optional interpretive information from basement geology maps, depth-to-basement interpretations and 3D geological models. The available geological information can also be extrapolated a short distance outwards based on observed structural orientations. The routine outputs appropriate constraint model files ready for inversion and those constraints can be quickly updated as new geological data becomes available.

15:30–17:30
Day 1 Session 4 Stream 1

PETROLEUM

Interpretation/Case Histories

FIVE POPULAR PITFALLS IN SEISMIC AMPLITUDE INTERPRETATION

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Seismic amplitude interpretation has come a long way since the early attempts at 'bright spot' analysis in the Gulf of Mexico. Many excellent training courses, papers and books exist on the subject yet somehow the true value of this technology is rarely realised in modern oil companies. I've observed the same mistakes made over and over again by seismic interpreters, geologists, managers and even geophysicists. The most popular pitfalls appear to be grouped into five themes:

(1) Understanding what can be inferred from seismic amplitudes for the target interval;
(2) Understanding what cannot be inferred from seismic amplitudes;
(3) Undue focus on a single or favoured attribute;
(4) Allowing an amplitude study to become a 'sideshow';
(5) The 'human factor', or overcoming the diehard sceptic.

I've borrowed examples from amplitude studies conducted around the world to illustrate these pitfalls and how to avoid them. The examples highlight a need to integrate better with the geology (and geologists) when attempting to calibrate the seismic amplitude response and also when updating prospect risk. If the first four pitfalls can be avoided, then eventually the fifth pitfall will cease to exist.

INTEGRATED POTENTIAL FIELD, FMI AND SEISMIC DATA INTERPRETATION FOR GEOMECHANICAL ANALYSIS OF THE ELK/ANTELOPE GAS FIELD

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The Elk/Antelope gas field was discovered during drilling of the Elk-1 and Elk-4 wildcat wells in the eastern Papuan Fold Belt. The gas field is located in a frontier greenfields area with limited wells, regional scale potential field data datasets and 2D seismic datasets of varying quality.

The Elk structure is a fractured carbonate reservoir while the Antelope structure is potentially a reefal carbonate reservoir with fracture control on permeability.

The integrated interpretation of potential filed, FMI and Seismic data has been conducted with the aim of investigating the relationship of faults, joints and folds to their likely movement sense and stress state within the current stress regime both within the gas field and the surrounding area.

The current SHmax from bore-hole break-out analysis at the Elk-1 and Triceratops-1 wells is SW/NE directed within a strike-slip stress regime. The main fault and or fold orientations in the region are N/S, NE-ENE/SW-WSW, SE/NW and E/W. The likely failure modes along these orientations are analysed.

The stress regime at the Elk-2 well exhibits a rotation of SHmax to ESE/WSW reflecting current faulting along a WSW/ENE striking fault. The relationship of fractures in the Elk-2 well is consistent with normal movement along this fault.

The kinematic history of the region is complex and has involved rifting followed by basement inversion and detatched thrusting. A full paleostress analysis of the area through its entire kinematic history is not possible with current datasets. However analysis of faults and joints in particular, to the current stress regime are important to building a geomechanical fracture model for the Elk/Antelope gas field.

GEOPHYSICAL STUDIES OF AUSTRALIA'S REMOTE EASTERN DEEP-WATER FRONTIER: RESULTS FROM THE CAPEL AND FAUST BASINS

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The Capel and Faust Basins in Australia's remote eastern offshore frontier, 800 km east of Brisbane in 1000–3000 m of water, are being studied as part of the Australian Government's Offshore Energy Security Program. This presentation will outline the current status of integrated interpretation of 2D seismic reflection data, sonobuoy refraction data and marine potential-field data.

In the remote eastern frontier region, negative residual gravity anomalies generally correlate with basins evident in seismic reflection data. The anomalies highlight elongate, roughly N–S-trending or arcuate depocentres, with limited strike extent, that are best developed in the north and northwest of the survey area where increased crustal extension appears to have occurred. Interpretation of seismic reflection data suggests the presence of four main syn-rift megasequence packages (?Early Cretaceous–?Santonian) and several post-rift sag packages (?Early Campanian–Recent). Maximum unequivocal depocentre thickness is ~4s TWT.

The 20–50 km separation between 2D seismic lines and the isolated nature of the basin depocentres complicates the process of linking structures between lines, but 3D mapping of faults and horizons is facilitated by the potential-field data. Instead of correlating with basement highs, reduced-to-pole magnetic anomalies may better reflect the distribution of volcanics and intrusives, variably evident as high-amplitude or low-frequency reflectors, and volcanic features at or near the seafloor. Forward and inverse modelling of the gravity and magnetic data in 3D is providing a means to characterise different basement terranes and to construct surfaces that represent the sequence boundaries within the depocentres.

Day 1 Session 4 Stream 2

MINERALS

Case Studies 2

APPLICATION OF GEOPHYSICS TO GOLD EXPLORATION IN GHANA: EXAMPLES FROM NEWMONT PROJECTS

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Ghana has been a producer of gold since the 16th century and today boasts one of the largest and richest reserves of gold in the world. The principal gold producing areas of Ghana occur within Palaeoproterozoic Birimian meta-volcanic and meta-sedimentary rocks, and within the marginally younger, overlying Tarkwaian meta-sedimentary succession. The giant 40+ million ounce (Moz) Ashanti deposit at Obuasi and 38+ Moz at Tarkwa are 2 monstrous gold deposits in Ghana. Other deposits include the Prestea/Bogoso (7 Moz), Konongo (2 Moz), Damang/Aboso (3 Moz), Bibiani (5 Moz) and Chirano (2 Moz).

Gold exploration in the past was primarily conventional stream sediment and soil sampling, followed by trenching and drilling. This methodology was used to discover a majority of the deposits. However, completely unexplored grounds in Ghana, where cursory, first-pass reconnaissance surface sampling methods lead to a major discovery, are virtually none existent. The modern phase of exploration calls for a more interdisciplinary approach involving the use of geophysics, geochemistry, and regolith mapping, as well as detailed structural and geologic observations. Newmont is one such company that integrates geophysics extensively in its gold exploration programmes in Ghana.

Some of the geophysical techniques used are airborne magnetics, radiometrics and electromagnetics. Ground based geophysical tools include gravity, magnetics and IP/Resistivity. Geophysical data are used to help with ground selection, direct drill targeting, and to help produce interpreted geology and regolith maps. Newmont Ghana has trained Ghanaian nationals to conduct a majority of the data collection, processing and interpretation. Several example data sets are shown.

3D IP AND RESISTIVITY FOR NICKEL EXPLORATION: CASE STUDY FROM WESTERN AUSTRALIA

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Geophysical exploration for nickel sulphides has historically focused on EM methods which rely on detecting interconnected bodies of sulphides, which in the case of surface data can often be complicated by responses from proximal/stratigraphic type conductors such as sulphide bearing sediments and/or conductive overburden.complex geology and strongly conductive overburdens have in the past limited the success of the IP method for exploration of nickel sulphides in the area. However, the increased depth penetration and resolution afforded through use of the MIM distributed acquisition system (MIMDAS) has resulted in accurate mapping of the mineralisation at the Green Dam nickel sulphide prospect, located approximately 120 km east-northeast of Kalgoorlie, Western Australia.

IP, DC Resistivity and MT data have been acquired using a three-dimensional array geometry which has enabled data interpretation using both two and three-dimensional inversion methods, leading to increased confidence in results. This has in turn improved geophysical interpretation and understanding of the variation in mineralisation along strike.

The results in the case study will show the IP data clearly map the dominant disseminated Ni-Cu-PGM sulphide mineralisation at Green Dam. The data have also accurately mapped the semi-massive to massive Ni-Cu-PGM sulphides and show a high degree of correlation with previously acquired moving loop TEM (MLTEM) and downhole TEM (DHTEM) data.

DEEP EXPLORATION TECHNOLOGIES FOR ILLUMINATING HIGHLY PROSPECTIVE GROUND IN THE SHADOW OF HEADFRAMES

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Brownfield mineral exploration activity is at a record high – driven by the dramatic rise in commodity prices and the old adage that, 'The best place to explore is in the shadow of a headframe'. Many companies have purchased 'old' mines to gain access to mineralisation that was 'missed' with previous generations of geoscience technologies and to assess new targets that may be nearby. Today, new deep geophysical technologies are assisting not only in exploration but also in ore delineation and mine development (ground condemnation).

Historically, however, it has been difficult to apply geophysical techniques around mines due to certain challenges. Cultural noise, scheduling, electrical noise, remoteness and resistance to new technologies are some of the traditional obstacles (to performing geophysical surveys in brownfield areas) that have been overcome with successful results.

One of the new technologies that has proven itself is deep electrical imaging—made available thanks to the Distributed Acquisition System (DAS) technology. DAS systems are characterised by a large multi-channel, fixed receiver array and several other factors that together contribute to improved depth of penetration, data quality and detectability.

In this paper, we review the components and capabilities of DAS systems, focusing on one system in particular as noted above, for brownfield work. Three case studies are presented, including two from porphyry copper environments in western Canada as well as a gold project from Bulgaria. These case studies represent the state-of-the art in geophysics for brownfield work and are a unique and novel application for today's DAS technologies.

RESULTS FROM THE FIRST FIELD TRIAL OF A BOREHOLE GRAVITY METER FOR MINING APPLICATIONS

Harold O. Seigel, Scintrex Ltd., Chris Nind, Scintrex Ltd., Jeff Macqueen, Microg-Lacoste Inc, Michel Chouteau and Bernard Giroux, Ecole Polytechnique*
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Scintrex is in the final stages of the development of a borehole gravity meter, for mining and geotechnical applications, designed to log inside NQ drill rods to 2000 m depth, using standard 4 conductor cable, with a sensitivity of better than 5 µgal, and operable in boreholes inclined from 30º to vertical. École Polytechnique of Montreal has developed forward modelling software, as part of this project.

The first field test of the prototype probe was successfully conducted in December 2008 for Vale Inco in a deep borehole located in Norman Township near Sudbury, Ontario. The results of this test show a large amplitude bipolar residual gravity anomaly, with the crossover at the location where the borehole intersected sulphides. Further analysis of the data is underway. A repeat log of the hole indicates that the Gravilog system has achieved operational specifications very close to its targets.

Field tests for the other sponsors are planned during the first half of 2009, with production surveys to follow during the second half of the year.

Gravity measurements inside boreholes provide evidence of density variations both in the immediate vicinity and at a distance from the hole. Scintrex's development of a new borehole gravimeter will, for the first time, allow the application of gravity logging in typical mining and geotechnical boreholes.

Primary applications of the Gravilog system in mining include the sensing and mass-estimates of massive sulphide bodies, either intersected by or remote from the hole and accurate bulk density measurements of formations intersected by the hole.

Day 1 Session 4 Stream 3

ENVIRONMENTAL

Airborne EM

FROM LITTLE THINGS, BIG THINGS GROW…. OR DO THEY? A ONE-EYED VIEW ON AIRBORNE EM IN ENVIRONMENTAL MANAGEMENT OVER THE LAST 20 YEARS

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Through the mid to late-1980s, the application of airborne electromagnetics for environmental management was limited to small surveys, and in Australia their primary purpose was aimed at encouraging the wide take-up of the technology by the natural resource management (NRM) community. This technology-led push fed off a growing national awareness of the threat of land salinisation, and AEM was principally marketed as the panacea to this threat. Unfortunately the early promises did not live up to expectations, in part reflecting the limitations of the technology at that time, particularly the inability to map conductivity reliably in the top 5 m of the land surface. Throughout the 1990s, applications continued on a piecemeal basis with small surveys being the norm. In the early 2000s, Federal Government-led initiatives, particularly the National Action Plan for Salinity and Water Quality, constrained by State representation, prompted a more considered, targeted approach for AEM applications. Projects in South Australia and Queensland revolutionised the way these technologies were used. Helping achieve this were significant developments in AEM system technologies, including the definition of system geometry and calibration, all contributing to the better definition of near surface conductivity. Coupled with advances in in data processing and inversion, the derived information has become much more relevant. Under the NAP some of the largest surveys ever flown in Australia have now been completed. Delivery of relevant products, not just maps of conductivity, which can be incorporated into predictive tools represent the way forward for AEM in environmental management.

SPATIAL MODELLING INCORPORATING AEM DATA TO SHOW THE EFFECTS OF MANIPULATING FLOW REGIMES AND GROUNDWATER LOWERING OPTIONS OVER THE CHOWILLA FLOODPLAIN, SA

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Along the floodplains of the Murray River in south eastern Australia, where the saline groundwater system is particularly close to the surface, evapotranspiration concentrates salt resulting in extensive salinisation, vegetation dieback or health decline. In many floodplain areas, ecologically important woodland species that inhabit the floodplain are dying from soil water salt concentrations that often exceed those of seawater. To better manage this problem and to protect the ecology and biodiversity on the floodplains along the river, a range of management strategies are being employed. Modelling tools are integral to their development, but key to their effectiveness is the availability of detailed biophysical data. In a study focussed on the Chowilla Floodplain in South Australia, we used WINDS, a spatial model that examines soil water availability, to show the possible effects of manipulating flow regimes and groundwater lowering options across the whole of the floodplain. We examine the value of using biophysical parameters derived from the helicopter electromagnetic (HEM) data, specifically groundwater conductivity and salt storage for specific zones in the saturated, capillary and unsaturated parts of the floodplain, as a basis for making vegetation health assessments or predictions at any particular time. The procedure for deriving this information in 3D is discussed. Using the AEM derived products resulted in an improved prediction of vegetation health across the floodplain against available information; the improvement rising from 60% to 76%. We believe the procedures defined in this study have application to other threatened floodplains where HEM data have been acquired.

INVESTIGATION ON THE GROUNDWATER RESOURCES OF THE SOUTH EYRE PENINSULA, SOUTH AUSTRALIA, DETERMINED FROM LATERALLY CONSTRAINED INVERSION OF TEMPEST DATA

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Groundwater in the Eyre Peninsula of South Australia is scarce with potable resources, often referred to as lenses, limited to the western coastal margin and the southern tip of the peninsula. Consequently an understanding of their extent has become increasingly important particularly with demand being close to current extraction limits. Further modelling of the groundwater systems to ensure confidence in the limits determined is now underway. Whilst it is known that the Coffin Bay A lens extends under the Coffin Bay National Park, land access for drilling is severely limited. An AEM survey was therefore carried out in order to define the limits of this lens system and the available resource. TEMPEST time domain EM data were acquired over the known extent of the lens systems. In this paper we present the results of the spatially constrained inversion (SCI) technique, which was applied for the first time to a fixed wing AEM system. In the SCI information migrates horizontally through spatial constraints and allows resolution of layers that would be locally poorly resolved and it greatly reduces the influence of noisy data. The SCI improves significantly the resolution of near surface parameters, also because system geometry is incorporated as inversion parameter allowing correcting for canopy effects, for example.

Hydrogeologically significant bounding surfaces were therefore defined. An indication of the extent of Coffin Bay A Lens under the National Park was determined. We also defined the extent of sea water intrusion into the aquifer systems.

UTILISING AIRBORNE ELECTROMAGNETIC DATA, HIGH RESOLUTION DEM AND HYDROGEOLOGICAL INFORMATION TO DERIVE CUSTOMISED PRODUCTS FOR NATURAL RESOURCE MANAGEMENT ALONG THE RIVER MURRAY CORRIDOR

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Approximately 450 km of Murray River floodplain and its adjacent upland rises, from Gunbower (Vic) to the South Australian border, have been surveyed using the RESOLVE frequency domain EM system. Due to the continuous decrease in surface elevation along this reach of the river to the Vic-SA border, an arbitrary surface of the youngest floodplain was set as the height datum for the EM elevation slices. This facilitates the interpretation of EM images as compared to the depth and elevation (AHD) slices. Maps that are based on the floodplain elevation slices include the river flush zone, thickness of Quaternary alluvium and Blanchetown Clay, and salt store. In addition, EM depth slices are used to derive conductive soils map, and depths to the Loxton Sands and Blanchetown Clay. Hydrogeological information derived from this AEM dataset includes the presence of deep flush zones between Robinvale and Hattah Lakes, disconnected surface hydrology and groundwater of the Gunbower Island, and the effects of Lake Victoria on the funnelling of saline groundwater influx from NSW to the floodplain. These products aim to answer land-use questions posed by the Catchment Management Authorities (CMAs) to better manage irrigation and floodplain ecosystem.

Day 1 Session 4 Stream 4

MINERALS

Advances in EM Technology

MONITORING CURRENT WAVEFORM OF THE SEATEM SYSTEM

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As a check on direct current measurements of the transmitted waveforms as measured with a wideband transducer, we monitored the EM field of the SeaTEM system during several flights over a ground loop. The ground loop was laid out over very resistive granite in Western Australia. Ground measurements included: current and voltage induced in the ground loop; point sampled total field and component magnetic field monitoring, as well as perpendicular, high-resolution digital photographic sequences to map airborne system pitch and roll. The analysis of the data is presented.

EXTRACTING MORE INFORMATION FROM ON-TIME DATA

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The AeroTEM system's rigid structure and bucking coil makes the recording of interpretable on-time data possible. When processed using standard methods the on-time dB/dt response is comparable in conductivity aperture to the off-time calculated B-field response. However, standard primary field removal methods distort both on-time dB/dt and calculated B-field responses. By modifying primary field removal routines to incorporate the rigidity of the system it is possible to minimise these distortions. While this directly improves dB/dt and calculated B-field responses, it opens the door to other advanced processing techniques that require the accurate removal of the primary field such as the deconvolution of data to the step response. Results from synthetic and field data are used to illustrate the effectiveness of the routines.

Z-TEM (AIRBORNE AFMAG) TESTS OVER UNCONFORMITY URANIUM DEPOSITS

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Geotech's Z-TEM system is the latest implementation of an airborne AFMAG system. Z-TEM uses a large, 8 metre diameter

airborne air core coil, slung from a helicopter, to measure the vertical component of the AFMAG signal. Two 4-metre square coils are deployed on the ground to measure the horizontal field. The Z-TEM has demonstrated that it can detect porphyry copper deposits in the southwest USA. It was tested in the Athabasca Basin in Canada in May of 2008 to determine its depth of investigation and to determine its suitability for mapping deep conductors in the crystalline basement. Unconformity uranium deposits of the Athabasca Basin are often associated with conductors located in the crystalline basement. The search for economic uranium deposits is moving to areas of the basin which are deeper and beyond the detection limits of modern airborne instrumentation. This creates the requirement for a system which can detect conductivity past the detection limits of modern EM systems. This was the motivation behind the field trials of the Z-TEM system in the Athabasca Basin. Several areas where known deep conductors (600 m+) were located were flown with good results. Also, a test survey block in the Fond du Lac was able to trace a deep and plunging conductor to depths that no other airborne system has been able to achieve. These results and comparisons to other ground and airborne system, where available, will be presented. The results are also modelled to determine the depth of investigation of Z-TEM.

SIGNIFICANTLY INCREASING TEM SURVEY PERFORMANCE BY MODIFYING FREQUENCY CONTENT OF TRANSMITTER WAVEFORM

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TEM surveys typically operate with a simple transmitter waveform, such as a 50% duty cycle alternating square wave. The frequency of transmission and the duration of measurement is decided before the survey or, frequently in the case of ground TEM surveys, adapted during the survey by the operator to suit the conditions.

With some sensor types in particular, achieving good quality data throughout all parts of the decay is difficult. Additionally, all surveys can be complicated by the presence of external sources of interference such as power transmission lines. We argue that significant improvements can be made by optimising the frequency content of the transmitter waveform. Additionally, in the case of ground surveys, the duration of an individual reading can be controlled in order to achieve rapid production and desired data quality. Variables are the EM noise spectrum (a function of the sensor and environment) and the conductivity of terrain. These change along the TEM profile and best results are obtained by regular re-evaluation in light of the target sought.

There are several options available to modify the effective frequency content of a TEM transmitter waveform. For a conventional square wave transmitter, an irregular pattern of polarity reversals can be transmitted. Another method is to use two or more base frequencies sequentially. The survey can be automated and data can be combined automatically into a single decay with optimal signal-to-noise ratio over the entire decay.

Theoretical examples and field data are presented to illustrate improvements in performance.

Day 1 Session 4 Stream 5

MINERALS

Airborne Geophysical Techniques (Non Electrical)

INTERPRETING GAMMA RADIOMETRICS IN THE NT

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A guideline for regolith interpretation from gamma radiometric images is presented. Following the recent AWAGS calibration survey by GA (presented elsewhere at this conference), quantitative analysis of the gamma signature of the regolith units of the Northern Territory is now possible. Uranium is particularly high in paludal sediments, and low in evaporite sediments. Thorium is particularly high in bauxite and residual material. Potassium is high in saprock and low in all other regolith units, particularly residual material and bauxite. First pass interpretation of statewide RGB radiometric images can be simplified by assigning red areas to clays, green areas to duricrust, and blue areas to alkaline ground.

VK 1 – A NEW GENERATION AIRBORNE GRAVITY GRADIOMETER

J. Anstie[1], T. Aravanis[2], M. Haederle[2], A. Mann[1], Stephen McIntosh[2], R. Smith[3], F. Van Kann[1], G. Wells[2] and J. Winterflood[1]*
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This paper will review the history of and recent progress in the development of a new airborne gravity gradiometer based on an innovative design originating at the University of Western Australia. Current work is being carried at the University of WA as a collaborative project with Rio Tinto.

- History of the project from its origins in the Physics Department at UWA in the 1980s through to the present day where, with backing from Rio Tinto, it is progressing rapidly towards an operational instrument.
- Principles and Objectives:
  - The instrument operates on an isolation platform with sensors on two crossed bars utilising common mode rejection to minimise residual linear and rotational accelerations.
  - The objective is to achieve an effective signal sensitivity of 1 Eö/√Hz.
- Current status
  - Development of an isolation platform.
  - Development of a new design suitable for operation in an aircraft.
  - Laboratory and flight test results.
  - Data simulations.
- Future Objectives
  - Initial use in Australia, ultimately anywhere.
  - Deployable anywhere.
  - Interpretation no longer limited by instrument noise.

- A similar development path to magnetics; from anomaly hunting to geological mapping in 3 and possibly 4 dimensions.

FURTHER DEVELOPMENTS WITH FULL TENSOR GRADIOMETRY DATASETS

Desmond Fitzgerald[1]*, *Dominik Argast*[1] *and Horst Holstein*[2]
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With the advent of new potential field full tensor gradient instrumentation, new methods have been developed to denoise and process these curvature gradients. Traditional Fourier Domain and Minimum Squares least squares residual of the linear differential relationships have been adapted.

This leads to levelling, gridding and grid filtering innovations. The result is a Full Tensor Grid representation of the curvature gradients that is coherent and compliant with the physics at all points in the grid. All of the observed data is thus honoured in the Tensor grid.

Superior anomaly interpretation and inferences can then be made. Depth and shape of the causative body becomes more constrained.

A suite of model studies and test and calibration scenarios has been developed to verify the correct behaviour of the new techniques. The results of some of these unit tests are then published on the internet to demonstrate continued compliance.

Case studies showing the improvement that can be obtained are presented.

Special attention is warranted for the Full Tensor Magnetic gradient signal. Multiple surveys of this quantity have been made in South Africa. The problem of reduction to the Pole is discussed.

Day 2: Tuesday 24 February 2009

8:30–10:30
Day 2 Session 1 Stream 1

PETROLEUM

Modelling and Inversion

EXTRACTING DETAILED LITHOLOGY FROM SEISMIC DATA

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The interpretation of seismic data in a traditional sense is limited by the bandlimited nature of the data. As a result the frequencies of the data determine a 'resolution limit'. When the seismic is inverted to obtain rock properties the results are inherently limited by the same resolution limit. The seismic 'detection limit' is another measure of the sensitivity of the seismic to changes in rock properties and is typically much smaller than the resolution limit. To properly exploit the detection limit requires a seismic inversion algorithm which intrinsically uses the clustering of elastic properties. These clusters are often associated with different lithologies with distinctive rock properties.

The presence of hydrocarbons is well known to affect the elastic properties of rocks. However, the large variation in reservoir rocks makes it nearly impossible to generalise on this effect. If multiple elastic properties can be measured the likelihood of identifying separation is increased. A cost effective way to obtain multiple elastic properties is by inverting the AVO character of pre-stack seismic data.

Using a series of synthetic and real data examples we will demonstrate how a geostatistical inversion algorithm can extract both detailed lithology and elastic properties from angle-stack seismic data. The inclusion of geostatistical parameters further constrains the results as the variograms impose constraints on the thicknesses and lateral continuity of the lithologies. The results are verified using blind wells, thereby demonstrating the value of the technique in predicting lithologies and elastic properties away from the wells.

UNDERSTANDING NEAR-SURFACE VELOCITY EFFECTS USING PHYSICAL MODELS

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Near surface effects are the bane of seismic exploration. Whenever seismic survey crews record data over basalts, sand dunes, karst topography, platforms, buried channels or waddies, the velocity contrast and the internal absorbing qualities of the materials (ignoring density issues) causes the outward-travelling wave-front to change direction and polarisation. As a result, it is very hard to make primary energy travel vertically down and then reflect from even shallow horizons, for recording at the surface.

This paper discusses two physical models which were used to understand the effects of near-surface anomalies on the seismic response. The first model was a simplistic representation of basalts and karst topography in which guided-waves were produced by the strong velocity contrast, causing much of the energy to travel sideways. The second model was used to understand the effects caused by absorbing sand dunes, basalt-like platforms, and buried channels or wadies. While the absorbing qualities of sand has suggested that this is the main attenuating mechanism, it can be argued that its shape and the velocity contrast at its base may be as important as absorption by sand.

The paper will discuss the building of the models and their recorded data, and how these can be improved using the new technology of virtual source imaging.

3D TRAVEL-TIME INVERSION OF INDUCED MICRO-SEISMIC EVENTS TO CONSTRUCT A DETAILED VELOCITY MODEL

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The determination of a detailed 3D velocity of a hydrocarbon reservoir is a classical problem as 3D surface seismic method has a limited resolution and thus unable to produce high resolution image. To be able to construct a detailed velocity image of the reservoir, however, one needs to have a hi-frequency source. Induced micro-seismic events produced within the hydrocarbon reservoir as a result of production activities can serve this purpose.

To achieve this for a hydrocarbon reservoir, a robust iterative linearised inversion of induced micro-seismic event travel-time for the determination of origin time and positions for the passive sources and for the construction of a detailed three-dimensional velocity model is presented. The method can be used for either P-wave or S-wave. The method is based on a local optimisation technique using the BFGS formula (due to Broylden, Fletcher, Goldfarb and Shannon). The BFGS formula has many attractive features: it starts like a steepest descent method, but ends like a Newton method; it also generates the inverse of the Hessian matrix as a by-product. The technique can also be used on VSP (vertical seismic profiling) data or SWD (seismic while drilling) data to build the velocity model.

Synthetic data is used to demonstrate the method's accuracy and conversion rate. Starting with erroneous data for sources positions and origin time, the method is tested to show the sensitivity of the method to realistic different noise levels. Laboratory data is used to validate the method.

Day 2 Session 1 Stream 2

PETROLEUM

Reservoir Stress Paths/Fracture Characterisation

REDUCING STRUCTURAL UNCERTAINTY IN SEISMIC INTERPRETATION BY MAPPING WALL-ROCK STRAINS TO GET A PLAUSIBLE GEOLOGICAL MODEL – THE STRAIN MINIMISATION APPROACH

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Estimates of wall-rock strains provide an objective means for discriminating between correct and incorrect structural interpretations of 2D and 3D seismic data. Good interpretation of faults should include a workflow that checks and keeps wall-rock strain below a geologically plausible maximum. We call this the strain minimisation approach.

Fault population statistics from 47 publications confirm that fault strike lengths and maximum throws have a log-normal distribution and that their geometries (length verses maximum throw) are scale invariant. This knowledge base indicates that maximum displacement on normal or reverse faults rarely exceeds 1/10 of their strike length before a new fault forms to take up the strain. Small scale variation of fault wall-rock strain should also adhere to this rule. Thus we can use this knowledge base as a check for geologically plausible seismic interpretations and prevent aliased fault patterns. If we assume that the maximum dip-dimension of faults is ½ the maximum strike dimension, then we can place an upper limit of 0.1 on plausible wall-rock shear strain and 0.2 for either maximum shortening or extensional wall-rock strain.

We reviewed an original structural model, which was work completed by a third party, and by mapping shear and extensional strain on their fault planes showed that the computed wall-rock strains for these parameters were commonly above 0.1 and 0.2 respectively. Thus this third party structural model was very suspect. We then reinterpreted the area in an iterative manner using the strain minimisation approach. By using regions of implied high wall-rock strain as an indicator high uncertainty in our interpretation, we were able to break out two self consistent faults sets. These had geologically plausible wall-rock strains, where previously there had only been one with highly implausible wall-rock strains.

When we had completed our new structural interpretation using 2D seismic data, we later found that it was consistent with an interpretation of a nearby 3D seismic volume that became publicly available after we did the original work.

SPECTRAL DECOMPOSITION OF A 3D SEISMIC MEGA-SURVEY FOR DEFINITION OF HYDROCARBON REMIGRATION SYSTEMS AND PREDICTION OF TRAPS INTEGRITY

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Fault seal potential and fluid migration pathways can be assessed using multi-attributes and spectral decomposition derived from 3D seismic. Investigation in the Timor Sea (Bonaparte Basin) demonstrates the relationship of acoustic impedance anomalies in the very shallow subsurface (VSS) to leaking fault planes and the use of energy-related attributes in assessing deep reservoir integrity.

Seal breach by fault reactivation represents a major exploration risk in the Timor Sea with critically stressed discontinuities promoting remigration and leading to dry or under-filled structures. In this area the seismic-based assessment of trap integrity at reservoir level is limited due to resolution limitation. Therefore in order to constrain a regional predictive model for trap integrity, the energy content of the VSS has been characterised, on the northern Vulcan 3D Mega-survey, using classic energy-related attributes and spectral decomposition attributes. The analysis of the energy distribution at various frequencies of the full bandwidth enables to investigate the variation of reflectivity beyond the tuning thickness and gives a richer vision of the interval of interest.

The results of the energy content characterisation show a tight spatial relationship between VSS bright-spots (<500 mSS) and Mesozoic reservoirs (3000–3500 mSS). They highlight preferential up-fault remigration pathways and potential seep points and allow discretisation of fault planes based on sealing or non-sealing behaviour. A qualitative correlation based on the integration of charge history of drilled structures and VSS anomaly morphologies is used to define a regional predictive scheme for trap integrity assessment and prospect risking and for the regional appraisal of petroleum system effectiveness.

STATE AND ORIGIN OF PRESENT-DAY STRESS FIELDS IN SEDIMENTARY BASINS

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The present-day stress field provides fundamental insight into the forces driving plate tectonics and intra-plate deformation. Furthermore, knowledge of the present-day stress field is essential in petroleum, geothermal and mining geomechanics applications such as the stability of boreholes and tunnels, and improving production through natural and induced fractures. The World Stress Map (WSM) Project has, for over 20 years, compiled a public global database of present-day tectonic stress information to determine and understand the state of stress in the Earth's lithosphere. The WSM database has revealed that plate-scale stress fields are controlled by forces exerted at plate boundaries (e.g. mid-ocean ridges, continental collision zones), commonly resulting in regional stress orientations sub-parallel to plate motion. However, the state and origin of present-day stress fields at smaller scales, such as within sedimentary basins, remains poorly understood in comparison. Detailed analysis of present-day stresses from within 70 sedimentary basins commonly reveals significant and complex variations in the present-day stress orientation, both across basins and within fields. For example, borehole breakouts in the North German Basin, Nile Delta and the Baram Delta province of northwest Borneo indicate broad regional rotations in the horizontal stress orientation. The present-day maximum horizontal stress orientations in the Gulf of Thailand are approximately north-south at the basin-scale (perpendicular to plate motion) and are perturbed locally to be sub-parallel to fault strike. The North Sea and Permian Basin of Texas display widely varying stress orientations between fields, with some neighbouring fields exhibiting perpendicular stress orientations. Basin- and field-scale stress fields result from the complex combination of numerous factors acting at different scales, including far-field forces (e.g. plate boundary forces), basin geometry (e.g. the shape of deltaic wedges), geological structures (e.g. diapirs, faults), mechanical contrasts (e.g. evaporites, overpressured shales, detachment zones), topography and deglaciation.

MECHANOSTRATIGRAPHIC CONTROL ON CARBONATE FRACTURED RESERVOIR EVALUATION: A PNG CASE STUDY

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Schlumberger Fullbore Formation MicroImager (FMI) logging in the Elk-1 and Elk-2 wells showed that the limestone formation is heavily and heterogeneously fractured. The alternate conductive and resistive signals on the FMI Logs are an indicative of different layers of carbonate lithotype facies with varying layer widths which have been correlated against whole core from Elk-2 well. The whole core exhibits a clear relationship to FMI response and was used as a template on the rest of the log.

Analysis of beds and fractures were conducted in only good to fair FMI data from Elk 2 well in the limestone section. The structures were initially picked on the FMI Log in WellCad. The beds identified in the order of frequency of occurrence are thin beds (<10 cm) > medium beds (<40 cm) > thick beds (>40 cm). A total thickness of 990 m of only good to fair image response of the entire 1060 m logged interval was statistically interpreted. Thin beds comprise 42%, medium beds 31% and thick beds 27% of the interpreted zone. The fractures are categorised into conductive fractures, partially conductive fractures and resistive fractures. A total of 2606 fractures were identified on the FMI Log in Elk 2 well. It was calculated that five fractures occur per metre in thin beds, two fractures per metre in medium beds and only 0.2 fractures per metre in thick beds.

Analysis of the orientation of bed types and fractures types showed that the beds have an azimuth of 0.30–0.50 degrees with dips ranging from 30–40 degrees. The fractures have steep dips ranging between 50–70 degrees and azimuths ranging from 120–240 degrees.

Fracture orientations could only be assumed to vary in time with a possibility that the mechanical properties of the sequence had changed by diagenesis.

The study of bed and fracture analysis from the FMI log showed that thin beds have high frequency of occurrence compared to medium and thick beds and also have higher intensity of fracturing. This indicates stratabound fractures and hence a mechanical relationship between bed thickness and fracturing.

Day 2 Session 1 Stream 3

MINERALS

AEM Modelling and Inversion

KEYNOTE ADDRESS: JOINT 3D INTERPRETATION OF ELECTROMAGNETIC AND SEISMIC DATA: CHALLENGES AND THE WAY FORWARD

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Electromagnetic (EM) methods provide vital constraints on fundamental flow and storage processes in the earth, at different spatial scales. Recent advances in multidimensional electromagnetic modelling and inversion have brought EM methods close to their theoretical resolving power, but there are still limitations in the way that data from multi-component and multi-scale field experiments in heterogeneous geological media are currently interpreted, especially because simulating the responses of 'field-realistic' earth structures is computationally demanding and the presence of measurement uncertainties limits model resolution to a large extent. Also, the fact that EM methods require large amounts of data to accurately image geological heterogeneity presents further computational challenges.

In this seminar, I will present my contributions in recently developed 2.5D and 3D EM inversion techniques for subsurface characterisation, methods developed for quantifying the impact of uncertainty in the interpretation of electromagnetic data (extreme bounds analysis), a recently developed method for simultaneous interpretation of electromagnetic and seismic travel-time data for improved characterisation of geological heterogeneity, and innovative multi-scale joint electromagnetic and seismic practical experiments whose realisations are presently hindered by lack of appropriate computational platform. Strategies to overcome some of the computational difficulties will be discussed and I will draw on examples from near-surface to mantle depths.

DISPERSION RELATIONS AND THE HILBERT TRANSFORM FOR EM SYSTEM RESPONSE – AN UPDATE

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With sponsorship from AMIRA P407B, the RMIT group has published methods of recalibrating historic HEM data for altitude, amplitude and phase. These methods have assumed that base level drift has been corrected, which is not always the case. The Kramers-Kronig relationship is an integral equation that relates in-phase and quadrature for any causal system. It can be used with surprising accuracy to predict (say) the in-phase responses of the Resolve system using only the quadrature data. When applied to field data from the Chowilla region, differences between the measures and predicted 8177 Hz in-phase data had a distribution with a standard deviation of 28 ppm. When plotted on a map, the differences show a remarkable spatial correlation with individual flights. Base level drift in one frequency, if present, would lead to a difference between predicted in-phase and measured data. Such differences would usually occur once per flight, as each flight commonly has two or more high-altitude checks to estimate base level. Based on the mean and trend of the differences, it is possible to predict base level drifts on historic HEM data.

FAST APPROXIMATE INVERSION OF SKYTEM AIRBORNE ELECTROMAGNETIC DATA

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A new rapid multilayer inversion algorithm has been developed for SkyTEM airborne electromagnetic data. The algorithm is roughly 50 times faster than conventional one-dimensional inversion, but the results are very similar to those obtained by traditional inversion. The fast inversion is achieved by combining a very fast forward mapping with a state-of-the-art inversion formulation and the inversion provides estimates of model uncertainty via the posterior parameter covariance matrix. Results are presented as model sections and plan maps of mean conductivity.

A novel method, termed Lateral Parameter Correlation (LPC), is applied to improve lateral continuity of model sections from the fast inversion. The LPC method is a three-staged process: (1) initial inversion using the fast inversion algorithm; (2) models are laterally smoothed through a constrained inversion process which incorporates the variances of the parameters of the uncorrelated models and a model covariance matrix; and (3) repeated inversion to improve the data fit, using the smoothed model parameters from step 2 as *a priori* constraints. The LPC method is a fast alternative to other methods currently used to generate laterally smooth 1D inversion results.

We present examples of data processed using the new algorithms from hydrogeophysical surveys at Toolibin Lake and Gillingarra, Western Australia. Model sections and plan maps produced by the fast inversion show excellent agreement with known hydrogeology in the survey areas, and with borehole induction and resistivity logs. In both survey areas, the fast inversion is shown to yield superior conductivity models to those obtained via conventional conductivity-depth transformation.

FAST APPROXIMATE INVERSION OF FDHEM DATA

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A new rapid multilayer inversion algorithm has been developed for frequency domain (FDHEM) data. The algorithm is roughly thirty times faster than conventional one-dimensional inversion. The fast inversion of frequency domain data is achieved by Fourier transforming the fast approximate time domain responses and combining the fast forward mapping with a state-of-the-art inversion formulation. The inversion provides estimates of model uncertainty via the posterior parameter covariance matrix. Inversion results are presented as model sections and as plan maps of mean conductivity within specified depth or elevation intervals.

We present examples from a RESOLVE FDHEM hydrogeophysical survey undertaken at Bookpurnong, in the South Australian Riverland. RESOLVE is a six frequency HEM system. Model sections and plan depth slices produced by the fast inversion show excellent agreement with known hydrogeology in the survey areas, with borehole induction logs and other field data. In this study, the fast inversion is shown to yield superior conductivity models to those obtained via conventional conductivity-depth transformations and the derived conductivity models show good agreement with those generated from a full non linear inversion.

Day 2 Session 1 Stream 4

MINERALS

Continent Scale Geophysics

THE RADIOMETRIC MAP OF AUSTRALIA

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Geoscience Australia and State and Territory Geological Surveys have systematically surveyed most of the Australian continent over the past 40 years using airborne gamma-ray spectrometry to map potassium, uranium and thorium elemental concentrations at the Earth's surface. However, the individual surveys that comprise the national gamma-ray spectrometric radioelement database are not all registered to the same datum. This limits the usefulness of the database as it is not possible to easily combine surveys into regional compilations or make accurate comparisons between radiometric signatures in different survey areas. To solve these problems, Geoscience Australia has undertaken an Australia-Wide Airborne Geophysical Survey (AWAGS), funded under the Australian Government's Onshore Energy Security Program, to serve as a radioelement baseline for all current and future airborne gamma-ray spectrometric surveys in Australia. The AWAGS survey has been back-calibrated to the International Atomic Energy Agency's (IAEA) radioelement datum. We have used the AWAGS data to level the national radioelement database by estimating survey correction factors that, once applied, minimise both the differences in radioelement estimates between surveys (where these surveys overlap) and the differences between the surveys and the AWAGS traverses. The database is thus effectively levelled to the IAEA datum. The levelled database has been used to produce the first 'Radiometric Map of Australia' – levelled and merged composite potassium (% K), uranium (ppm eU) and thorium (ppm eTh) grids over Australia at 100 m resolution. Interpreters can use the map to reliably compare the radiometric signatures observed over different parts of Australia. This enables the assessment of key mineralogical and geochemical properties of bedrock and regolith materials from different geological provinces and regions with contrasting landscape histories.

THE AUSTRALIA-WIDE AIRBORNE GEOPHYSICAL SURVEY – ACCURATE CONTINENTAL MAGNETIC COVERAGE

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The Australia-wide Airborne Geophysical Survey (AWAGS) project was conducted in 2007 to collect total-field magnetic and gamma-ray spectrometric data across Australia on north-south lines spaced 75 km apart, east-west tie lines spaced 400 km apart and a nominal terrain clearance of 80 m. These data were acquired by Geoscience Australia (GA) as part of the Australian Government's Onshore Energy Security Program. The magnetic data are required to accurately define intermediate spatial wavelengths between 100 km and 400 km, which are only poorly represented in continental-scale merges of existing data, due to limitations of survey size and data processing. Removal of time variations of the Earth's magnetic field during the AWAGS survey required base instrument deployment on a rolling basis as the survey progressed, and a method has been developed to accurately remove time variations from multiple base sites. This method requires 24 hour recording at the base sites, and also utilises data recorded at the six GA continental geomagnetic observatories. All temporary base midnight quiet values are referenced to interpolated observatory midnight quiet values at each temporary location. The observatory midnight quiet values varied smoothly across the continent for the duration of the AWAGS survey, and this method attempts to remove all time variations, including the secular variation, back to a reference time centred on quiet magnetic days prior to the survey commencement. The success of the method is initially judged by examination of the flight/tie cross-over differences, which should be minimal if accurate diurnal removal is achieved.

ACQUIRING HIGH RESOLUTION AIRBORNE GEOPHYSICAL DATA AND RECOGNITION OF NEW MINERAL EXPLORATION POTENTIAL AS PART OF A DEVELOPMENT PROGRAM LAUNCHED BY THE SOUTH AFRICAN GOVERNMENT

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The Council for Geoscience, South Africa, has embarked on a program of flying the entire country with high resolution – high density airborne magnetic and radiometric data. It was during the seventies and the eighties of the past century when the existing regional coverage was flown with flight lines 1000 m apart at a nominal flight height of 120 m a.g.l. This kind of first generation data is not any longer satisfying the requirements of highest possible spatial resolution set up by the exploration and environmental industries. This demand was recently acknowledged by the South African Government and has been materialised by launching a new high resolution airborne survey program with 200 m line spacing and nominal flight height of 80 m a.g.l. The Council for Geoscience, as the national geological survey organisation, has been committed to carry out airborne surveying, data processing and screening the new data for exploration target generation including desktop studies and ground truth control. Data acquisition will briefly be described, a few new data examples will be depicted comparing them with existing regional data and the usefulness of ground truth control to best elucidate both geophysical anomalies and underlying geology will be discussed on the base of two case studies from the Namaqualand Metamorphic Belt and the Northern Marginal Zone of the Bushveld Mafic Layered Complex, respectively.

AIRBORNE GEOPHYSICS AS A TOOL TO PROMOTE MINERAL INVESTMENT IN AFRICA

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Airborne geophysics, particularly aeromagnetic and gamma-ray spectrometer (radiometric) surveys, forms a critical component of geological mapping and mineral resource inventory programs in many African countries. In the 1960s and 70s, regional aeromagnetic surveys were fairly widespread over much of the continent, in both sedimentary and hard rock terrains. In the 1980s and 90s, higher resolution surveys, incorporating radiometrics, were carried out in several countries, particularly in southern Africa. In the last decade, a number of national initiatives (e.g. Madagascar, Mozambique, Namibia, Morocco, Mauritania, Nigeria, Ghana, etc.) have seen the high-resolution geophysical coverage greatly improve. The surveys form part of larger initiatives to improve the geological knowledge of a country or region, with the ultimate objective of increasing mineral investment and developing a sustainable mining industry. These geoscience programs are typically accompanied by reforms in the mining law to promote such investment. International funding agencies such as the World Bank, European Community and African Development Bank have seen the value in such programs, and ensure that airborne geophysics receive a large share of project budgets. In jurisdictions throughout the world, it has been demonstrated that high-quality geophysical coverage leads directly to increased and more focused exploration. A trend in the last few years has been the inclusion of an airborne electromagnetic follow-up component to the airborne program.

This paper will provide current examples from two countries. In Uganda, more than 600 000 line-km of magnetic and radiometric data are being acquired over most of the country. In addition, eight blocks with high mineral potential are being flown with electromagnetic systems (TEMPEST and heliGEOTEM). In Senegal, the entire hard rock region has been covered by 130 000 line-km of magnetic and radiometric data, and a TEMPEST survey over three blocks is underway. Most of the data will be available for inclusion in the expanded abstract and paper.

11:00–12:30
Day 2 Session 2 Stream 1

PETROLEUM

Seismic Acquisition

ASSESSING THE REPEATABILITY OF REFLECTION SEISMIC DATA IN THE PRESENCE OF COMPLEX NEAR-SURFACE CONDITIONS CO2CRC OTWAY PROJECT, VICTORIA, AUSTRALIA

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Time-lapse or 4D data are increasingly used to study and image the changes in the seismic response induced by the production oil hydrocarbons or the injection of CO_2 into a reservoir. Unfortunately, time-lapse seismic changes are also produced by variations in the near-surface conditions, source signature variation, acquisition geometry (positioning and spacing), acquisition equipment and recording fidelity differences between the surveys, processing methods and environmental noise. The confidence level during interpreting any seismic changes depends on how good the seismic repeatability is in the area. However, residual differences in the repeated time-lapse data that do not represent changes in the subsurface geology impact the effectiveness of the method. In this paper we show that the changes in near surface ground conditions, specifically saturation of the ground have very profound effect on seismic repeatability. A feature of the injection test site area is the near-surface karst topography. The aim of this work was to develop seismic methods to better understand the effects of near surface conditions (wet and dry) on seismic imaging, with particular application to the constraints it imposes on the time-lapse 3D seismic response to injected CO_2. Comparison of numerical and field data may allow the changing properties of the reservoir to be better understood in terms of how the rock physics properties respond to surface conditions, as well as understand CO_2 injection processes and movement of CO_2 in the reservoir over time while providing new knowledge in the practice of future sequestration monitoring programs.

This study utilises repeated numerical tests based on the field observations during time-lapse seismic surveys. The numerical tests were aimed at explaining the significant scattering effects observed in field experiments. Of particular interest was to simulate large scattering variations related to top soil saturation as observed in field data. The results of this work may impact on other areas not associated with CO_2 sequestration, such as imaging oil production over areas where producing fields suffer from having a karst topography, such as in the Middle East and Australia.

SIGNAL RESOLUTION AND PENETRATION FROM DUAL-SENSOR STREAMER DATA ON THE NW SHELF OF AUSTRALIA

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A comparison is made of spatially coincident 2D seismic data acquired at 7 m receiver depth in 2007 with a conventional streamer, acquired at 15 m receiver depth in 2008 with a dual-sensor streamer. The 2D survey used for all data comparisons here was acquired in two regionally overlapping phases. Phase I was acquired with a 7950 m fluid-fill streamer and Phase II was acquired with an 8100 m solid-fill dual-sensor streamer.

Swell effects on pressure sensors are less at 15 m streamer depth than at 7 m streamer depth. Furthermore, any broadside noise such as interference noise is less on velocity sensors than for pressure sensors. Overall, dual-sensor streamer acquisition offers several operational advantages.

Analysis of the dual-sensor streamer data demonstrates that target Triassic pre-rift fault blocks have an improved frequency range of about 20–30 Hz using a 12 db down criteria. Low and high frequency amplitudes are boosted, and the dual-sensor data demonstrate better dip event stacking and less ambiguous event character for at least several seconds below water bottom. The low frequency boost arises from deeper streamer towing and the removal of the effects of the receiver ghost. Less noise is also recorded for deeper streamer towing, stabilising the wavefield separation processing. On the high end, frequencies beyond the source ghost have much stronger amplitudes, up to at least 200 Hz. Velocity semblance spectra are also focused better for accurate velocity picking of up-going (de-ghosted) pressure data. Overall, the dual-sensor dataset has better resolution and is more interpretable at all depths.

NEW GEOPHYSICAL DATA ACQUISITION IN FRONTIER BASINS ALONG THE SOUTHWEST AUSTRALIAN CONTINENTAL MARGIN

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Under the Australian Government's Energy Security Program, Geoscience Australia is conducting a commercial seismic survey and a marine reconnaissance survey to acquire new geophysical data and obtain geological samples over frontier basin areas along the southwest Australian continental margin. Specific areas of interest include the Mentelle Basin, northern Perth Basin, Wallaby Plateau and Southern Carnarvon Basin.

The regional seismic survey will record up to 8000 km of industry-standard 2D reflection seismic data utilising an 8 km solid streamer and 12 s record length, together with gravity and magnetics. Seismic refraction transects will also be acquired in key basin areas using the seismic vessel's air guns as an energy source, and recorded using Ocean Bottom Seismometers offshore and land recording stations onshore. Together with over 7000 km of re-processed open-file seismic, these new geophysical data sets will allow interpretation and mapping of the regional geology, determination of total sediment thickness, interpretation of the nature and thickness of crust that underlies sediment depocentres, modelling of tectonic evolution, and an assessment of petroleum prospectivity of frontier basins along the southwest margin.

The overall scientific aim of the marine survey is to collect swath bathymetry, gravity, magnetics, geological and biophysical data to assist in understanding the petroleum prospectivity, geological setting and environmental significance of frontier basin areas.

Day 2 Session 2 Stream 2

PETROLEUM

Petroleum – EM

KEYNOTE ADDRESS: INTEGRATION OF GEOPHYSICAL DATA: WELLS, SEISMIC AND ELECTROMAGNETICS

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Improved reservoir management and production optimisation demands require accurate characterisation of reservoir properties and their changes through time. However, when only a single data type is considered, ambiguities in the interpretation can remain. Integration of disparate geophysical data types allows the strengths of each to be exploited. Here we will concentrate on three contrasting methods: surface seismic, marine controlled source electromagnetic (CSEM) and well-log data.

Seismic data are commonly used to provide images of the sub-surface, and develop high resolution geological models of structure and stratigraphy. However seismic data alone in many situations cannot give a complete picture of the reservoir. Analysis of marine CSEM data allows remote mapping of the resistivity structure beneath the seafloor. The CSEM technique lacks the fine structural resolution of seismic data; however the method is particularly sensitive to the properties and distribution of fluids within the earth. Well logs provide a high resolution measurement of the properties of a reservoir in the strata local to the well. However often measurement of reservoir properties across the extent of a field is desirable.

Experience shows that applying structural constraints derived from seismic data is effective in improving the resolution of resistivity profiles obtained from inverting CSEM data. This allows us to combine resistivity with seismically-derived impedances in order to estimate rock and fluid properties. Property estimates require calibration with well logs and a good understanding of the rock physics since this provides a framework within which seismic and EM data can be interpreted. By integrating complementary sources of information estimates of rock and fluid properties such as gas saturation and porosity can be obtained with greater confidence than from any one data type alone.

AIRBORNE-EM HYDROCARBON MAPPING IN MOZAMBIQUE

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We describe a helicopter, time domain EM survey covering an area of some 2.000 square-km in central Mozambique to map near surface hydrocarbon seepage alteration zones.

The AEM survey is located in the northern area of the Inhaminga licence, north of Beira. The geological setting comprises a half-graben structure striking NE. Especially the flanks of the graben are heavily faulted (as seen on 2D seismic images) and the faults might be a pathway for hydrocarbon seepage. Gas and oil seeps have been observed and reported in the area.

Fluids which migrate from buried hydrocarbon reservoirs all the way to the surface (seepages) interact with the near surface geology, e.g. cause alteration effects in mineralogy and pore water in limestones and clastic rocks. These alterations potentially create anomalies in the physical properties of the rocks and then can be mapped by airborne geophysical methods.

Given the expected geological background and target properties, we choose a time domain helicopter borne EM system provided by Aeroquest Ltd (AeroTEM IV). The full instrument package provides earth magnetic field intensity, a Gamma Ray Spectrometer and finally EM data in high detail (50 channels of on- and off-time data, vertical and horizontal fields). The survey is scheduled to commence in July 2008 and interpretation must be concluded by September. This tight schedule asks for near real-time data processing, QC and interpretation, a challenge in this industry.

THE EFFECT OF RESISTIVITY ANISOTROPY ON EARTH IMPULSE RESPONSES

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Resistivity anisotropy arises through a variety of scales from intrinsic anisotropy on the micro, e.g. grain size, aspect ratio, sorting and diagenetic changes of the rock fabric, to macro scale, e.g. thin bedded sand-shale sequences that give rise to effective media anisotropy. Induction logs measure the resistivity perpendicular to the well-bore, whereas the laterolog measures the resistivity parallel to the well-bore, i.e. the horizontal and vertical resistivity component respectively in a vertical well. These different measurements can give quite varying results especially with the older logging tools, and we are more often working with legacy data rather than with the most recent log data. Hence a need to apply compensation factors to make them represent more accurate renditions of horizontal and vertical resistivity.

The Multi-Transient ElectroMagnetic (MTEM) method determines subsurface resistivity variations through transient current injection into the ground. Both the injected current and the resulting electric field are measured and deconvolution reveals the Earth's impulse response function. Inversion of impulse response functions yields the Earth's resistivity. Modelling and inversion of real data often use only isotropic representations of resistivities. However, capability exists for both 1D and 3D modelling incorporating anisotropic resistivities. In this paper we show effects of resistivity anisotropy on earth impulse responses. We decompose earth responses into transverse electric (TE) and transverse magnetic (TM) modes and show how these modes are affected by anisotropic resistivities. This decomposition leads to a better understanding of the relationship between well logs and resistivities determined through the inversion of transient EM data.

Day 2 Session 2 Stream 3

MINERALS

EM Case Studies

A CASE STUDY OF DEEP ELECTROMAGNETIC EXPLORATION IN CONDUCTIVE COVER

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Anglo American has been conducting deep electromagnetic exploration on a nickel sulphide target approximately 150 km north of Cloncurry in Queensland, Australia. The project area has greater than 400 m of Recent and Mesozoic cover masking the basement targets. This cover has an average conductance of approximately 200 Siemens, making the detection of basement conductors a challenging task.

The area was initially explored in 1994 and 1995 however no useful electrical geophysical data could be collected with technology that existed at that time. Anglo American together with their joint venture partner Falcon Minerals have used Low Temperature Squid technology to collect high quality transient electromagnetic data over much of the project area during 2007 and 2008.

A number of strong bedrock conductors with conductance values up to 10 000 Siemens and time constants in excess of 1 second have been found from this survey. Vertical and horizontal components of these data have been modeled using the LEROI software package. The best of these targets have been proposed for drill testing in late 2008.

GREENFIELDS NICKEL EXPLORATION USING AIRBORNE AND GROUND EM TECHNIQUES

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This paper discusses the airborne, ground and downhole EM results obtained during the search for a greenfields nickel discovery in the Northern Territory. Past exploration has targeted the magnetic mafic and ultramafic units in the region with surface geochemistry and ground EM in order to identify potential massive sulphide mineralisation. The potential for massive sulphide mineralisation however also exists in the non magnetic stratigraphy as some mafic units can be non magnetic. It is therefore preferable when exploring large, new, greenfields areas to blanket the area with regional airborne EM as a first pass exploration tool in order to quickly and effectively sample as much of the area as possible rather than target selected magnetic horizons.

A large, airborne EM anomaly with little magnetic association was identified using the previously mentioned exploration approach. A comparison between the dB/dT and B Field airborne EM results show improvements in the detection of good conductors using B Field airborne EM systems. Ground EM follow-up of the airborne EM target confirms the presence of conductors undetected by the airborne EM system and suggests that all airborne EM conductors should be followed up with ground EM prior to drill targeting. A comparison of the dB/dT and B Field ground EM results confirms the advantage of collecting B Field information when exploring for deep, highly conductive targets. These results imply that B Field data should be collected in conjunction with or in place of dB/dT data when using ground EM techniques to explore for good conductors.

Day 2 Session 2 Stream 4

MINERALS

Geophysical Concepts and Applications

NEW DATA AND IDEAS FOR ENERGY EXPLORATION IN AUSTRALIA

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The Onshore Energy Security Program (OESP) announced by the Commonwealth Government in 2006 is a major initiative to encourage exploration for energy resources in Australia. Geoscience Australia (GA) will receive funding of $59 million over five years for data acquisition and scientific programs focussed on petroleum, uranium, thorium and geothermal energy systems. National scale surveys such as the Australia Wide Geophysical Survey (AWAGS) will provide uniform, objective data for assessing the energy potential of terrains across the continent. Geological provinces considered prospective for energy commodities are being targeted by regional projects based on the acquisition of seismic\MT, airborne electromagnetics, gravity, and magnetics data. A mineral-systems approach is being used to assess the uranium and geothermal prospectivity of the Mt Isa and Georgetown regions of north Queensland, and to scope an extensive seismic\MT acquisition program. Interpretation of these data is providing new insights into these provinces which have been under-explored for energy. Analysis of onshore sedimentary basins suggested oil and gas potential exists in the frontier Darling Basin in western NSW. Subsequent regional seismic traverses delineated a fault bounded trough with six kilometres thickness of sediment and a possible underlying older basin. In the Cooper Basin, 3D modelling of an improved gravity dataset was used with seismic and well information to predict the location of hot granites beneath thick overlying sediments, indicating geothermal potential. These examples illustrate the nature of the programs being undertaken by GA which will deliver data and ideas to industry to reduce risk in exploration for energy resources in Australia.

GEOLOGICAL MAPPING AND TARGET DEFINITION TO DEPTH THROUGH THE APPLICATION OF DISTRIBUTED ELECTRICAL DEEP EARTH IMAGING AND THE INTEGRATION OF GEOLOGICAL INFORMATION

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Advances in various technologies continue to contribute to our exploration efforts, specifically towards reducing the time to execute tasks. Several technologies have made their introductions within the last several years and despite generally slow uptake by the industry more and more groups are utilizing technology to achieve improved success through effective deep exploration. However, application of new technologies does not necessarily mean that new discoveries will immediately follow. As we try to sense deeper and find improved means of effectively drilling, we will, more often than not, uncover new information that was unexpected and this may require more thought and time than we had initially intended. This makes the use of technology by itself complicated and using it may require that we re-think the way we do things such as learning new concepts and scientific fundamentals.

Making a discovery is difficult and is arguably more difficult as undiscovered deposits today are more likely found at greater depths. In addition, the financial risk with deep drilling is hindering deep exploration. Technology advances have been hindered because the mining industry has been traditionally slow to embrace new technologies particularly if they are not easily understood or when the cost paradigm is out of sync with traditional spending habits regarding drilling versus other technologies.

This paper discusses the importance of deep exploration and the significance of 3D exploration to the discovery process. A process for thorough deep search exploration will be highlighted through case examples.

13:30–15:00
Day 2 Session 3 Stream 1

PETROLEUM

Seismic Acquisition

KEYNOTE ADDRESS: NEW DEVELOPMENTS IN SEISMIC ACQUISITION

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The economic climate in the energy industry today has created unprecedented investment in exploration and development of hydrocarbon resources. As a result, seismic acquisition is experiencing a renaissance in both technique and equipment that is aimed at producing better seismic information. For example, the seismic challenges posed by the deep water, sub-salt Gulf of Mexico plays are addressed with field efforts unimaginable just a few years ago. To collect wide azimuth surveys efficiently, multiple vessels are employed in a dizzying array of configurations sometimes with several boats recording, but always with several boats shooting. On land, the quest for noise reduction, wider bandwidth and better estimation of reservoir properties has resulted in the use of single sensor recording systems capable of recording more than 30 000 live channels.

Such technologies – breakthroughs in and of themselves – are spurring further developments that promise to revolutionise the way we acquire and process data. In particular, the use of simultaneous marine sources offers the exciting possibility to significantly increase marine acquisition efficiency. Although developed for specific problems in specific regions, it is clear now that such efforts will spread to many different applications around the world.

In this talk, I will review recent developments in acquisition technologies and strategies and examine the ensuing effects that are developing as a result. Much research remains to be done, but early indications are that we are at the start of a paradigm shift in seismic acquisition and processing.

BOOKABOURDIE Q-LAND* 3D PROOF OF CONCEPT STUDY: MAPPING SAND THICKNESS AND QUALITY IN THE COOPER BASIN

Tim Bunting, Martin Bayly, Michelle Tham, Phil McBride, Mark Daly and Frazer Barclay*
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The Cooper Basin is the location of the largest onshore hydrocarbon reserve in Australia and was discovered in the 1960s. Drilling, in the Cooper Basin, has shown the reservoir sands to be very variable both in terms of thickness and sand quality. While 3D seismic has been acquired extensively in the area, resulting datasets have struggled to provide the detail to allow accurate prediction of the reservoir sand quality. This paper presents the results of a pilot study to assess whether high end acquisition and processing techniques in conjunction with a fully integrated approach from survey design through generation of reservoir attributes, could fulfil the objective of mapping the reservoir sands.

In August 2007, WesternGeco designed and acquired a proof of concept 3D survey in the Bookabourdie Field – Cooper Basin, South Australia. The project goals were to use the seismic dataset to map sand quality and thickness. The survey design focused on improving resolution within the final seismic image but also on providing a dataset optimised for AVO inversion and lithology prediction. Analysis of well data from an adjacent field demonstrated that Acoustic impedance/poisons ratio pairs could be used to estimate quantity of clay, suggesting that seismically derived in-elastic properties could be used to establish reservoir sand quality.

The acquisition was focussed on extending the bandwidth at the high end to improve image resolution but also at the low end to generate a more stable input for AVO inversion. The survey utilised specially designed non linear sweeps, sweeping between 3 Hz and 100 Hz and high density single sensor and single source points to correctly sample the low frequency low velocity surface noise.

The data processing sequence focussed on retaining the relative amplitudes all the way through the sequence, again to ensure the suitability of the dataset for AVO analysis.

The paper will go into some detail on the survey design and the techniques used in acquisition and processing to maintain bandwidth and preserve amplitudes. Additionally comparisons with a recently acquired dataset (acquired immediately prior to the pilot study) using a standard Cooper basin acquisition and processing approach will be shown along with final inversion and lithology prediction results.

RESULTS OF A 3D HI-RESOLUTION VIBROSEIS ACQUISITION TRIAL IN THE COOPER BASIN

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The 3D acquisition geometry utilised in the Cooper Basin has remained relatively unchanged for the past 14 years, due largely to the efficient and cost effective method employed. Significant changes and progress have been made over these years in data processing, ensuring the seismic data have achieved the respective project objectives. However, with changing targets, greater emphasis on stratigraphic plays and the need for attribute analysis it is clear processing techniques applied to the data have reached their limit and consequently the acquisition needs to yield better data.

This paper covers the results of an acquisition trial conducted in the Cooper Basin, the objective being, primarily to determine what effort was required to image or better image certain shallow poor reflectors such as the oil bearing Hutton formation, through improved noise reduction by better spatial sampling. The secondary objective was to improve offset distribution to enable improved data regularisation for near and far offset traces, which in turn would improve the effectiveness of the migration process and consequently the robustness of the PSTM gathers for attribute analysis.

Day 2 Session 3 Stream 2

MINERALS AND COAL SEISMIC

FEASIBILITY OF THE APPLICATION OF BOREHOLE SEISMOLOGY FOR HARD ROCK EXPLORATION

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Complex geology, steeply dipping interfaces, regolith and high seismic velocities in hard rocks hinder processing and interpretation of seismic data. The interfaces are highly irregular, have complex ray paths and small velocity contrasts which result in small variations in reflectivity. Despite this, shear zones are often highly reflective and have high frequency content. In contrast, interfaces between hard rocks in contact exhibit generally low reflectivity and lower frequency content.

Borehole seismic methods reduce the effects of wavefield scattering by placing either the receiver or source within the bedrock. These result in higher signal to noise ratios, higher frequency content and accurate velocities being observed, ultimately giving higher resolution images. The use of borehole 3-component geophones allow wave polarisation to be identified. Polarisation can be used to calculate the azimuth of reflectors. Employing multi-offset multiple-azimuth Vertical Seismic Profiling (VSP) surveys provide a favourable geometry for mapping both steeply and gently dipping features and help identify anisotropic features. The use of both P and S-waves also enable computation of dynamic elastic moduli.

In this paper we explore the feasibility of VSP in hard rocks through full elastic waveform modelling and Western Australia hard rock case studies. Focus has been on the origins of reflectivity, shear zones and imaging away from the well. Examples with field data will also be shown and discussed.

SUB-BASALT COAL SEAM STRUCTURE IMAGING – RESULTS FROM NUMERICAL MODELLING

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Seismic surveying is one of the most widely used and effective techniques for coal seam structure delineation and risk mitigation in underground longwall mining. However, its application to image coal seam structures in areas of Tertiary volcanic cover, especially within the Bowen Basin in Australia, is difficult and often produces sub-surface images of variable quality. The difficulty of exploring beneath the basalt cover makes these areas significantly less attractive for coal mining. Techniques for imaging sub-basalt structures are needed.

Many innovative methods have been suggested to tackle this issue with encouraging results. In all these methods, the long-offset data acquisition is the most promising technique due to its potential for improved signal-to-noise ratio with increased reflection coefficients for the mid to long offsets. In this paper, we will use elastic wave-equation-based forward modelling techniques to investigate the effects and characteristics of seismic wave propagation under different settings such as different depth/thickness of seams below different layers of basalts. With this knowledge, acquisition parameters and processing sequences can be chosen to improve our ability to image the coal seam structures beneath the basalt cover. In addition, the feasibility of imaging the sub-basalt coal seam structures with the long-offset configuration will be demonstrated using the synthetic shot gathers.

AZIMUTHAL IMAGING CHALLENGES IN COAL-SCALE 3D MULTI-COMPONENT SEISMIC REFLECTION

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In conventional (P) seismic-reflection surveys, P-waves are generated at the surface, and are reflected from coal seams to provide an image of the subsurface. When P-waves are reflected from a target layer some of the energy is transformed into a shear (S) wave. This type of reflection is known as a converted wave or PS-wave. In recent years Velseis has acquired and processed a number of 2D PS-wave surveys including research trials and commercial surveys. Integrated interpretation of P and PS imagery has been shown to yield improved geological interpretation. Additionally, PS-waves can image open-cut prospects, which are often too shallow to be imaged using conventional reflection.

Conventional P-wave surveys are acquired using either 2D or 3D geometries. This is dependent on the competing economic and resolution requirements. There is, however, an increasing trend toward 3D surveys as they produce a better spatial interpretation. It would be reasonable to assume that 3D PS-wave surveys would also lead to an improved geological interpretation. However, 2D PS-wave surveys have identified a number of issues that will make 3D PS exploration more complicated than the conventional case. For example different geological interpretations may result from images created with positive (forward shooting) or negative (back shooting) offsets. This may be caused by diodic-illumination and azimuthal anisotropy. For the 3D case these effects will be exacerbated as there is now full azimuthal variation instead of only two directions as in the 2D case.

We are currently acquiring and processing a trial 3D PS-wave survey with the aim of examining these azimuthal complexities, and developing a commercially viable 3D 3C seismic method for coal-scale targets. This dataset consists of an approximately 300 × 1000 m swath collected over a known target which contains a significant fault. This survey will have a very high shot density, compared to conventional single-component data. This is allowing us to produce four full-fold datasets of varying azimuth, which is being used to examine the effects of anisotropy and diodic-illumination. We are simultaneously examining the P-wave sections to determine if these are also affected by anisotropic problems. Preliminary results from this investigation will be presented.

Day 2 Session 3 Stream 3

MINERALS/ENVIRONMENTAL

AEM Inversion

APPLICATION OF A HOLISTIC INVERSION METHOD IN SALINITY RISK AND GROUNDWATER RESOURCE MAPPING IN THE RIVER MURRAY CORRIDOR, SE AUSTRALIA

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Data from airborne electromagnetics (AEM) surveys are increasingly used to address specific gaps in the biophysical knowledge framework and provide a decision support system for dynamic modelling and the targeted management of salinity and groundwater issues. The utility of AEM datasets in tackling these issues has been increased greatly by development of a holistic inversion method that inverts all of the airborne samples in one large inversion. This allows it to capitalise upon the spatial coherency in the data to produce a spatially continuous conductivity model defined by spline meshes. It also allows the inversion to account for systematic calibration errors that may not have been identified and removed during the data processing.

These new inversion and interpretation methods were applied to an airborne electromagnetic (AEM) survey along a 450 km reach of the River Murray Corridor (RMC) in SE Australia. In these surveys we solved for system bias (zero-level) calibration errors and for the conductivities of an 18 layer, fixed layer thickness, conductivity model. The conductivities were constrained by downhole conductivity log data and by horizontal and vertical smoothness constraints. The inversion also used the measured roll and pitch angles of the towed bird assembly to reduce the effects of bird manoeuvre noise. The superior spatial continuity of the holistic model allowed us to interpret more subtle features in the data, facilitating development of more advanced interpretation products. This method also obviates the need for iterative, time-consuming calibration-processing-recalibration paradigm, and allows for more rapid-turn around in developing interpretation products.

HOLISTIC INVERSION OF TIME DOMAIN AEM DATA

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A holistic inversion algorithm has been developed for time-domain airborne electromagnetic (AEM) data. The algorithm simultaneously recovers a layered earth conductivity structure as well as unmeasured elements of the system geometry. It inverts a complete flight line of data in one inversion. This allows us to take advantage of the expected along-line continuity of conductivity and system geometry, which cannot be exploited when each sample is inverted independently. The conductivity and thickness of each layer and geometry variable is parameterised by the node coefficients of separate cubic-spline basis functions, which implicitly represent smooth continuous along line variations. Each of the cubic splines may have different node spacings that are chosen to adequately represent the expected scale length of lateral variability of conductivity and system geometry. The regularised inversion scheme is formulated to minimise an objective function comprised of data misfit, reference model misfit, and vertical and horizontal roughness terms. The minimisation is implemented via a gradient-based iterative scheme in which a sparse linearised system is solved by the conjugate gradient method within each iteration. The method has been applied to fixed-wing and helicopter AEM data. The results demonstrate that the method produces conductivity models that are geologically credible and consistent with downhole conductivity logs. They also show improved continuity and interpretability in comparison to sample by sample inversions. We found that the estimation of transmitter-receiver separation and receiver pitch geometry parameters was stabilised by the implicit along line continuity constraints.

ONE SOFTWARE PACKAGE FOR PROCESSING, INVERSION AND PRESENTATION OF AEM DATA OF DIFFERENT SYSTEMS: THE AARHUS WORKBENCH

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The Aarhus workbench has been under continuous development since 2002 to meet the research needs of the hydrogeophysics group of Aarhus University. It allows to process, invert and present in GIS environment, geoelectrical and EM data in one software. The main innovation relevant to the mineral exploration fields is the possibility to invert AEM data from any AEM system (both time and frequency domain) using the spatially constrained inversion. In the SCI information migrates horizontally through spatial constraints and allows resolution of layers that would be locally poorly resolved and it greatly reduces the influence of noisy data. It produces quasi 3-D modelling of AEM data. A priori information inserted anywhere along the survey spreads spatially through the constraints. The spatial constraints can be set to reflect the expected geological variability in the survey area. Bird height and system geometry information enter the procedure as inversion parameters, allowing to compensate, for example, for canopy effects, bird pitch or levelling inaccuracies. The full non linear inversion produces also model parameter sensitivity analysis permitting a detailed analysis of inversion results. The results can be presented as resistivity cross sections or thematic maps such as mean resistivity slices, or depth to conductor, etc. The GIS component is available at any time, helping with the processing and the evaluation of the inversion results.

Day 2 Session 3 Stream 4

NEAR SURFACE

Groundwater

GROUNDWATER RECHARGE INVESTIGATION USING TOWED IMAGING DEVICES

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Groundwater recharge investigation requires good spatial and depth resolution of flow pathways from surface water sources through to aquifers. Groundwater is a low value, and often complexly distributed commodity so investigation generally precludes the use of conventional ground geophysical field procedures used in mineral exploration, however, towed and airborne field procedures are cost effective. Airborne equipment, however, is not appropriate for many investigations due to inadequate near surface resolution, inability to adequately exclude cultural interference and high mobilization cost. Towed devices are therefore left with a niche market. Towed frequency domain electromagnetic devices have been used extensively for near surface investigation but commercial application has lacked depth resolution. Towed transient electromagnetic devices have not been applied much in Australia, yet with Australia's vast unobstructed cleared areas of agricultural land, they have great potential for deeper investigation. Invention of large robust towed devices capable of transmitting large magnetic moments opens up the possibility of flexible groundwater investigation at all appropriate depths at farm and larger scales. Similarly, invention of galvanic streamer based systems for use on inland water bodies opens up the possibility of imaging connectivity between these bodies and aquifers.

IMPROVEMENTS IN MAPPING OF FLOODPLAIN DYNAMICS BY INTEGRATING DRILLING INFORMATION WITH AIRBORNE EM, GROUND PENETRATING RADAR AND GROUND BASED, HIGH RESOLUTION EM

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Improved knowledge of alluvial architecture is becoming crucial to investigators to understand the dynamics of large river systems like the Murray in southern Australia. Historically information has been gathered by analysis of drill-hole information, which provides information about fine-scale vertical structure. This is often interpolated laterally over large areas, with mixed results. Increasingly Airborne Electromagnetic surveys (AEM) have been used to help fill in information gaps. Even this information is coarser than needed to define fine structure. This leaves a niche for high resolution ground geophysical surveys, both to validate the AEM, but also to fill in where other methods are too coarse.

For this study, we report the results from a coordinated geophysical and drilling program on highly conductive floodplains near Mildura, Victoria. Three accessible lines (based on existing roads) were chosen over recently acquired AEM surveys. High resolution EM (moving rig NanoTEM) and low frequency (25 MHz) GPR were run over each line. Additionally, depending on the length of the traverse, up to 6 holes were cored (using Geocoastal's hydraulic coring unit to collect complete hydrolithological samples) along each line.

Preliminary comparisons of the three data sets show good correlation between small to medium scale vertical and lateral variations in the geophysical data with observable aspects of the alluvial architecture. These variations can be correlated with features visible in other available data sets in the same area (satellite imagery and high resolution digital elevation models (DEMs)). They also assist in informing interpretation of the broader scale and coarser resolution AEM data.

AN INTEGRATED GEOSTRATEGY FOR MAPPING OF STRUCTURES FAVOURABLE TO GROUND WATER OCCURRENCE – A CASE STUDY

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An integrated geophysical strategy comprising magnetic, electrical resistivity and seismic refraction methods was used to delineate geological contacts associated with an outlier in biotite gneiss and sandstones located near Tiruvuru, Andhra Pradesh, India. Generally these contacts are favourable for ground water occurrence and exploration. In this study, magnetic method used as a reconnaissance tool was found to be highly effective for delineating contacts and estimating the depths to the basement based on Hilbert transform analysis, Fourier spectral method followed by Geosoft modelling. Also, the width of the outlier was established using the amplitude of the analytical signal of the magnetic anomalies. Refraction seismic studies proved to be useful in determining accurately the thickness of various layers. Certain low velocity pockets which are favourable to ground water accumulation were also identified. Location of contacts was supported by vertical electrical soundings (VES) through pseudosections; the depth to the subsurface contact within the outlier was derived from geoelectrical section. Reliability of interpretation is substantiated by correlating the signal with known geology and borewell data.

15:30–17:30
Day 2 Session 4 Stream 1

PETROLEUM

Reservoir Stress Paths/Fracture Characterisation

SUCCESSFUL FLUID DISCRIMINATION IN TIGHT, OVERPRESSURED RESERVOIRS USING AVO INVERSION

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It is well documented that the use of seismic inversion for fluid discrimination is more successful in reservoir rocks with higher effective porosity. Explorationists often dismiss the idea of using quantitative interpretation in reservoirs with less than 15–18% porosity, based on the assumption that the fluid effect at those porosities will be negligible in comparison with seismic noise levels. This assumption is based on porosities being the same in water-saturated and hydrocarbon-saturated reservoirs and is generally reinforced by the fact that porosities decrease with depth while seismic noise increases.

We present a case study of the Longtom Field, Gippsland Basin, where fluid discrimination is successful in the overpressured Admiral sandstone reservoirs with average porosities below 15%. An analysis of P-Impedance and $\mathbf{v}_p/\mathbf{v}_s$ well data demonstrate the feasibility of the fluid discrimination within the sandstone reservoir and show the discrimination of other facies such as shale and volcanics. We see two principal reasons for these rock physics results: a) porosity preservation in the gas charged parts of the Admiral sandstone and b) the overpressure of the reservoir and presumably the encasing shales.

To obtain in-situ estimates of P-Impedance and $\mathbf{v}_p/\mathbf{v}_s$ we use the simultaneous inversion of seismic angle stacks to exploit the amplitude-variation-with-offset (AVO) effects. Recent drilling, which encountered a cumulative reservoir intersection of more than 1000 m, has demonstrated a clear correspondence between the inversion results and the distribution of fluids.

VELOCITY-SATURATION RELATION TRANSITION DURING ROCKS SATURATION: DIRECT LABORATORY OBSERVATION BY COMPUTER TOMOGRAPHY AND ULTRASONIC TECHNIQUE

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Porous rocks in hydrocarbon reservoirs are often saturated with a mixture of two or more fluids. Interpretation of seismic data requires understanding of the relationship between distribution of fluids patches and acoustic properties of rocks. The size of patches and their distribution may have a significant effect on the seismic response. We present results of simultaneous measurements of P-wave velocities and mapping of fluid distribution inside rock sample during fluid injection. If size of the patches is smaller than the passing wave's wavelength, then pressure equilibration is achieved and the bulk modulus of the rock saturated with a homogenous mixture is defined by the Gassmann equations with the saturation-weight average of the bulk moduli of fluid bulk modulus (Wood equation). For larger patch size, there is no pressure communication between different patches; thus fluid-flow effects can be neglected and overall rock may be considered equivalent to an elastic composite material consisting of homogeneous parts, whose properties are given by Gassmann theory combined with Hill's equation for the bulk modulus. Substantial attenuation in saturated samples was observed in all experiments. At low saturations the results are well described by Gassmann-Wood relationships; however sharp increase in velocity of more than 7% was observed while level of saturation is increased. At higher saturations the velocity-saturation relationship becomes close to that described by Gassmann-Hill equations. We explain this effect by the increase of the average fluid patche size.

QUANTITATIVE CHARACTERISATION OF HYDROCARBON RESERVOIR USING INTEGRATED SEISMIC ROCK PHYSICS ANALYSIS: AN INTEGRATED APPROACH USING SEISMIC DATA, SEISMIC ROCK PHYSICS OF WELL-LOG AND CORE

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Quantitative characterisation of hydrocarbon reservoir is an important step to predict the existence of hydrocarbon reservoir, lithology contents, porosity distribution, and pore fluid type of that reservoir.

In this paper, we would like to show the steps of quantitative reservoir characterisation by means of seismic rock physics study in order to tie seismic wave to reservoir properties. Some examples show the advantages of seismic rock physics application in reservoir characterisation.

To create quantitative reservoir characterisation, we should have data of seismic wave in varying conditions of reservoir, such as: pressure, pore fluid type and even temperature. To produce these parameters of seismic wave physically in various condition, special measurement should be done using seismic core measurement. The seismic core rock physics is a physical modeling of seismic wave through natural rock sample of reservoir. The rock sample is measured under condition which is similar with real reservoir conditon. Then, all of possible parameters of seismic wave in various condition that affected by pressure, temperature, pore fluid, and lithology content can be produced precisely. By having relationship database between seismic wave and reservoir parameter, we can make a strategy to characterise the reservoir quantitatively using seismic wave parameter. We also combine other subsurface information such as well log and petrophysics data, production data, petrology or geological data with seismic core rock physics result in order to do this seismic rock physics study.

We show some examples of seismic rock physics study in various reservoir rocks. The interesting results are shown, i.e. seismic wave can distinguish between oil and water, and also contradictory result between theory and physical modeling of seismic rock physics especially in carbonate rock. An application of integrating among seismic rock physics study and seismic wave through artificial neural network shows clearly that seismic wave parameters can distinguish among fluid type, i.e: gas and brine zone.

3D MICROANALYSIS OF GEOLOGICAL SAMPLES WITH NANOFOCUS COMPUTED TOMOGRAPHY

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During the last decade, Computed Tomography (CT) has progressed to higher resolution and faster reconstruction of the 3D-volume. Most recently it even allows a three-dimensional look into the inside of geological samples with submicron resolution. By means of nanofocus® tube technology, nanoCT®-systems are pushing forward into application fields that were exclusive to expensive synchrotron techniques.

Computed tomography for geological purposes can lead to a new dimension of understanding the distribution of rock properties; especially for the spatial distribution of pores and pore-connections, as well as cementation properties, which are of utmost importance in the evaluating reservoir properties. Moreover, rock analysis with the aid of X-ray Computed Tomography may lead to better analysis and prediction of well stimulation jobs. For example, a plug can be scanned before and after being stimulated with acid. The possibility to visualize the whole plug volume in a non-destructive way and to use the same plug for further analysis is undoubtedly currently the most valuable feature of this new type of rock analysis and will be a new area of routine application of X-ray Computed Tomography in the near future.

The paper will outline the hard- and software requirements for high resolution CT. It will showcase several geological applications which were performed with the nanotom, the first 180 kV nanofocus® CT system tailored specifically for highest-resolution scans of samples up to 120 mm in diameter and weighing up to 1 kg with exceptional voxel-resolutions down to <500 nm (<0.5 microns).

Day 2 Session 4 Stream 2

NEAR SURFACE

Hydrogeophysics – AEM

MINERAL AND GROUNDWATER EXPLORATION WITH THE SKYTEM SYSTEM

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The TDHEM SkyTEM system was originally successfully developed for ground water mapping. Presently, the method is widely used also for mineral exploration because of its high lateral and vertical resolution. In this paper we present examples of surveys demonstrating the advantages of using an airborne electromagnetic system developed with focus on high accuracy.

In a sedimentary environment where small resistivity contrasts are significant, it is essential that the system produces data with high accuracy and that data includes very early times gates. To be able to deliver such data and still cover the late time gates the SkyTEM system utilises a dual transmitter mode technique: a low moment mode where low current, high base frequency and fast transmitter turnoff provide early time data; and a high moment mode where a high current, more transmitter turns and lower base frequency provide late time data.

The vertical resolution of the upper layers is comparable with airborne frequency domain systems. The horizontal resolution is high due to less filtering as the signal-to-noise ratio at early times is generally very good for TEM systems.

The presentation will show examples of the results obtained when the purpose is to map distinct targets of mineral exploration interest and buried paleo-channels of interest for ground water and uranium exploration.

UTILISING AIRBORNE ELECTROMAGNETIC DATA TO MAP GROUNDWATER SALINITY AND SALT STORE AT CHOWILLA, SA

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We report on a new approach to acquire critical data on the character of sediments of the Murray floodplains and quality of the water contained therein, as salinity relates to the spatial patterns observed in the frequency domain airborne electromagnetic (AEM) data covering the ecologically significant Murray River floodplain at Chowilla in South Australia. Using an advanced vibro-coring technique developed by GeoCoastal Operations, we have been successful in recovering core from depths in excess of 25 m on the floodplains. Chemical analyses of pore fluids indicate salinities range from 150 mg/L (river flush zone) to >100 000 mg/L TDS. Using ArcGIS technique, we derive salinity model (as TDS mg/L) and salt store (as t/ha) from the holistic inversion depth slices. These results confirm the influx of highly saline groundwater from the north and help position future salt interception bores.

CONSTRAINED INVERSION OF AEM DATA FOR MAPPING OF BATHYMETRY, SEABED SEDIMENTS AND AQUIFERS

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A shallow (depth <20 m) layer of water, fresh, brackish or saline, covers tens of thousands of km^2 of sediments and bedrock along European coastlines, rivers, lakes, and lagoons. These geological units are extremely important, both environmentally and economically. Airborne electromagnetic (AEM) data has been lately used to obtain the bathymetry of shallow surface water. Some attempts have also been made to retrieve information about the sub-bottom. The limited research carried out so far calls for improvements and further developments, both hardware and in data processing and modelling. This manuscript aims at giving a contribution at data inversion level, by applying the constrained inversion methodology to different AEM datasets flown over water. In this technique, adjacent model parameters are regularised through lateral constraints that allow information to flow from soundings that contain more to those that contain less. We present results from constrained inversion (smooth and few layers) of a portion of SkyTEM survey flown over the North Sea. Bird height was included as an inversion parameter to compensate for errors in laser altimeter reading over water. Both the seabed and the freshwater coming from land and protruding into the sediment under the seabed are imaged. Other case studies from lakes and rivers will be presented at the conference.

DEVELOPMENT OF A HELICOPTER TIME DOMAIN SYSTEM FOR BATHYMETRIC MAPPING AND SEAFLOOR CHARACTERISATION IN SHALLOW WATER

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Interpretation of data recorded from a survey over seawater, using a prototype helicopter-borne time-domain airborne electromagnetic system (SeaTEM) system, highlighted the need for carefully calibrated instrumentation and accurate altimetry in order to obtain reliable water depths and estimates of sediment thickness. Three independent studies were undertaken to address these shortcomings. Firstly, the EM responses of SeaTEM hardware located over seawater were recorded to determine water depth and estimate the depth of unconsolidated sediment. In this series of experiments, the transmitter-receiver coil system was suspended over a towed floating platform at a fixed known height. This study was also supplemented by a marine seismic reflection survey in order to provide an independent and more reliable estimate of sediment depth. Secondly, airborne and ground EM measurements over resistive granite were used to study the SeaTEM system self-response. A wideband current transformer accurately recorded the transmitter waveform. In the case of ground measurements, the level of EM interference caused by operating navigational and altimetry sensors located within or between the transmitter-receiver loops, and their effect on the self-response, was also studied in order to design an appropriate mechanical framework for supporting combined EM, navigational and altimetry instrumentation. Thirdly, airborne 2D laser scanner measurements over seawater can provide an accurate 2D-altimetry map which is expected to be more reliable than single-point ranges obtained from laser and radar altimeters. We present the results of these studies and their impact on the development of SeaTEM for bathymetric mapping and seafloor characterisation.

Day 2 Session 4 Stream 3

GENERAL INTEREST

Big Picture Geophysics

MODELLING THE EFFECTS OF OCEAN AND SEDIMENTS ON ELECTROMAGNETIC FIELDS, EXAMPLES FROM THE GAWLER CRATON, SOUTH AUSTRALIA

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Magnetotelluric (MT) data have been frequently collected over the past few years in the form of 2D and 3D surveys across much of the Gawler Craton. The increasing coverage of sites allows a regional analysis of the underlying resistivity distribution with the help of 2D and 3D inversion routines and helps constrain the delineation and nature of geological boundaries. Increasingly, the resistivity models have been combined with existing geological and geochronological knowledge to analyse the tectonic evolution of the Gawler Craton.

The pitfall of large-scale regional analyses of MT data is the conductive influence of the ocean and thick sedimentary sequences on the MT responses. In the case of the Gawler Craton, the sediments, with resistivities of around 10 Ωm and thicknesses up to a few kilometers, contribute significantly to the inductive effect and can cause artifacts in the resistivity modeling. It is therefore essential to differentiate the inductive effect of the lithosphere and that of sediments and sea water.

We present a way of quantifying the sediment and ocean effects by means of 3D forward modeling of the electromagnetic fields associated with them. We use conventional finite-difference methods and also newly developed finite-element codes, which have the ability to include topography/bathymetry more easily by using tetrahedral grids. We show that such an analysis is highly beneficial to further modeling of lithospheric structures.

GEOPHYSICAL MODELLING OF THE GAWLER CRATON, SA – INTERPRETING GEOPHYSICS WITH GEOLOGY

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Geophysical 'worming' was applied to potential field data over the Gawler Craton. 'Worming' is a multi-scale edge analysis technique that can aid in identifying structural controls and depth to anomalies. A geological interpretation of the worming results was then undertaken; integrating drill-hole information, ground mapping and tectonic understanding with geophysical modelling to gain a better comprehension of the dominant structures present.

The 'worming' process provides potential solutions for the lack of outcrop, particularly that which is representative of three-dimensional architecture. The latter is particularly important in understanding how terrains are juxtaposed or dissected tectonically, which in turn influences the style of any mineral system which may be present (for example, is a structure really likely to be associated with mantle-tapping fluids?). Moreover, correct identification of structural geometry and cross-cutting relationships allows a more confident assessment of fault kinematics and potential dilatancy. In particular, the degree of U-mineralisation in IOCG systems in the Gawler Craton may be dependent on the interconnectivity of fault plumbing in three dimensions to nearby uraniferous Mesoproterozoic granitoids.

SOME ISSUES AND INSIGHTS FOR GRAVITY AND MAGNETIC MODELLING AT THE REGION TO CONTINENT SCALE

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Although there is general acknowledgment that the curvature of the Earth is important when performing gravity or magnetic modelling of long traverses or large regions, there are few, if any, detailed studies of the errors involved if a Cartesian (or rectangular) coordinate reference system is used. In part, the use of a Cartesian coordinate system can be attributed to the absence of an alternative in the commercial modelling software packages and the need for additional computational resources if modelling is carried out in a spherical or ellipsoidal reference system. A series of parametric studies have been carried out to quantify the differences in vertical gravity, vertical gravity gradient and total magnetic intensity response for a source element in Cartesian or spherical coordinate reference systems. Recently published algorithms for calculating the gravity and magnetic fields for spherical prism elements have been applied to global crustal rock property models to calculate the associated potential field response for broad regions of the Australian continent. Geoscience Australia intends to utilise the improved long wavelength gravity and magnetic data that are being acquired as part of the Onshore Energy Security Program in combination with appropriate modelling software to investigate region to continent scale property models. In addition to providing insights into the geology at this scale, these models will be used as a consistent and coherent framework for nesting more detailed investigations of the gravity and magnetic data.

AN EXTENSION OF THE CLOSED-FORM SOLUTION FOR THE GRAVITY CURVATURE (BULLARD B) CORRECTION IN THE MARINE AND AIRBORNE CASES

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Geoscience Australia recently revised the corrections applied to the Australian National Gravity Database (ANGD) and switched from applying the simple Bouguer correction to the observed gravity values in its database to applying the more accurate gravity curvature (Bullard B) correction. This change is a straightforward procedure in the case of land-based gravity surveys. However, due to the inherent non-linearity of the Bullard B correction, the original formula for the gravity curvature correction is not applicable to observed data from gravity surveys which involve layers of different materials, as is the case for marine or airborne gravity surveys. Here we present an extension of the closed-form solution for the Bullard B correction which allows its proper application in any gravity survey setting. In particular, we present formulas to correctly apply the Bullard B correction to observed gravity data from airborne and marine gravity surveys.

Day 2 Session 4 Stream 4

NEAR SURFACE

Engineering Geophysics

APPLICATION OF GEOPHYSICS TO UNDERGROUND SPACE DEVELOPMENT FOR IMPROVEMENT OF URBAN ENVIRONMENTS

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The history of human civilisation shows a continuous trend towards urban life as the basis for social organisation. Over the last 50 years, this trend is accelerating with the proportion of the world urban population expected to reach 61% by 2030. Maintaining quality of life in urban areas and creating sustainable urban environments at a time of likely rapid climate change is one the most crucial current human challenges. Increasingly, urban environmental problems are addressed by using underground space for infrastructure development and geophysics is a key, environmentally-friendly technology, to assist this development.

The Epping to Chatswood Rail Line will be completed in 2008. This is a 13 km long, twin rail tunnel with four new stations, all entirely underground and is major urban infrastructure development that will provide long-term environmental benefits to the Sydney metropolitan area. When this Link was first proposed it included a bridge crossing of the Lane Cove River within a National Park. Subsequently, wide-spread community concern led to this approach being abandoned in favour of a tunnel beneath the river. A case study of this underground space development shows how geophysics, completed under strict environmental guidelines, was applied to quantify subsurface conditions beneath the river and within the river valley. Underwater seismic refraction, borehole seismic imaging from limited number of boreholes reduced geotechnical risks for this project and assisted tunnel design. This case study demonstrates the benefits of applying geophysics to environmentally sensitive underground space developments in urban areas.

3D TREATMENT OF MASW DATA FOR MONITORING GROUND IMPROVEMENT AT AN UNCONTROLLED FILL SITE

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The output from a Multichannel Analysis of Surface Waves (MASW) survey is essentially a series of 1-dimensional S-wave velocity profiles, which are often expressed in 2D sections along each of the survey lines. Each 1D data point can be defined using X-Y coordinates, and an S-wave velocity profile with depth can be obtained at each data point location. An MASW survey provides a dense coverage of analysis points, making it possible to obtain output across a surveyed area in a 3D data set.

An MASW survey was carried out at an industrial development site in northern New South Wales, where uncontrolled fill was encountered. The fill at the site was subsequently improved and compacted using a 4-sided impact roller. The purpose of the MASW survey was to monitor the uniformity of the fill after ground improvement.

Results from the MASW survey were compared with field density tests, dynamic cone penetration (DCP) testing and the excavation and logging of trial pits. Good correlation was achieved between the different testing methods, when comparing MASW survey data presented in 1-, 2-, or 3-dimensional formats. The MASW survey was used to distinguish between areas of site that were deemed satisfactory and other areas where further ground improvement was needed to facilitate future development at the site.

The high density sampling frequency of the MASW survey enabled loose fill layers at depth to be identified and quantified in 3D space, which lead to timely and cost-effective project outcomes.

MULTICHANNEL ANALYSIS OF SURFACE WAVES FOR BEDROCK DEPTH ESTIMATION OVER GRANITES, HYDERABAD, INDIA

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The dispersive characteristics of Rayleigh type surface waves were utilised to estimate the shear wave velocity (VS) profile by imaging the shallow subsurface granitic layers near Hyderabad, India. The reliability of multichannel analysis of surface waves (MASW) depends on the accurate determination of phase velocities for horizontally travelling fundamental mode Rayleigh waves. Multichannel recording leads to effective identification and location of various factors of noise. Calculating the 1-D shear wave velocity (VS) field from surface waves ensures high degree of accuracy irrespective of cultural noise. The main advantage of mapping the bedrock surface with shear wave velocity is the insensitivity of MASW to velocity inversion besides being free from many constraints such as contrast in physical properties etc. Modelling of surface waves data results a shear wave velocity (V_S) of 250 m/sec covering the top soil to weathering and up to bedrock corresponding to a depth range of 10–30 m. Results are discussed over a selected set of data highlighting the salient features of MASW.

SHAFT SINKING RISK ANALYSIS THROUGH THE INTEGRATION OF BOREHOLE RADAR AND ACOUSTIC TELEVIEWER DATA IN DEEP GEOTECHNICAL BOREHOLES

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Anglo Platinum is planning to bring a new platinum mine on-line in South Africa's Bushveld Complex. Major capital investment is required in order to sink the twin shafts required to access underground platinum reefs located up to 2000 m below surface. Deep pilot shaft boreholes are drilled along the proposed shaft axis. These holes are logged extensively with a suite of geophysical tools in order to detect any potentially hazardous structures that may influence shaft sinking operations.

This paper examines the integration of borehole radar and acoustic televiewer data down the proposed main- and vent shaft positions. Borehole radar was used in reflection-mode in these boreholes in order to delineate any near-vertical structures close to the intended shaft positions. The major drawback of current slim-line borehole radar probes is that they are omni-directional; hence it is not possible to determine the orientation of borehole radar reflectors in relation to the borehole.

The acoustic televiewer (ATV) is used to pick structures that intersect boreholes, and can provide information on the dip, dip direction as well as structure of the rock mass through which the shafts will penetrate. Borehole radar reflectors, that intersect the borehole, can be depth correlated to structures identified using the ATV. In this way borehole radar reflectors can be oriented in space using the dip direction obtained from the ATV data.

The integrated borehole radar and ATV-data were imported into GOCAD© along with the planned shaft infrastructure in order to identify geological structures that may potentially influence the sinking of these two shafts.

Day 3: Wednesday 25 February 2009

9:00–10:30
Day 3 Session 1 Stream 1

PETROLEUM

Seismic Acquisition

THE ROLE OF IN-FIELD SEISMIC PROCESSING IN EARLY EVALUATION IN UNDER-EXPLORED AREAS OF THE DARLING BASIN

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The 2008 Rankins Springs Seismic Survey was a joint initiative by Geoscience Australia and NSW Department of Primary Industries under the Onshore Energy Security Program (OESP) in the under-explored southeastern Darling Basin. Regional acquisition parameters of 300 channels, 40 m group interval and 80 m vibration point interval nevertheless allowed detailed imaging of a 3 second (TWT) thick sedimentary sequence in the Yathong Trough. Use of three 12 second vari-sweeps from truck mounted Hemi 50 (50 000 lb) vibrators provided sufficient energy to image from immediately below regolith to the Moho. The sweep frequency ranges 6–64, 10–96 and 8–80 Hz were chosen both for deep penetration and high resolution in the sedimentary section. In-field processing produced a high quality preliminary section on a daily basis using an iterative process of automatic residual statics calculation on a deep gate and interactive stacking velocity analysis. Both automatic statics and stacking velocity were essential for successful imaging, but velocity was more important, as initial estimates based on first arrival velocities produced a degraded section. The field seismic section clearly shows a fault bounded trough, with evidence of compressional structures in the upper part and hints of underlying older sedimentary basins. The in-field stacking velocity analysis also provided immediate evaluation of the maximum depth of the trough, namely 6 km, deeper than expected. Efficient in-field processing allows early notification to project partners of a successful survey, facilitating future planning, and provides a sound basis for streamlined subsequent processing.

TOWARDS COST-EFFECTIVE PERMANENT SEISMIC RESERVOIR MONITORING

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A new fibre optic seismic acquisition system for permanent seismic reservoir monitoring has been designed and constructed. In contrast to conventional electrical systems, the fibre optic acquisition system has lower construction costs, greater long-term reliability and improved signal quality. This is expected to help accelerate uptake of permanent seismic reservoir monitoring installations.

Permanent seafloor seismic systems offer time-lapse seismic with higher repeatability and greater sensitivity than towed-streamer surveys, as well as the advantage of multi-component recording. Permanent seismic installations can help remotely detect changes in fluid saturation and pressure, and monitor reservoir compaction during production. At the Valhall Field on the Norwegian continental shelf, shear-wave splitting data collected at regular time intervals highlights the compaction behaviour of the chalk reservoir. PS-wave data contribute to the characterisation of the Valhall reservoir beneath gas clouds in the area, and P- and PS-wave pre-stack depth migrated volumes produced over time are used to extract relevant 4D seismic attributes that will, for example, assist with the placement of infill wells, and identification of step-out opportunities.

The new fibre optic system, designed to contribute to cost-effective reservoir monitoring, incorporates sensors that are optical transducers made using Michelson interferometers. The fibre optic cable uses a Dense Wavelength Division Multiplexing telemetry scheme to optically power the sensors. Each cable contains more than 2000 channels with a dynamic range greater than 140 dB. Field trials conducted to date in the Gulf of Mexico and the North Sea have demonstrated that data acquired by the fibre optic hardware correlate well with data collected using a conventional electrical sea-floor acquisition system.

Day 3 Session 1 Stream 2

GENERAL INTEREST

Crustal Solid Earth

GEOPHYSICAL DATASET INTEGRATION OF THE VREDEFORT DOME, SOUTH AFRICA

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Aeromagnetic, gravity, SRTM DEM and Landsat TM data covering the Vredefort Dome are analysed and compared using similarity images and cross grey level co-occurrence matrix texture transforms. The Vredefort Dome is the 80 km wide central uplift of a very large 2Ga meteorite impact, consisting of a core of Archean crystalline rocks surrounded by a collar of Archean-Palaeoproterozoic supracrustals. The upturned supracrustals outcrop in the north and west and are clearly visible in Landsat and SRTM DEM images. Karoo sediments cover the southern part of the Dome. The aeromagnetic data show clear evidence of remanent magnetisation and similarity plots of the analytic signal of the fractional vertical integral and reduction to the pole incorporating remanence played an important role in the interpretation. Reduction to the pole was carried out with variable remanence inclination using available palaeomagnetic data. Isostatic residual gravity data show a complex picture. The core response consists of a central gravity high due to granulites (lower crustal?) with an annular gravity low due to amphibolite facies basement gneisses. The supracrustal collar response shows multi-ring gravity highs and lows.combining the various datasets using similarity plots provides a much clearer picture of the Vredefort Dome. Circular shaded relief applied to the similarity images gave the best resolution of the complex ring structures.

COHERENCE BETWEEN TELESEISMIC TOMOGRAPHY AND LONG-WAVELENGTH FEATURES OF THE GRAVITY AND MAGNETIC FIELDS OF SOUTHEASTERN AUSTRALIA

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Recent teleseismic data acquisition in southern New South Wales have yielded a new mantle lithosphere velocity model that extends across Victoria and southwestern New South Wales. Belts of anomalous P-wave velocity broadly correspond to the Proterozoic Delamerian (high v_p) and Phanerozoic Lachlan (low v_p) orogens in the upper crust, although the eastern boundary of the high v_p belt lies east of the geological division between the Delamerian and Lachlan orogens. Smaller areas of high v_p below the Lachlan Orogen may correspond to Proterozoic lithospheric fragments underlying the upper crust. Major tectonic divisions within the Lachlan Orogen do not appear to be reflected in the mantle lithosphere velocity structure.

We have attempted to resolve differences between the tectonic framework of the upper crust and the velocity structure of the upper mantle by considering long-wavelength features in the isostatic gravity and magnetic fields, which we attribute to sources in the middle (magnetic) to lower (gravity) crust. A broad magnetic high corresponds closely to the low v_p belt. Gravity is less clearly correlated, but the low v_p Phanerozoic belt is marked by a long-wavelength gravity high. Grid merging requires manipulation of trends between individual surveys, and so long-wavelength features may be suppressed by, or be an artefact of, the merging procedure. However, the same broad correlations between the upper mantle velocity and the gravity and magnetic fields are also visible, albeit at a lower resolution, in satellite (GRACE and CHAMP) earth field models over southeastern Australia.

GEOPHYSICALLY IMAGING PALEOPROTEROZOIC TERRANE BOUNDARIES IN THE UNEXPOSED NORTHERN GAWLER CRATON, MARLA REGION

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The unexposed basement architecture of the northern Gawler Craton is poorly constrained yet is of primary importance for models of continental growth as these rocks should preserve the best record of the Gawler Craton's interactions with its neighbours during the amalgamation of Proterozoic Australia. Unfortunately, these rocks are almost completely covered by Neoproterozoic and younger sedimentary rocks (with <<1% basement outcrop), so are amongst the least studied on the Australian continent.

We focus on the basement architecture in the Marla region of the northernmost Gawler Craton. We use geophysical techniques and apply a top-down approach to penetrate the significant thickness of cover and determine the structure of the unexposed northern Gawler Craton. We use surficial geology, borehole data and seismic reflection profiles to determine the structure of overlying cover sequences and constrain the role of basement structures in later intra-cratonic orogenies. The effect of these cover sequences is then removed from gravity and magnetic data highlighting basement structures. The architecture of the basement with depth is determined by combining Euler deconvolution, petrophysical data, with forward and inverse modelling techniques.

Specific results of this analysis include the observation that a broad magnetic anomaly observed over the Ammaroodinna Ridge is due to shoaling of the basement rather than a change in its petrophysical properties. Whereas the Middle Bore Fault represents a major Paleoproterozoic terrane boundary juxtaposing high density mafic rocks against metasediments. The basement structure revealed by this approach constrain the processes responsible for the growth and evolution of the northern Gawler Craton and its role in the Proterozoic amalgamation of Australia.

Day 3 Session 1 Stream 3

MINERALS

Case Studies – AEM

COMPARISON OF GROUND TEM AND VTEM RESPONSES OVER KIMBERLITES IN THE KALAHARI OF BOTSWANA

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Ground TEM surveying proved to be the most effective magnetic signature screening technique for the identification of kimberlite intrusions overlain by 40 to 120 metres of Kalahari cover in the Kokong kimberlite field of Botswana. Greater than 90% of those kimberlite magnetic signatures screened by ground TEM had diagnostic TEM signatures, whereas ground gravity, the next most effective kimberlite magnetic signature screening technique, had about a 75% diagnostic signature identification rate. Following the success of kimberlite identification by ground TEM, a VTEM survey was undertaken over a part of the Kokong kimberlite field to determine if airborne TEM surveying would be as effective as ground TEM surveying for the screening of kimberlitic magnetic signatures. Both ground TEM and airborne VTEM surveying were able to identify kimberlite pipes beneath 100+ metre thick sequences of Kalahari cover. A comparison and discussion of ground TEM and VTEM responses over select Kalahari Sequence covered kimberlites traversed by both TEM survey methods and their comparative effectiveness for kimberlite discovery is presented.

BASE METAL DISCOVERIES IN AFRICA AND AUSTRALIA FROM VTEM DATA

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The conductive overburden found on the African and Australian continents are normally considered a challenge for airborne EM surveys, severely limiting the depth of investigation and reducing anomaly amplitudes of basement conductors. However, interpretation of airborne TDEM data acquired with the VTEM system has led to the discovery of a number of base metal deposits in Africa and Australia over the last three years. These successes are ascribed to a combination of the VTEM's high signal to noise ratio and interpretation skills of experienced geophysicists. Examples of these discoveries include Bertram NiS and Sunchaser VMS (Fox Resources) and West Balla and Balla Balla (Straits Whim Creek Copper) in Australia as well as a discovery in Zambia for Zambezi minerals. These will be discussed in terms of their geological setting, TDEM response signatures and interpretation procedures which were followed.

CASE HISTORIES ILLUSTRATING THE CHARACTERISTICS OF THE HELIGEOTEM SYSTEM

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The introduction of broadband coils has given the HeliGEOTEM system greater sensitivity to poor conductors, enabling the system to see these conductors in addition to the slow decays from excellent conductors. This is illustrated with data acquired in a nickel exploration project north of Sudbury.

A comparison with the DIGHEMV AEM system at Maimon shows that the HeliGEOTEM is able to see deeper, but does not have quite as good capability to resolve features close to the surface. Also, fixed-wing interpretation procedures can be applied to the HeliGEOTEM data to interpret a conductivity-depth image (if a layered earth model is assumed), or the dip, depth and conductivity-radius-squared (if a discrete conductor model).

In northern Alberta, HeliGEOTEM is not able to identify some of the very small features close to surface that are evident on the RESOLVE AEM data, but it is able to map larger ones that are not evident in the GEOTEM data. The depth penetration of the HeliGEOTEM is greater than the RESOLVE and almost as great as the GEOTEM.

Recent tests of a large-dipole-moment system over the Nighthawk deposit show that the deposit could be can be identified if it were be buried 325 m below the surface.

A difficult test for AEM systems is the Caber deposit, which is a small vertical cylinder target, with a depth to top of 150 m. A recent test with the higher-power version of the HeliGEOTEM system shows a clear response from the Caber deposit.

Day 3 Session 1 Stream 4

MINERALS

Potential Field Inversions

QUERYING POTENTIAL FIELD INVERSIONS FOR SIGNATURES OF CHEMICAL ALTERATION: AN EXAMPLE FROM COBAR, NSW

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Alteration minerals associated with base metal and gold deposits of the Cobar region, NSW, have densities and magnetic susceptibilities that are vastly different from those of their host rocks. An estimate of the subsurface densities and magnetic susceptibilities is provided by 3D potential field property inversions such as the UBC-GIF style inversions. Evaluating the properties, which have been derived by inverting available magnetic and gravity data for the region, for individual geological units (as defined by a regional 3D map, created by a one-on-one ***pmd****CRC project between Triako Resources, Peak Gold Mines, CBH Resources, Cobar Management PL, Tritton Resources, the NSW DPI and ***pmd****CRC) allows us to define regions of anomalous properties in 3D space. These zones of anomalous properties can be inferred to represent alteration to magnetite, iron-rich pyrrhotite, pyrite or iron-poor pyrrhotite, and sericite. This represents a new way of targeting in the region; the methodology has the potential to be applied to other regions including those areas under cover.

CONSTRAINED POTENTIAL FIELD INVERSIONS IN AREAS UNDER COVER: EXAMPLES FROM GAWLER CRATON IOGG PROSPECTS

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The future of greenfields mineral exploration will be driven towards covered terranes with little or no outcrop. Consequently, the inherent risk and costs of such exploration will rise. The exploration focus will be pushed towards inexpensive methods and more importantly obtaining the most value from them. Potential field geophysics provide a solution to this impending issue with regional datasets often available in the public domain and higher resolution data being relatively inexpensive to acquire. Constrained potential field inversion represents a method for adding or maximising the value from the associated datasets.

Many greenfields environments have an apparent absence of *a priori* data to constrain the first pass inversion. This paper suggests that although this absence may exist, meaningful 'soft' constraints will still be present which when included in the model objective function, improve and add value to the inversion process. Additionally the same constraints can be used to test whether a proposed geological hypothesis is a viable model.

Using gravity data over covered IOCG prospects within the Gawler Craton, this paper demonstrates how 'soft' constraints can be employed to enhance the inversion process. Simplified layered geological models representing cover and basement have been discretised, using realistic petrophysical bounds that when incorporated into the model objective function yield more accurate results. Furthermore, the potential of a prospect to host IOCG mineralisation can be simply tested in a similar fashion. When inversion results describe bodies that are geologically unrealistic, the target can be downgraded saving a potentially expensive drillhole.

CONSTRAINING GRAVITY AND MAGNETICS INVERSIONS FOR MINERAL EXPLORATION USING LIMITED GEOLOGICAL DATA

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Physical property models recovered from geologically-constrained inversion of gravity and magnetic data provide a more reliable prediction of the subsurface than can be obtained without constraints. Constraint models for inversions are commonly thought to consist of full 3D geological interpretations of the subsurface that must be prepared prior to performing inversions; however that degree of knowledge is not necessary. Moreover sparsely distributed raw geological and geophysical observations, which constitute a more prevalent set of constraints, are often all that is available. In this paper we show that inclusion of such observations from maps, sampling, limited drilling, analogous areas or neighbouring regions can dramatically improve the reliability of recovered physical properties models without imposing unreasonable time costs.

Even in greenfields mineral exploration there will be some geological information available in addition to the geophysical data. These constraints can be supplied to the inversion software, with adjustable levels of certainty, via a reference model of expected properties, bounds on the expected properties, or smoothness weights based on positions and orientations of the rocks. The UBC-GIF inversion software will produce holistic physical property models consistent with all the supplied information. The types of constraints that can be included, and their effectiveness, are demonstrated in this study using gravity inversions over a simple geologically-based synthetic example. The same principles and techniques are then applied to real gravity inversions to aid near-mine exploration. The models that are obtained using different types of constraints are in all cases superior to the model obtained from a default parameter, geologically-unconstrained inversion.

11:00–12:30
Day 3 Session 2 Stream 1

PETROLEUM

Seismic Anisotropy

AN EQUIVALENT OFFSET TIME MIGRATION FOR ANISOTROPIC DATA

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The equivalent offset method of time migration is a fast method that is based on the Kirchhoff algorithm. It produces prestack migration gathers that are formed with no time shifting of the input and are suitable for velocity analysis. The prestack migration is completed with scaling and moveout correction.

The method equates travel-times that are computed from the double-square-root (DSR) equation to a single hyperbolic equation that contains the RMS velocities and the equivalent offset. Energy from the input trace is summed into the prestack migration gather at the equivalent offset. The equivalent offset is related to the actual geometry of the input trace that not only includes the source receiver offset, but also includes the displacement of the common-midpoint (CMP).

This new application includes the effects of anisotropy in the non-hyperbolic DSR equation which is then equated to the hyperbolic equation that contains no anisotropy terms. The equivalent offset obtained from the hyperbolic equation places the reflection energy on a hyperbolic path in the prestack migration gather, suitable for accurate velocity analysis as the non-hyperbolic distortions have been removed. The estimated RMS velocities are an accurate representation of the vertical velocities in a TI medium.

IMPROVING SEISMIC ANISOTROPY ESTIMATION BY MULTI DIRECTIONAL RESIDUAL CURVATURE ANALYSIS

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Anisotropy is an important part of depth-velocity models used for seismic data processing and imaging. Standard anisotropy analysis techniques require seismic data recorder with wide reflection angles. Because maximal cable length is always limited, these techniques became less capable as we move to deeper intervals. Also, standard processing of narrow azimuth seismic data is limited to producing VTI or TTI anisotropic velocity models when it becomes widely accepted that azimuthal orthorhombic anisotropy plays an important role in forming seismic wave fields and has to be taken into consideration.

We show how these limitations can be mitigated by using reflections from dipping horizons and fault planes (multi directional residual curvature analysis – MDRCA). When a geological model contains dipping reflectors, our seismic data include events travelled with angles much wider than those estimated by maximum offset to depth ratio. Such seismic data also include multi azimuth arrivals even in the case of single (narrow) azimuth acquisition. So, we use natural dips of all present seismic reflectors to widen standard reflection angle range determined by maximum offset to depth ratio. Because real geological reflectors have arbitrary azimuths, MDRCA can potentially estimate azimuthal anisotropy even using single (narrow) azimuth input seismic data.

MDRCA has been incorporated into iterative tomographic depth-velocity modelling technique.

Real data examples show estimation of VTI anisotropy for deep intervals and measuring azimuthal velocity anisotropy using single azimuth seismic data. These examples demonstrate how additional information obtained by MDRCA can improve the quality of depth processing results.

NONLINEAR ESTIMATION OF THOMSEN ANISOTROPY PARAMETERS IN TI MEDIA

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Transverse isotropy with the horizontal axis of symmetry (HTI) is the simplest anisotropic model to characterise a geological formation with vertical fractures. We formulate an azimuthally dependent parametric equation for P-wave travel-times in a layered HTI medium. This travel-time equation has been parametrised by ray parameter; hence it is convenient for ray tracing purposes in homogenous layered media. Also, assuming a known vertical velocity model, we estimate simultaneously the fracture orientation and Thomsen's anisotropy parameters in a stack of horizontal layers using a modified preconditioning conjugate gradient algorithm. The comparison of travel-times using the parametric equation and Tsvankin's equations (1997) shows very small differences. We have used a numerical model with homogenous layers with VTI and HTI anisotropy to compute the travel-times. These travel-times will be used for parameter estimation as measured data. To verify the robustness of the inverse model we draw a random prior model for the Thomsen's parameters within the weak anisotropy assumption and also fracture orientation from a uniform distribution. All model parameters have been estimated satisfactorily after only several iterations.

Day 3 Session 2 Stream 2

MINERALS

Hyperspectral Mapping

MINERAL AND COMPOSITIONAL MAPPING USING AIRBORNE HYPERSPECTRAL AND GEOPHYSICAL PRODUCTS, NORTH QUEENSLAND

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Large areas of prospective North Queensland have been surveyed by airborne hyperspectral sensor, HyMap and airborne geophysics, as part of the 'Smart' exploration initiative by the Geological Survey of Queensland since 2006. In particular, 25000 km^2 of hyperspectral mineral and compositional map products, at 4.5 m^2 spatial resolution, have been generated and made available via the internet (http://www.em.csiro.au/NGMM; http://www.dme.qld.gov.au/mines/hyperspectral.cfm) Airborne radiometric and magnetic data, acquired over the same North Queensland areas at a maximum of 400 metre flight line spacing, provides a significant opportunity to compare the mineral mapping potential of both techniques, for a wide range of geological and vegetated environments. Case studies described in this study include soil mapping within the Tick Hill area, Duchess, and geological/exploration mapping at Mt Henry, Mt Isa Block. In particular, this study investigates the scope for an improved interpretation via a synergistic approach, either via GIS or by testing integrated product, using both spectrally derived mineral and airborne radiometric/magnetic inputs. Previous researchers have attempted generating integrated products using multispectral ASTER and airborne magnetics/radiometric data. However further refinements are possible when interpreting higher spectral resolution hyperspectral data with airborne geophysics. For example, the improved mineral discrimination derived from hyperspectral data and radiometric data is demonstrated for lithologies containing potassium bearing clay minerals (e.g. muscovite) and potassium bearing feldspars (e.g. orthoclase) in otherwise radiometrically homogenous anomalous units.

MAPPING REGIONAL ALTERATION PATTERNS IN THE CURNAMONA PROVINCE USING HYPERSPECTRAL CORE SCANNING TECHNOLOGY

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Before the advent of the CSIRO HyLogger technology, semi-quantitative mineralogy was beyond the realms of practical application being expensive and time consuming. With a high density, high volume, spectral dataset, down hole mineralogy can be mapped, not only by presence, but also by abundance and chemical gradient. Four main mineral suites are presented here: white mica/clays (Al(OH)), chlorite (Fe, Mg(OH)), carbonate (CO3) and Fe Oxide.

In the Curnamona Province (South Australia) 45 drill holes have been scanned, using HyLogger technology. By translating the spectral response into metres of detected minerals per hole it has proved possible to map the chemical gradients of the province. With this information Eh-pH trends can be estimated and used to vector various styles of mineralisation.

ACID SULPHATE SOIL MAPPING WITH HYPERSPECTRAL IMAGERY AT SOUTH YUNDERUP, WESTERN AUSTRALIA

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Airborne hyperspectral (HyMap) data were collected over a portion of South Yunderup, Western Australia in December 2005. Processing of the data and field sampling were performed in January 2008 to investigate if the acid sulphate conditions could be mapped using remote sensing methods. Kaolinite, goethite, hydrated iron oxyhydroxide, jarosite, cellulose (dry plant material), green vegetation, gypsum, calcium carbonate and clay minerals were identified by the airborne hyperspectral data. Laboratory spectral measurements and XRD and SEM/EDS analysis of the field samples confirmed the presence of these minerals, along with schwertmannite, which was not directly diagnosed as occurring in the imagery. This was likely due to the high abundance of water in the scene, as the data acquisition occurred in early summer. An acquisition later in the dry season would have exposed more minerals and reduced discrimination difficulties encountered due to the effects of water in the soil materials.

An acid sulphate soil surface map was produced from the 2005 airborne hyperspectral data using the surface mineralogy. The map shows areas where there is a higher potential for the generation and current presence of acidic conditions at or near the surface. Large areas adjacent to the canals and urban areas were categorised as high risk areas due to the presence of kaolinite and goethite minerals at the surface, with the likelihood of iron oxyhydroxysulphate minerals occurring at shallow depths.

The surface expression of acid sulphate minerals is known to be highly influenced by local climate and rainfall events. Although there had been a considerable gap between collection of the remotely sensed data and field validation, the airborne hyperspectral imagery was an effective tool for identifying minerals and materials related to acid sulphate conditions present at the exposed surface.

Day 3 Session 2 Stream 3

MINERALS

African Geophysics – AEM

VTEM RESPONSE OF THE TUSKER GOLD DEPOSIT, TANZANIA

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The Tusker gold deposit, located in the Lake Victoria Goldfields of Tanzania, has an indicated/inferred resource of 4.5 Moz gold grading 1.15 g/t from 123.2 Mt. Since its discovery, many geophysical techniques have been trialled over the deposit, including dipole-dipole IP/resistivity, airborne magnetics/radiometrics and airborne time domain EM (VTEM). Down hole and laboratory petrophysical measurements have also been acquired. While all geophysical datasets over the deposit are discussed, this paper focuses on the VTEM signature of the deposit.

The Tusker orebody is hosted within a variety of clastic sediments and minor volcaniclastics, considered to be upper Nyanzian in age. Magnetic data map a fine grained magnetic mudstone package and show structures controlling the emplacement of the orebody. The orebody is associated with sulphides, primarily arsenopyrite, and possesses a strong chargeability response.

Sulphides associated with the orebody are conductive, and display a strong late time channel response in VTEM data, acquired by Geotech Airborne Limited in August 2006. Data were acquired at 50 m line spacing over an area of 44 km^2.

Forward and inverse modelling of VTEM data is presented, and results are discussed in relation to down hole and laboratory petrophysical measurements.

GEOPHYSICAL RESPONSE OF THE MUNALI NI-CU DEPOSIT, ZAMBIA

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The Munali deposit was discovered in the early 1970s and a resource of approximately 2.2 Mt @ 1.07% nickel and 0.15% copper was defined by the mid-1970s. Due to the low grade and remote location, little work was carried out in the period 1980–1990s until 2002 when Albidon Limited optioned the property and began a systematic assessment of the deposit and surrounding area. As part of this assessment, a VTEM airborne EM and magnetics survey was flown over the deposit in 2006, followed up with detailed ground EM surveys. This paper examines the outcomes of the airborne and ground surveys in light of the known geology. The Munali deposit is currently in pre-production development.

THE APPLICATION OF AIRBORNE GEOPHYSICS IN THE EXPLORATION FOR IRON ORE IN THE ZOUERAT AREA OF MAURITANIA

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An airborne time domain electromagnetic and magnetic survey (Geotech VTEM system) was flown over Kedia and Mhaoudat in Mauritania. Hematite has been mined in both these areas for many years. The objectives of this survey were to determine if additional ore bodies existed below old mined areas and to find and delineate possible new ore bodies. Decay curve analysis was done of the VTEM data as a fast, first pass delineation of conductive areas. Good correlation with existing mines was found. CDI's were consequently calculated for all flight lines. These were used to calculate conductivity contour maps at various depth intervals. Conductive areas were correlated with the magnetic data as well as the known geology. In several areas known iron ore was associated with the edges of anomalies that continued at depth and distance, indicating possible extensions of the ore. Further anomalies occurred in a sand covered area south of Mhaoudat, leading to the possibility of new iron ore deposits. Based on the interpretation of the airborne data, a number of drill targets were selected.

Day 3 Session 2 Stream 4

MINERALS

Potential Fields, Advances in Processing

TERRACING POTENTIAL FIELD DATA

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Terracing is an operator that is applied to potential field data to produce regions of constant field amplitude that are separated by sharp boundaries. The objective of terracing is to recast potential field maps into a geological map like format. Terracing is performed by moving a window through the data and computing the curvature at each point. The curvature of the field is calculated using a numerical approximation to the Laplacian derivative operator. The output value (located at the centre of the window) takes on one of three possible values. It becomes the value at the centre of the window, if this is greater than or lower than the rest of the data values in the window. If the curvature is positive then the output value is set to the minimum of the data values in the window, while if it is negative then the output value is set to the maximum of the data values in the window. Terracing is performed in an iterative manner, with the data being sharpened progressively. Previous work found that the terracing algorithm tended to square off the corners of anomalies, resulting in ragged domain boundaries. To compensate for this the total horizontal derivative of the data was computed, and then its local maxima was tracked, producing ridges which were then overlain on the terraced data. We propose that the problem of square domain boundaries was due to the curvature being computed using only the second horizontal derivatives in the x and y directions, and that it can be solved by using instead the profile curvature, which is the curvature computed in the direction of steepest ascent at each point of the data. The method is demonstrated on gravity data from South Africa and Australia.

ENHANCEMENT OF LAMPROITE MAGNETIC SIGNALS

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Lamproites are peralkaline lamprophyric rocks of volcanic or hypabyssal origin, which occur in shallow craters, often in the shape of a champagne glass with crater diameters ranging from a few hundred metres to 1500 metres. An unusual feature is that volcaniclastic rocks in many lamproite craters are intruded by a magmatic phase that forms lava lakes or domes. Magnetic signatures of lamproites are quite variable with usually only the magmatic phases providing a clear magnetic signature. Primary spinels vary from non-magnetic chrome-spinel to ferrimagnetic Fe-Ti oxides with large variation in Fe content. In olivine lamproites, the olivine usually serpentinises during eruption producing secondary magnetite which may produce significant magnetic anomalies.

Semi-automatic interpretation, using specialised filters and analytical techniques specifically designed to detect near circular magnetic anomalies provide objective information on magnetic anomaly attributes. Useful techniques include separation filtering, Keating matched filtering using a cylinder model, a dipole tracking filter based on grey-level co-occurrence matrices, a modified version of the Hough transform and circular gradients and shading. These techniques have been applied to aeromagnetic data from part of the Ellendale Lamproite Province in the West Kimberley of Western Australia with varying degrees of success. Separation filtering, Keating matched filtering and texture filters dipole tracking have performed well, handling the range in size, shape and magnetisation seen in these lamproites. Clearly no single technique provides all the answers. The economic diamondiferous lamproite, Ellendale 9 is best defined by the Keating filter and GLCM results but is a difficult target as much of the pipe is non-magnetic diamondiferous tuffite.

STRATEGIES TO INVERT A SUITE OF MAGNETIC FIELD ANOMALIES DUE TO REMANENT MAGNETISATION: AN EXAMPLE FROM THE GEORGETOWN AREA OF QUEENSLAND

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Inversion of a magnetic field anomaly does not require prior determination of the direction of magnetisation, but an unknown magnetisation direction introduces some trade-offs in estimation of the spatial and magnetisation parameters of the source body. Fortunately magnetisation events are generally manifest in several or many anomalies, providing the opportunity to derive a more reliable magnetisation direction from multiple estimates. However, within a group of anomalies the magnetisation direction varies due to different ratios of induced and remanent magnetisations, changes in geomagnetic field direction during the magnetisation event and any post-magnetisation structural reorientation. Furthermore, the suitability of anomalies to provide estimates of magnetisation direction depends on their shape, amplitude and setting. Inversion of a group of anomalies therefore requires a flexible strategy to estimate the best population magnetisation direction, while accommodating variations in the magnetisation direction of some bodies.

In this paper we present a study of magnetic field anomalies due to remanent magnetisation in the Georgetown area of Queensland. Examples from this study illustrate magnetisation direction inversion and magnetic moment analysis of both circular and elongate anomalies. The examples also show the importance of isolating the anomalies from superimposed background fields. Conclusions drawn from the examples are used to develop a strategy to optimise inversion of the full suite of anomalies.

13:30–15:00
Day 3 Session 3 Stream 1

PETROLEUM

Seismic Processing

REVISITING THE VIBROSEIS WAVELET

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As incremental improvements in seismic technology become more subtle, it is timely to re-examine the fundamental influence of the Vibroseis wavelet on the final processed image. Here we describe such an analysis, incorporating numerical modelling and field trials.

Vibroseis recordings are typically correlated against the theoretical sweep, even though this is not what is actually injected into the ground. Intuitively, a logical alternative sweep might incorporate mechanical imperfections at the source, and the filtering effects at the geophone. Numerical and field experiments confirm, however, that the optimum output wavelet is, indeed, derived using the theoretical sweep.

Many different sweep designs have been trialled throughout the history of Vibroseis. In-field sweep tests are, however, sometimes conducted without due regard for the influence of subsequent processing stages, such as minimum-phase conversion and deconvolution. We have examined these issues for various sweep designs, including standard linear, Vari-sweep, Continuous Piecewise Linear (CPL), and Pseudo-Random. A CPL sweep designed with similar frequency content to Vari-sweep produces equivalent seismic images, with the advantage of being easier to implement, with reduced overall recording times. While the Vari-sweep and Pseudo-Random sweeps have simpler auto-correlations than the Linear Sweep, this advantage is lost once minimum-phase and deconvolution operators are applied.

By incorporating typical coal and petroleum scale attenuations, we deduce that the imaging differences between sweep techniques become less pronounced with depth. This suggests that the choice of sweep is more critical for shallower exploration.

USING MODERN PROCESSING TECHNOLOGY TO IMPROVE SIGNAL TO NOISE RATIO, A PERTH BASIN 3D LAND CASE STUDY

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In poor signal to noise ratio land seismic data, such as the one acquired in the Perth Basin, improving the final image is rarely the result of applying a one processing step solution. On the contrary, every step of the processing sequence counts towards improving the final signal to noise ratio. In this context, gathering modern 3D land processing technology from around the world helps bring added value that the processing sequence can gather.

Recently both pre-imaging and imaging technologies have improved significantly and have become more easily available.

In this Perth Basin case study, we look at signal to noise improving new technologies such as, wavelet domain shot by shot adaptive ground roll attenuation, multi passes of frequency targeted projective filtering in the f-x domain, radial mix stack for velocity scanning, offset vector binning and depth imaging using both Kirchhoff and Controlled Beam Migration (CBM) as ways to improve the final results.

Results show that none of these processes, taken individually, stand as a one off solution to improving the final image signal to noise ratio. However, combined and tested in a non-sequential way they clearly add value to the final image when compared to a more standard sequence.

PRACTICAL ISSUES OF REVERSE TIME MIGRATION: TRUE AMPLITUDE GATHERS, NOISE REMOVAL AND HARMONIC-SOURCE ENCODING

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Recently, reverse-time migration (RTM) has drawn a lot of attention in the industry. Unlike one-way wave equation migration, RTM does not need to deal with the theory of singular pseudo-differential operators. A straightforward implementation of RTM correctly handles complex velocities and produces a complete set of acoustic waves (reflections, refractions, diffractions, multiples, evanescent waves, etc.). The RTM propagator also carries the correct propagation amplitude and imposes no dip limitations on the image. In the past, the strong migration artifacts and the intensive computational cost have been the two major problems that prevented RTM from being used in production. We will show that modifying the initial-value problem into a boundary-value problem for the source wavefield plus implementing an appropriate imaging condition yields a true-amplitude version of RTM. We will also discuss different ways to suppress the low frequency migration artifacts. Finally, we will introduce a 'harmonic-source' phase-encoding method which allows a relatively efficient implementation of delayed-shot or plane-wave RTM. Taken together, these yield a powerful true-amplitude migration method that uses the complete two-way acoustic wave equation to image complex structures.

Day 3 Session 3 Stream 2

MINERALS

Electrical Geophysics

SPM AND AIRBORNE EM

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Superparamagnetism (SPM) has been previously documented to interfere with ground EM surveys. However, airborne EM data were considered to be immune from SPM effects due to the elevated transmitter and small sensor.

New EM systems are now detecting SPM. This represents a significant issue for interpretation and drill target definition. The SPM response typically manifests as a slow decaying late time response, which is very similar to the response from highly conductive massive sulphides and may easily result in the mis-interpretation of sulphides from SPM anomalies. Theoretically inductive targets may be distinguished from SPM decays by the nature of the decay but in practice it is difficult on airborne EM data and the results are ambiguous. SPM anomalies may have wavelengths and strike lengths similar to sulphide orebodies and may be associated with massive sulphide mineralisation.

Historically survey techniques to minimise and avoid SPM in ground EM surveys are to use an offset transmitter and receiver loop or a small receiver sensor in the middle of a large transmitter loop. Both techniques do not always work. Fixed loop surveys are also highly affected by SPM. The use of an offset receiving sensor (i.e. slingram configuration) has been found to be the best way to eliminate all but the worst of SPM problems.

Techniques have also been developed to easily check for SPM in the field using conventional survey equipment using a small solenoid. Techniques have also been used to measure the SPM properties of drill core which assists in defining the SPM source location.

USE OF PRINCIPAL COMPONENT IMAGES FOR CLASSIFICATION OF THE EM RESPONSE OF UNEXPLODED ORDNANCE

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The location and identification of unexploded ordnance (UXO) is a major challenge for environmental rehabilitation of former military firing ranges and bombing target areas. EM methods are in widespread use for the location of metal objects; however the presence of large quantities of scrap metal from successful detonation of munitions makes discrimination between munitions and scrap and munitions of various sizes a necessity in order for efficient location, digging and removal of UXOs to proceed. Several recent papers show that detailed three-component EM measurements followed by inversion to dipole moments of an EM target is effective in characterising a target, however such techniques require precise data, usually from stationary data acquisition.

EM data acquired from a moving ground platform for UXO detection is typically high in motion-induced noise which limits the usefulness of decay-curve analysis in target characterisation. We use a data set from the Australian Air Force Newholme UXO Test Range, Armidale, NSW, and show that

(a) images of time-window data are unsuccessful in discriminating between different types of munitions,
(b) adaptive decay index methods are ineffective due to high noise levels on the observed decay curves, and
(c) principal-component transforms of the data are successful in differentiating between different types of munitions.

The method provides a tool for initial classification and prioritisation of anomalies from a surveyed area, thus facilitating preparation of an efficient program of follow-up surveys and site clean-up.

A REVISED MATHEMATICAL FORMULATION FOR INDUCED POLARISATION

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Researchers involved in induced polarisation studies are well familiar with Seigel's definition of chargeability. According to this theory, the presence of chargeable material has the net effect of decreasing the DC conductivity of the medium. Based on this assumption, he proved that, in a layered earth, the apparent chargeability is the summation of the intrinsic chargeability of layers, weighed against the sensitivity matrix of the DC resistivity of each layer. This important result is at the basis of many algorithms currently used for inversion of IP data. Despite its wide acceptance and considerable merit, especially in the inversion of IP data, Seigel's formulation contradicts the even more widely accepted theory that the presence of chargeable material actually increases the DC conductivity of a medium because it provides a supplementary, parallel path to the conduction of current. In Seigel's theory the potential drop arising immediately after the current is turned on is the DC potential, whereas the potential drop before current turn off (which is what we usually have access to in the field) is the chargeability affected one. This is counter intuitive from a physical point of view. It also calls for recovery of 'true' DC background resistivity before the IP data can be inverted. In this paper I reconcile Seigel's formulation with the presently accepted IP theory, providing also a more precisely formulated mathematical background for inversion of IP data. The results are particularly applicable to hydrogeophysical applications, where IP anomalies are usually low.

Day 3 Session 3 Stream 3

MINERALS

AEM Mapping

AIRBORNE ELECTROMAGNETIC SURVEY RESULTS FROM THE PATERSON PROVINCE, WA

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As part of the Onshore Energy Security Program (OESP), Geoscience Australia (GA) is carrying out regional airborne electromagnetic (AEM) surveys across areas of Australia that are considered prospective for energy commodities, to encourage industry exploration. An area of ~45 000 km^2 of the Paterson Province in WA was the first region flown under the OESP initiative. A total of ~24 000 line-kilometres were acquired in the Paterson survey area during 2007–08.

The TEMPEST fixed wing AEM system was selected by GA from a list of candidate systems as the most suitable for meeting the energy-focussed objectives of the Paterson survey. The selection process employed several criteria that included results from a numerical modelling study of the ability of each system to detect a number of geological target models.

A quantitative analysis of the Paterson survey dataset was carried out, including determination of system noise levels from high altitude and repeat line data. The data were inverted using a full non-linear layered earth inversion (LEI) algorithm that solves for a 1D conductivity structure and unmeasured elements of the system geometry at each sample. Regularisation was imposed via vertical smoothness and reference model constraints. Discrete anomalies were identified from the profile data. The conductivity estimates have contributed to an enhanced understanding of the geology of the Paterson region, particularly where it is obscured by the sand dunes of the Great Sandy Desert. For example, the conductivity patterns have revealed the presence of on-lapping sediments of the Canning Basin, and near surface Cenozoic palaeovalleys.

STRUCTURAL MAPPING UNDER COVER WITH AIRBORNE EM

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Magnetic data are routinely collected for structural mapping in various terranes. In both Tanzania and Mali, magnetic data have been of limited use to Resolute's mineral exploration programs: in Tanzania, intense BIF signatures and remanent magnetisation complicate signatures and swamp more subtle features, while in Mali, magnetically featureless cover rocks hide almost all structural expression in the basement. Airborne time domain EM has proven invaluable in tracing lithological contacts, subtle stratigraphic horizons, and intrusive bodies through conductive weathering up to 100 m deep. Helicopter systems with high transmitter moments penetrate deep enough to escape contamination by surficial conductivity features such as drainage patterns. The results under basin cover in Mali are particularly impressive in their ability to provide a clean picture of basement geological structure.

THE AEROTEM EXPERIENCE IN AFRICA

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The AeroTEM HTEM system's breadth of recorded data includes true on-time, off-time, and both the X-component and Z-component of the secondary field. These parameters make the system broadly applicable, and for a given project, provide a broader insight into the geology. We explore the usefulness of AeroTEM survey data by way of two application case studies in Africa. In the first, we explore the use of the early off-time data for sensitivity in the very near-surface and in more resistive mapping applications. In the second, we explore the interpretation of the geometry of the geological sources of interest for further exploration.

Day 3 Session 3 Stream 4

MINERALS

Electrical and EM Geophysics

DC RESISTIVITY FRECHET DERIVATIVES FOR A UNIFORM ANISOTROPIC MEDIUM WITH A TILTED AXIS OF SYMMETRY

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The Frechet derivative (or sensitivity function) indicates the change in measured potential due to a perturbation of conductivity at a point in the subsurface, for a given electrode configuration. It is a crucial quantity that forms the elements of the Jacobian matrix used in inversion, optimised experimental design and model resolution studies. We present an analytic solution to the problem of a surface current source above an otherwise homogeneous but anisotropic medium. We take the special case of a transversely isotropic medium with a tilted axis of symmetry, such as might occur for dipping beds, inclined fractures, oriented jointing, rock cleavage and other stratifications/foliations. We derive the basic equations for the voltage, the current density and the sensitivity functions at an arbitrary interior point in the medium. Formulation of the Frechet derivatives in terms of the anisotropic model parameters (longitudinal and transverse conductivity, dip and strike angles, coefficient of anisotropy, mean conductivity) are presented and systematically investigated for a range of orientations of the symmetry axis, varying degrees of anisotropy and differing electrode arrays (pole-pole, dipole-dipole, Wenner). The anisotropic sensitivity patterns for respective parameters have features that are dependent on the orientation of the anisotropy, and can be explained in terms of current density flow in longitudinal and transverse directions. Understanding the Frechet derivative for anisotropic conductivity distributions will enable further work in designing electrode layouts that obtain maximised subsurface information.

FAST APPROXIMATE 3D INVERSION OF GROUND TEM DATA UTILISING THE CONCEPT OF MAGNETIC MOMENTS

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A fast approximate three dimensional inversion scheme for interpreting ground transient electromagnetic (TEM) data is presented. The scheme relies on linear superposition of magnetic moments. The moment transform of TEM data is a time-weighted integral of the impulse response. The time weighting emphasises late times, when EM interactions are weaker and hence when the total response can be approximated as a simple sum of the responses of individual conductive elements. Time weighting also has the effect of emphasising deeper features, which are often of greater exploration interest.

The TEM moment response is modelled as a combination of a continuous 'background response' and a discrete 'target response'. The background is represented as a homogeneous half-space, while the target is comprised of closely-packed cubic cells. Analytical expressions have been derived for the first order moments of a half-space, excited by a rectangular loop. The moment contributions from the cubic cells are computed using a simplified form of the expression for a sphere in free space; the contribution from each cell is proportional to its time constant.

In effect, the moment transformation converts the 3D TEM inversion problem into a 3D magnetic inversion problem, with accuracy traded for speed. A starting model is generated from conductivity-depth sections, and the inversion is conditioned using standard potential field inversion devices such as depth weighting.

The efficacy and limitations of the approach are illustrated via application to both synthetic and real fixed loop and moving loop TEM data.

2.5-D/3-D RESISTIVITY MODELLING IN ANISOTROPIC MEDIA USING GAUSSIAN QUADRATURE GRIDS

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Presented is a new numerical scheme for 2.5-D/3-D direct current resistivity modelling in heterogeneous, anisotropic media. This method co-operatively combines the solution of the Variational Principle of the partial differential equation, Gaussian quadrature abscissae and local cardinal functions so that it has the main advantages of the finite element method and the spectral method. The formulation shows that the method is close to the spectral element method, but it does not require an element mesh or the element integrations, and it makes it much easier to deal with geological models having a 2-D/3-D complex topography than with the traditional numerical methods. It can achieve a similar convergence rate to the spectral element method. We show it transforms the 2.5-D/3-D resistivity modelling problem into a sparse and symmetric linear equation system, which can be solved by an iterative or matrix inversion method.

Comparison with analytic solutions for homogeneous isotropic and anisotropic models shows that the error is less than 1% except for near the source. Several other synthetic examples, both homogeneous and inhomogeneous, incorporating sloping, undulating and severe topography are presented and found to yield results comparable to finite element solutions involving a dense mesh.

15:30–16:30 Day 3 Session 4 Stream 1

PETROLEUM

Seismic Processing

INTERPOLATING A 2D ACQUISITION INTO A 3D USING A FOURIER RECONSTRUCTION METHOD

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3D marine acquisitions never yield the ideal, perfectly regular, dataset migration algorithms need, even in flat dips geological environments. Irregularities in the geometry of the recorded data such as mid-point position, offset and azimuth will result in sub-optimal interference of the pre-stack Kirchhoff migration operator.

Fourier reconstruction data regularisation techniques have been shown to work in various environments including steep dips where even the lower end of the frequency spectrum can be aliased. Fourier reconstruction decomposes the irregular input into a set of continuous functions that can be evaluated at any spatial positions. The data is then mapped back onto a regular grid.

Although those techniques have been primarily designed to regularise data geometry prior to migrations algorithms, they can also be used to interpolate and 'map back' gaps of missing data.

In this 2D acquired dataset example, where a one source one streamer configuration has acquired parallel 'sail-lines' every 200 metres in a 3D like manner, we look at the effect of applying Fourier reconstruction with the aim of processing the data in a 3D manner. The irregular 2D input data that lays on a 12.5 m × 200 m theoretical grid is decomposed into spatial frequencies and mapped back into a perfectly regular 12.5 m × 50 m grid that is then considered suitable as input to a 3D Kirchhoff pre-stack time algorithm and 3D processing. The results show that although not as detailed, accurate, and 'risk free' as a multi streamer multi source 3D acquisition, the 'pseudo 3D' volume is suitable for (pseudo) cross lines interpretation even in a highly structured geological environment.

3D TOMOGRAPHIC AMPLITUDE INVERSION FOR COMPENSATING AMPLITUDE ATTENUATION

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Spatial variations in the transmission properties of the overburden cause seismic amplitude distortions on deeper horizons and hence pose problems to the AVO analysis. One of the common causes of these transmission anomalies is gas within shallow sediment, which is not an uncommon observed phenomenon in Asia Pacific. This induces anomalous amplitude decay in zones beneath the gas anomaly, often making the identification and interpretation of deeper reflectors difficult. This in turn affects the ability to accurately predict reservoir properties. Thus, there is a need to compensate the amplitude loss caused by this kind of transmission anomalies.

In this paper, a tomographic inversion approach using prestack depth migrated common image gathers (CIGs) is utilised to compensate reflection data for amplitude loss caused by transmission anomalies in the overburden. The essence of our approach is to obtain the amplitude perturbations in a represented model by back-projecting the amplitude variations from 3D prestack depth migrated data along the traced ray paths and then minimising the amplitude discrepancies in CIGs. After obtaining the amplitude perturbations, they can then be used for mitigating the amplitude attenuation due to the transmission loss.

Real data examples show that the method can mitigate amplitude attenuation caused by transmission anomalies and should be considered as one of the processes for amplitude preserving processing that is important for AVO analysis when transmission anomalies are present.

Day 3 Session 4 Stream 2

PETROLEUM

Gravity and Magnetics

BASEMENT CONSTRAINTS ON OFFSHORE BASIN ARCHITECTURE AS DETERMINED BY NEW AEROMAGNETIC DATA ACQUIRED OVER BASS STRAIT AND WESTERN MARGIN OF TASMANIA

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In early 2008 Geoscience Australia and Mineral Resources Tasmania acquired 141 234 km of high resolution (800 m line spacing) aeromagnetic data over Bass Strait and the offshore marginal basins of western Tasmania. The data fill a gap in the existing aeromagnetic coverage between Tasmania and mainland Australia and provide fresh insights into basement structure and its control on basin architecture and sedimentation patterns during the Gondwanan continental break-up and the separation of Australia from Antarctica. Prominent in the new data are several northwest-trending basement faults that extend from the mainland into westernmost Tasmania and the South Tasman Rise; they appear to represent an offshore extension of previously mapped structures in western Victoria (Hummocks and Yarramyljup Faults). These structures postdate, truncate and offset in a sinistral sense many older north- and northeast-trending basement structures, including the late Neoproterozoic Arthur lineament in Tasmania, the Bambra fault in central Victoria and the boundary between the Lachlan and Delamerian Orogens (Moyston Thrust) in western Victoria. The Hummocks Fault coincides with a narrow belt of ultramafic rocks and possibly continues offshore as a series of prominent magnetic anomalies whereas the Yarramyljup Fault may form the western limit of Proterozoic (Tyennan) basement in Tasmania. The distribution and geometry of Mesozoic-Tertiary offshore sedimentary basins in western Tasmania and the South Tasman Rise is consistent with reactivation of the older basement structures in a north-south-directed transtensional tectonic regime. Magmatic rocks intruded into the Bass, Otway and Sorell Basins and Torquay Sub-Basin are clearly delineated in the new aeromagnetic data.

Day 3 Session 4 Stream 3

NEAR SURFACE

Microearthquakes

AN ELASTIC PROPERTIES COMPUTATION TO PREDICT 4D SEISMIC EFFECTS FOR CO_2 SEQUESTRATION – A METHODOLOGY

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During Otway Basin CO_2 sequestration program, a small amount of CO_2 is currently being injected into a depleted Naylor gas field, onshore Victoria. The reservoir is relatively deep (2 km) and complex with area extent of approximately 0.5 km^2. This limits the monitoring program to the application of seismic methods only. However, the injection of CO_2 into this heterogeneous reservoir, where residual gas saturation is present throughout most of the sand column, is expected to cause very subtle changes in elastic properties of the reservoir rock. Indeed initial modeling of 4D seismic response showed that only 4–6% change in the elastic parameters could be expected. Such small effect could be 'lost' even through an inaccurate fluid substitution methodology. Considering inherently low repeatability of land seismic it becomes even more important to accurately predict 4D seismic at this site.

For that purpose we have investigated various methodologies that could increase the accuracy of the predicted changes in elastic properties of the reservoir rock. We derived a methodology for accurate prediction of elastic properties of the reservoir rock through calibration of the log and petrophysical data with core sample. The result showed core saturated velocities and log measurement agree with each other when the 'effective' K_{grain} is applied. It suggested that 'effective' K_{grain} could be used to represent the average mineralogy of the grains. However, comparative analysis and calibration of log measurement with core samples proved that accurate fluid substitution methodology at this site is hard to achieve without having dense core sample test results measured from the reservoir interval.

MICROTREMOR OBSERVATIONS IN TAMAR VALLEY, LAUNCESTON, TASMANIA: EVIDENCE OF 2D RESONANCE FROM OBSERVED MICROTREMOR AND NUMERICAL MODELLING

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We use the microtremor survey method to record ambient ground vibrations in Launceston, Tasmania. The presence of the ancient Tamar Valley, in-filled with soft sediments that vary rapidly in thickness from 0 to 250 m over a few hundred metres, is thought to induce a 2D resonance pattern, amplifying the surface motions over the valley and in Launceston. The spatially averaged coherency (SPAC) and horizontal to vertical spectrum ratio (HVSR) microtremor survey methods are combined to characterise site effects over the Tamar Valley.

We present observations at three selected sites to study the resonance pattern. Two of these sites (*DBL* and *KPK*) are located inside the Tamar valley, while the third site (*GUN*) is located on assumed 1D geology. We record array microtremor measurements (SPAC) to estimate the shear wave velocity profile at all sites. Results show that sediments thicknesses vary significantly throughout Launceston. In addition to the traditional spatial averaging of coherencies, we decompose coherencies into pairs of sensors, oriented perpendicular and parallel to the valley axis, and use time averaging of coherencies. Using multi-radii arrays, we analyse the impact of increasing radius on the spatial and time averaged coherencies recorded at all sites.

We decompose HVSR observations into parallel and perpendicular components to the valley axis to identify the different modes of resonance of surface waves. On HVSR profiles at *DBL* and *KPK* sites, we identify the in-plane to valley axis shear mode of resonance (*SV*) and the normal plane to valley axis shear mode of resonance (*SH*). This decomposition is not observed at *GUN*, which HVSR observations present a single peak at the frequency of resonance.

SECTION 4

POSTER ABSTRACTS

LIST OF POSTERS

All the posters will be displayed for three days: the whole of Monday, Tuesday and Wednesday.

The roster for when the presenters will be available to talk about their posters will be available at the Convention.

No.	Authors	Organisation	Paper Title
1	Peter R. Milligan, Jenna Roberts and Indrajit G. Roy	Geoscience Australia	Trials of spectral domain techniques to determine Curie-point depths under the Cooper Basin, Australia
2	Noor Alamsyah AND Sihman Marmosuwito	Petrochina International Jabung Ltd	Reservoir differentiation using the Threshold-Inversion Method in the Lower Talang Akar Formation, West Betara Field, South Sumatra Basin, Indonesia
3	Anghel Sorin	National Institute of Marine Geology and Geoecology – Geoecomar	Magnetometric researches used in the archaeological studies of the Greek Roman fortress located on the shore of Razelm Lake
4	Carlos Cevallos	NSW Department of Primary Industries, Geological Survey of NSW	Defining a hypothetical boundary between two phases of the Braidwood Granodiorite
5	Marina Costelloe, Camilla Sorensen AND Pauline English	Geoscience Australia	Pine Creek Airborne Electromagnetic Survey, Onshore Energy and Minerals, Geoscience Australia
6	Tania Dhu, Gary Reed, Wayne Cowley and Martin Fairclough	Minerals and Energy Resources, PIRSA	Mapping depth to crystalline basement in South Australia
7	Tanya Fomin, Erdinc Saygin, Bruce Goleby and Tony Meixner	Geoscience Australia	Advances in combining wide-angle and reflection Vibroseis surveys from the latest experiments, onshore Australia
8	Alexey Goncharov, Joanne Whittaker, Hannah Lane, Jennifer Totterdell, Dietmar Müller and German Leitchenkov	Geoscience Australia; School of Geosciences, University of Sydney; Vniiokeangeologia	Australian–Antarctic Rifting: new insights from plate tectonic reconstructions of total sediment thickness and crustal seismic velocity grids
9	Rosemary Hegarty	Geological Survey of New South Wales, NSW Department of Primary Industries	Gravity gradients and aeromagnetic textures – unlocking the structural architecture of the boundary between the Thomson and Lachlan Orogens in the Bourke Region, NSW
10	Laszlo Katona,Tania Dhu, Gary Reed and Martin Fairclough	Mineral and Energy Resources, PIRSA	Mapping iron oxide copper gold prospectivity, South Australia
11	Allan Campbell, Leon Dahlhaus, Aline Gendrin, Scott Leaney, Shoichi Nakahishi, Kapil Seth, Sergei Tcherkashnev, Don Sherlock and Milovan Urosevic	Schlumberger; Chevron; Curtin University	Seismic monitoring for the Otway CO_2 Sequestration: acquisition and analysis of borehole seismic data
12	Yun Wang and Junjie Yin	Institute of Geology and Geophysics, Chinese Academy of Sciences	The numerical simulation and imaging of seismic scattered waves applied to base metal exploration
13	David Love	Primary Industries and Resources South Australia	Focal mechanism – Flinders Ranges Earthquake ML 4.7, 26 December 2007
14	Hyoungrae Rim, Yeoung-Sue Park, Muteak Lim, Sung Bon Koo and Byung Doo Kwon	Korea Institute of Geoscience and Mineral Resources, Seoul National University	New separation method of regional-residual gravity anomalies by means of geostatistical filtering
15	Peter Petkovic, Ron Hackney and Michael Morse	Geoscience Australia	Geophysical mapping strategy for Australia's remote eastern deep-water frontier: the Capel and Faust Basins
16	Bambang Prasetiyo and Trisakti Kurniawan	Pertamina EP, BU Tanjung Raya Block	Optimising oil production in low permeability oil reservoir at Tanjung Field, Barito Basin – South Kalimantan Indonesia
17	Jonathan Ross and Graham Heinson	University of Adelaide	Viva La Resistance! The utility of cross-hole electrical resistivity tomography to image resistive pathways

TRIALS OF SPECTRAL DOMAIN TECHNIQUES TO DETERMINE CURIE-POINT DEPTHS UNDER THE COOPER BASIN, AUSTRALIA

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Measurement of the thermal structure of the crust is essential for several geodynamic investigations, such as identifying heat-flow anomalies, determining mechanical strength and tectonic setting, and locating prospective regions for mature hydrocarbon deposits in sedimentary basins. Depth estimates to the Curie Point isotherm (CPD) can assist this measurement. The CPD is the depth at which both induced and remanent magnetisation of ferromagnetic minerals is lost due to temperatures being reached in excess of the Curie Temperature (traditionally 580°C). Spectral domain techniques are widely used to measure the CPD from magnetic anomaly data. Under certain conditions, the slope – and in some cases, the long-wavelength peak – of radially averaged spectra are related to the depth-to-top, depth-to-centroid, and depth-to-bottom of prismatic magnetic bodies. The accuracy of such depth determinations is important, because measuring the depth-to-bottom of crustal magnetic sources is fundamentally difficult. Where possible, the depth estimates are calibrated with other independent data, such as bore-hole depth and temperature measurements, seismic interpretations, and other modelling. Tests of spectral domain techniques were conducted in the Cooper Basin (with significant geothermal and petroleum prospectivity) as part of Geoscience Australia's Onshore Energy Security Program.

RESERVOIR DIFFERENTIATION USING THRESHOLD-INVERSION METHOD IN LOWER TALANG AKAR FORMATION, WEST BETARA FIELD, SOUTH SUMATRA BASIN INDONESIA

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The threshold-inversion method has been applied on 30 km^2 of West Betara (WB) Field generated from 3D post-stack seismic data with the WB-1, WB-3 and WB-4 wells as the control. Different reservoir properties and facies in WB structure becomes a challenge for the team to find relevant geophysical study on this field.

Threshold-inversion method is the interpretation methods which are the combination between threshold attribute and amplitude of seismic inversion cube. The purposes of this method are to distinguish and define the reservoir distribution within certain cut-off value.

The result has been successfully used to distinguish and to define the distribution of Lower Talang Akar Formation (LTAF) reservoir where showing the conglomeratic and coarse grained sandstones reservoirs delineation which is consistent with well data. Technically, the above methods give better contribution in development and production strategies in Jabung block especially WB field. It can minimise the risk of proposing additional development well locations to maximise the oil production in LTAF formation in this fields and it is proven by development drilling program which showing significant success ratio.

MAGNETOMETRIC RESEARCHES USED IN THE ARCHAEOLOGICAL STUDIES OF THE GREEK ROMAN FORTRESS LOCATED ON THE SHORE OF RAZELM LAKE

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In Romania, geophysical methods are normally used to estimate the distribution of cultural relics, before digging. Objects of archaeological interest are usually located within a few metres of the surface.

The geophysical studies were carried out within the archaeological site both in 2005 as well as in 2006.Geophysical works were conducted using Geometrics equipment (G856 proton procession magnetometer) with a 0.1nT precision. This allowed for a highly detailed local morphology of the geomagnetic field and for the mapping of the magnetic anomaly. The working technology has been chosen to emphasise mainly abnormal effects produced by sources located at depths of 0–5 m.

On the south side of the late Roman fortification, outside the precinct wall, an artisanal area including a furnace for manufacturing building materials dated from the late Roman period, was found as well as some Greek furnaces for manufacturing ordinary brick.

The south area of the site has been studied within this research project using the magnetometrics. Geophysical studies will prove very useful for further archaeological diggings, supplying them with a more clearly defined image on the substratum situation.

Magnetometric researches are usually carried out with gradient devices, which imply performing certain simultaneous measurements of the total intensity or of the vertical component of geomagnetic field at two levels, and are usually used within any archaeo-geophysical study. There is a growing involvement lately, in matters related to archaeogeophysics, of electromagnetic methods, which also have an extremely high productivity.

Geophysical works have been carried out using Geometrics equipment with a 0.1nT precision, which allowed for highly detailed images of the local morphology of geomagnetic field and drawing of maps presenting the magnetic anomaly.

The working technology has been chosen to enable to emphasise mainly abnormal effects produced by sources located at depths of 0–5 m. Under the circumstances, taking into account works carried out in 2005 and the previous experience gained during other archaeo-magnetism contracts, the same equipment and magnetometrical mapping method have been used.

DEFINING A HYPOTHETICAL BOUNDARY BETWEEN TWO PHASES OF THE BRAIDWOOD GRANODIORITE

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In support of reconnaissance regional mapping, the geophysical interpretation of Total Magnetic Intensity (TMI), Landsat7, gravity and radiometric data has defined a hypothetical boundary between two texturally different hornblende–biotite phases on the northern part of the Braidwood Granodiorite. The western phase has acicular hornblende up to about 10 mm long and in the eastern phase the hornblende is always more equant and no more than 2 mm long.

Distinguishing the different phases of the Braidwood Granodiorite is important, as most mineral occurrences are hosted by the western phase.

The interpretation relies mainly on two sets of images, particularly the first one:

(1) The pseudocolour image with zenithal sunshade illumination of the TMI Reduced to Pole.
(2) Supervised classification scheme images of all the channels of the Landsat7 data using broad nonparametric spectral signatures (large training polygons).

In the first image, the unusual illumination direction shows that the western phase has a higher density of fractures. In the second set of images, the use of large training polygons allows the classification schemes to proceed without the need to know the precise location of the different phase outcrops. This procedure is novel as it differs from the normal procedure of trying to pinpoint the best training polygons.

Currently, field observations are being carried out to test the position of the boundary; if found accurate, it will greatly aid the regional mapping of the area.

PINE CREEK AIRBORNE ELECTROMAGNETIC SURVEY, ONSHORE ENERGY AND MINERALS, GEOSCIENCE AUSTRALIA

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The Pine Creek Airborne Electromagnetic (AEM) survey is the second regional AEM survey funded by the Onshore Energy Security Program (OESP) at Geoscience Australia. The Pine Creek AEM survey is the largest AEM survey to be undertaken in the Northern Territory covering more than 71 000 km^2. In 2008 Geoscience Australia, through Fugro Airborne Surveys and Geotech Airborne Geophysical Surveys, acquired both TEMPEST and VTEM data with broad line spacings (up to 5 km). Three survey areas were defined, the Woolner Granite, Rum Jungle and Kombolgie. The survey areas covered sections from the Fog Bay, Darwin, Coburg Peninsula, Junction Bay, Alligator River, Milingimbi, Mount Evelyn, Katherine, Pine Creek, Cape Scott, Port Keats, Fergusson River 1:250 000 Map Sheets. The survey results have helped to improve our understanding of the area's geology and mineral potential by mapping the conductivities of different geological and hydrogeological units under cover. The datasets will contribute to interpretations regarding the presence of conductive units in the Pine Creek Orogen; depth to the unconformity between the Pine Creek Orogen and the Kombolgie Subgroup; depth and extent of the Woolner Granite and Koolpinyah Dolomite and the location of major structures. This poster outlines the survey specifications and objectives, and describes some of the geophysical modelling and processing methods being developed by Geoscience Australia.

MAPPING DEPTH TO CRYSTALLINE BASEMENT IN SOUTH AUSTRALIA

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An accurate understanding of the depth to basement is important in many mineral exploration activities. One example is the search for unconformity related uranium within South Australia. On the eastern margin of the Gawler Craton, imaging of the unconformity at the top of Palaeo- to Mesoproterozoic uraniferous basement below the Mesoproterozoic Pandurra Formation has yielded several constraints of interest to uranium explorers, i.e. unconformity geometry and basement faults propagating into overlying sediments. However, what is actually defined as economic basement varies depending on the target, what is defined as basement in paleochannel hosted uranium exploration differs from that for base metals exploration, changing what petrophysical properties can be used to estimate depth. As large regions of South Australia are under cover this becomes an important problem to untangle.

In this study various techniques (Euler, spectral and basic curvature analysis) are applied to magnetic and gravity data in different regions across the state. Originally test cases are undertaken on small data sets in well constrained regions to test the applicability of different techniques on different regions. These are then applied across the entire region and the subsequent depth to basement grids merged together.

The depth to basement map is then weighted using drill-hole data to estimate depth to crystalline rather than economic basement – a unit that has been objectively defined for the different geological regions within South Australia. This map is again refined using structural information and outcrop polygons to create a state image of approximate depth to crystalline basement that is geologically constrained but relies on geophysical data in those areas of minimal known geology.

ADVANCES IN COMBINING WIDE-ANGLE AND REFLECTION VIBROSEIS SURVEYS FROM THE LATEST EXPERIMENTS, ONSHORE AUSTRALIA

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The Vibroseis wide-angle refraction seismic survey is coincident with a regional reflection transect through the Tanami Region. High-quality Vibroseis wide-angle seismic data were collected to offsets of 70 km simultaneously with a deep reflection survey using the same Vibroseis sources. The 2D velocity model derived from wide-angle data shows velocity variations in the upper crust and can be constrained down to a depth of 15 km.

This transect crossed the granites, which have previously been interpreted as structural domes. The base of granites at 1 to 3 km was interpreted from reflection data based on changes in reflectivity pattern from low reflectivity to high reflectivity. Gravity modeling suggested that the depth of the granites are approximately 6 to 8 km, and are therefore much thicker than the seismic reflection interpretation. The granite-gneissic layer modeled from wide-angle data at a depth of 3.5 to 6 km is more consistent with the gravity modeling. We conclude, therefore, that the granite bodies in the Tanami region do not always have a low reflectivity seismic signature as has been interpreted in other regions.

Wide-angle reflections from steeply dipping structures associated with the interpreted granites were observed in wide-angle data. Ray-tracing modeling of these steeply dipping boundaries suggests that dipping reflectors mapped in the reflection data do not have an associated bulk velocity contrast in the wide-angle model.

Combined interpretation of the Vibroseis wide-angle and deep seismic reflection data with gravity modeling demonstrates the benefit of using multi-discipline techniques resulting in a better geological interpretation.

AUSTRALIAN–ANTARCTIC RIFTING: NEW INSIGHTS FROM PLATE TECTONIC RECONSTRUCTIONS OF TOTAL SEDIMENT THICKNESS AND CRUSTAL SEISMIC VELOCITY GRIDS

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Estimates of total sediment thickness on both conjugate margins were obtained on the basis of detailed analysis of seismic velocity-depth functions. This required calibration of stacking-derived velocities against refraction velocities from data recorded by sonobuoys. Refraction-derived velocities were further analyzed to produce velocity slices through the consolidated crust at a set of fixed depths down to 15 km.

New magnetic anomaly identifications, using data recently acquired by Russian Antarctic Expeditions, were integrated with earlier interpretations thus enabling calculation of the new poles of rotation. These poles were then used to reconstruct plate tectonically velocity slices data, and to generate velocity grids at a sequence of time markers. Analysis of these grids shows that there is a change in velocity zonation at ~125°E, possibly indicative of decoupling between the upper and lower crust in the process of rifting.

First-pass analysis of total sediment thicknesses suggests that sediment distribution is grossly asymmetric. The thickest sediment accumulation (not less than 14 km) occurs on the Australian Margin within the Ceduna Sub-basin. Sediments on the Antarctic Margin only reach thickness of 8 km. Some asymmetry in sediment distribution can be expected due to differences in pre-breakup and post-breakup evolution of the margins. However, further research is needed to accurately estimate pre- and post-breakup sediment thicknesses, and to ascertain what fraction of this asymmetry is due to geological factors rather than due to differences in seismic interpretations on respective margins. Such work has recently been completed and its first results are presented.

GRAVITY GRADIENTS AND AEROMAGNETIC TEXTURES – UNLOCKING THE STRUCTURAL ARCHITECTURE OF THE BOUNDARY BETWEEN THE THOMSON AND LACHLAN OROGENS IN THE BOURKE REGION, NSW

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While the Lachlan Orogen in eastern and central NSW has been an extensively mapped and explored terrane hosting major copper and gold deposits, its northern extent and relationship with the ‘frontier’ Thomson Orogen are obscured by younger sedimentary rocks and regolith. The Bourke 1:250 000 map sheet area is situated in a critical area – straddling the boundary between the two Palaeozoic orogens – and potential field data currently provide almost all the information about the geometry of this complex structural transition zone.

A regional geophysical/geological interpretation study of this area is underway. Information from existing mapping and drilling in the Bourke area has been integrated with regional aeromagnetic and gravity data to define mappable Palaeozoic units at surface and within basement. Striking variations in aeromagnetic character are evident for Siluro-Devonian plutons, and their distribution has been related to limited available geochemical sampling and age dating. Subtle variations in aeromagnetic image texture allowed interpretation of units within Ordovician metasediments previously mapped as the Girilambone Group. Recent geological mapping indicates that these units reflect both original lithology and the degree of metamorphism.

A detailed structural framework for the region has been generated from aeromagnetic trends and discontinuities. Multiscale edge detection analysis (‘worming’) of significant potential field gradients was used to indicate the morphology of some major structures and intrusions at depth. Finally, geophysical modelling of key sections has enabled examination of the transition zone to visualise its deeper structural architecture.

MAPPING IRON OXIDE COPPER GOLD PROSPECTIVITY, SOUTH AUSTRALIA

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Iron oxide copper gold (IOCG) mineralising systems are associated with spatially offset gravity and magnetic highs related to the presence/absence of magnetite and hematite. The offset can be considered to reflect a fundamental metallogenic zonation in the mineral system, differentiating it from other possible geological solutions. Therefore techniques for combining and comparing gravity and magnetic geophysical data can be used as criterion for mapping IOCG prospectivity.

The regional fields are removed from magnetic and gravity data over different trial areas within South Australia. Worming and depth slicing are then used to highlight anomalies which are mapped via shape and position. These resultant data sets are then integrated using a proximity analysis which relates the spatial size, magnitude of anomaly and resultant offset. Finally this information is combined with depth to basement knowledge to create an image of one measure of IOCG prospectivity.

SEISMIC MONITORING FOR THE OTWAY CO_2 SEQUESTRATION: ACQUISITION AND ANALYSIS OF BOREHOLE SEISMIC DATA

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The Australian Cooperative Research Centre for Greenhouse Gas Technologies (CO_2CRC) is currently undertaking the Otway

Project, which involves the injection and storage of 100 000 tonnes of carbon dioxide within the subsurface. CO_2 injection will be into Naylor onshore depleted gas reservoir and, therefore, the project will provide important experience for monitoring and verification under these conditions. The overall complexities of the field, its deep, small size and in particular the presence of both free and residual gas zones present a serious challenge for time-lapse seismic monitoring.

Borehole seismic has a strong advantage over surface seismic: energy crosses surface layers only once, and hence is much less sensitive to the variations in the weathered layer properties than surface seismic. Consequently a comprehensive borehole seismic observational program was designed at the Otway project. In the initial phase a Zero Offset VSP, an Offset VSP, and walkaway VSP data were acquired with a minivibroseis (6000 lb) seismic source in the Naylor-1 well in May 2006. In 2007, in the newly drilled injection well (CRC-1) a series of wireline logs, a Zero Offset, an Offset VSP and the first 3DVSP was acquired with a weight drop source simultaneously with 3D surface seismic.

The results of VSP data analysis will be shown and discussed in light of its improved repeatability and image resolution in comparison to surface seismic data. We will also discuss evolving workflows developed to overcome inherently poor land seismic repeatability which is mainly related to changes in the near surface layer conditions.

THE NUMERICAL SIMULATION AND IMAGING OF SEISMIC SCATTERED WAVES APPLIED TO BASE METAL EXPLORATION

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The seismic data collected during the base metal exploration can be hampered by a variety of non-reflecting signals because of the heterogeneity of ore bodies and host rocks. It is difficult to produce a high-quality seismic profile when conventional seismic processing algorithms are applied to the data. According to the Huygens–Fresnel principle, every grid node can be considered as a vibrating source, and geological model can be discrete within the grids. Therefore we have stacked all kinds of waves, including scattered waves from these grids. It seems that more scattered signals are used and the better the migrated section is. Two geological models are simulated and tested, one is the Tongling copper mine in the eastern China, and another is Gegeo tin mine in Yunnan Province of the south-western China. We have simulated the seismic scattering wave, and thus generated the high-quality migrated seismic profiles, which match the geological models very well. It proves that imaging of the seismic scattered wave may be appropriate tool to process the seismic data related to the base metal exploration.

FOCAL MECHANISM – FLINDERS RANGES EARTHQUAKE ML 4.7, 26 DECEMBER 2007

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Despite regular earthquakes in the Flinders Ranges, there are few focal mechanisms, and most of these are not well constrained. We examine the Cradock earthquake of 2007-12-26, Magnitude 4.7. By using aftershock data from a temporary deployment combined with mainshock data, we produce an approximate focal mechanism. It shows thrust and strike-slip motion, but is not well constrained.

To collect more focal mechanism information, we need to focus more accurately on the requirements, and design surveys accordingly. Large earthquakes are too few, and existing deployments have always had too few instruments, or too wide spacing to get useful information. Two particular strategies will supply useful data. For moderate magnitude, shallow earthquakes, both within the ranges and elsewhere, rapid deployment of about 12 instruments with very close spacing (0.2 to 5 km) will usually produce results from aftershocks. For the Flinders Ranges, where regular activity occurs from near surface to about 25 km depth, grid deployments of 20 or more instruments with spacing of 5 to 10 km will produce fairly rapid results. The use of very high sample rates for aftershocks of shallow events has the possibility of mapping the fault plane. The use of broadband sensors may be of value for occasional moderate sized events, to model the rupture.

NEW SEPARATION METHOD OF REGIONAL-RESIDUAL GRAVITY ANOMALIES BY MEANS OF GEOSTATISTICAL FILTERING

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In this paper, we propose a spatial filtering scheme using factorial kriging, a kind of geostatistical filtering method in order to separate regional and residual gravity anomaly. Spatial filtering assumes that regional anomalies have longer distance relation and residual anomalies have effected on smaller range. Gravity anomaly was decomposed into two variogram models depending on long and short effective ranges. And best-fitted variogram models produced the separated regional-residual anomalies by means of factorial kriging. This algorithm was examined with synthetic gravity data, and also applied to a real microgravity data to figure out abandoned mineshaft.

GEOPHYSICAL MAPPING STRATEGY FOR AUSTRALIA'S REMOTE EASTERN DEEP-WATER FRONTIER: THE CAPEL AND FAUST BASINS

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The frontier Capel and Faust Basins, 800 km east of Brisbane in water depths of 1000–3000 m, are generating interest in light of Australia's energy security concerns. The basins are a focus of Geoscience Australia's efforts to provide pre-competitive knowledge of offshore frontier regions to the petroleum exploration industry. This presentation reviews the geophysical data recently obtained over these basins and outlines the strategy used to further our understanding of basin structure in this remote frontier region.

A regional-scale residual gravity map, prepared from satellite-altimetry data and upward continuation, highlighted a series of N–S elongate gravity lows interpreted to represent basin depocentres. A 2D reflection seismic survey was designed on the basis of this inferred basin distribution. The survey was conducted during the summer of 2006/07 and provided 106-fold data to 12 s

TWT on 5920 km of dip and strike lines spaced 20–50 km apart. Sonobuoy data were recorded for velocity information. Gravity and magnetic data were collected during the seismic survey and on a subsequent swath bathymetry and geological sampling survey in late 2007. The latter survey focussed on the north-western part of the seismic grid where depocentres are best developed. The presence of small depocentres with limited strike extent means that 2.5D potential field modelling is not appropriate. However, potential field data are being used as constraints to interpolate horizon and basement picks between the seismic lines. 3D gravity modelling is being developed as a means to assist determination of the sediment thickness and prospectivity of these deep-water basins on Australia's remote eastern frontier.

OPTIMISING OIL PRODUCTION IN LOW PERMEABILITY OIL RESERVOIRS AT TANJUNG FIELD, BARITO BASIN – SOUTH KALIMANTAN INDONESIA

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Tanjung Field is Pertamina EP's own operation located in the Barito Basin, South Kalimantan which is known as the largest basin in Southest Kalimantan. The main reservoir is the Eocene age Lower Tanjung formation (LTF), which was deposited on rifted series of NW-SE horst and graben structures as a transgressive sequence of alluvial fans in the lower part, to shallow marine deposits at the top. It was discovered in 1937 by Shell with successfully discovery well T-001. Recently, production performance is achieved up to 5200 BOPD from 88 production wells.

The focus of this study is to derive optimisation production from low permeability in tight formation. This study also provides a summary of recent work which has been conducted in the diagnosis and remediation of problems associated with tight conglomeratic reservoirs. Low permeability zone occur in the main reservoir sand A and B from the lower part of LTF. Low permeability caused by significant concentration of clay. Smectite and kaolinite was present due to reduce rock–fluid interaction and high concentration of radioactive content comes from plagioclase (feldspar) will also brought a problem to evaluate volume of shale. Low salinity water, which indicates the possibility of a two water system in the reservoirs, makes interpretation even more complicated.

In summary, when petrophysics has a limitation for predicting log properties in identifying facies changes, then stochastic mineral modelling is then applied to give more opportunities to identify reservoir connectivity and reduce the uncertainty.

VIVA LA RESISTANCE! THE UTILITY OF CROSS-HOLE ELECTRICAL RESISTIVITY TOMOGRAPHY TO IMAGE RESISTIVE PATHWAYS

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The aims of this study were to test the application of cross-hole electrical resistivity tomography to image the resistive sand layer between the two conductive clay layers of the Beverley uranium deposit and to determine continuity of the sand layer between holes with the use of pole-pole and dipole-dipole array configurations. Grids of synthetic pole-pole data are used to show how raw pole-pole data can express information about structure and continuity between holes.

Cross-hole measurements were made across 15 different borehole separations – nine of 25 m, three of 43 m, and three of 50 m width. Pole-pole data across all 15 borehole separations and dipole-dipole data across one 25 m separation were inverted. Inversions of the pole-pole data imply that there is a resistive layer between two conductive layers across each borehole separation. A discontinuity in the sand layer is imaged on the dipole-dipole inversion much more distinctively than on the corresponding pole-pole inversion. It is on this borehole separation that the pole-pole and dipole-dipole configurations are analysed.

The error in the pole-pole data was estimated by considering variation between reciprocal potential measurements (1.88%) and spatial uncertainties in measuring the electrode depths (2%, approx.). Comparing these estimated errors to the absolute error in the inversion (1.00%) implies that the inversion is reliable. However, the ambiguities between the sands and clays on the inversion and between continuity and discontinuity on the data grid suggest a limitation of the pole-pole set and that the dipole-dipole configuration may be capable of greater sensitivity.

SECTION 5

BIOGRAPHIES

YOUSUF AL JABRI is a PhD student in Exploration Geophysics Department at Curtin University of Technology. He completed his Honour Degree in Geophysical Sciences from Leeds University in June 2006. His research interest areas are seismic acquisition, processing and interpretation. Currently, he is researching an integrated approach to study the effects of Time-Lapse Seismic for Monitoring CO_2 in Otway Basin, Naylor Field, Australia. He is a member of OBPP. He is sponsored by Petroleum Development Oman and is a member of SEG, EAGE, ASEG, SPE, AAPG and PESA.
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MUBARAK ALI has been an Assistant Prof. at Sultan Qaboos University since 2001. He started his teaching career in 1972 after completing his MSc in Geophysics from Pakistan in 1970, then earned a PhD in the UK in 1983, working on shear waves to improve seismic modelling of Lewesian rocks. He has served at the Quaid-e-Azam University (Pakistan) for more than two decades, remaining involved in applications of geophysics in a variety of problems such as natural resources, geotechnical, and crustal studies. Applied Geophysics is his area of interest. He also worked with the High Resolution Seismic Reflection group of Kansas Geological Survey (Kansas University, Lawrence).
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DAVID ALLEN manages Groundwater Imaging Pty Ltd from Dubbo, Central NSW, having completed his PhD in Groundwater Management at the University of Technology, Sydney in 2007. He is involved in the development and application of towed geophysical devices in the groundwater and minerals exploration industry. Using experience gained during ten years with Geoterrex/Fugro as a project geophysicist, David has developed galvanic and electromagnetic systems for rapid electrical conductivity imaging of sediment beneath inland waterbodies and cleared land.
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DOMINIK ARGAST is a software engineer working for Intrepid Geophysics, a software provider in Melbourne, Australia, specialising in the use of computer methods for oil, mining and geophysics. Before joining Intrepid Geophysics he completed a PhD in Astrophysics at the University of Basel, Switzerland, and was working for several years as a research fellow at the Physics Institute of the University of Basel and the Centre for Astrophysics and Supercomputing of Swinburne University of Technology in Melbourne. At present, he is responsible for the mathematical development and scientific integrity of the geophysical applications provided by Intrepid Geophysics.
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MICHAEL ASTEN is a consulting geophysicist and Partner with Flagstaff Geo-Consultants, Melbourne, and has a specialist interest in electromagnetic methods for mineral exploration and un-exploded ordnance detection. He is also a part-time Professorial Fellow at Monash University and founding member of the Centre for Environmental and Geotechnical Applications of Surface Waves (CEGAS). He leads a team funded by SERDP (a civilian agency of the US Army) which has developed an EM system with an array of B-field sensors for the purpose of detection and discrimination of unexploded ordnance objects.
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GRAHAM BAINES is a potential field geophysicist whose research integrates geological observations with geophysical data, in order to understand the geodynamic evolution of Earth's lithosphere. Having completed undergraduate studies in Geology and Geophysics at the University of Liverpool, UK, he undertook PhD research in Geophysics at the University of Wyoming, USA. His PhD research constrained the tectonic evolution of >130 000 km^2 of oceanic lithosphere at the Southwest Indian Mid-Ocean Ridge. Having completed his PhD in mid-2006, Baines took up a postdoctoral position at the South Australian Centre for Mineral Exploration Under Cover at the University of Adelaide, where he uses geophysical techniques to constrain the basement architecture and evolution of the buried Archean-Mesoproterozoic Northern Gawler Craton.
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JOHN BANCROFT is a faculty member of the University of Calgary and a Senior Research Geophysicist with the CREWES consortium. He specialises in static analysis, velocity estimation, and seismic imaging that includes anisotropic and converted-wave prestack migration. John is an Instructor for the SEG, which has published two of his volumes on poststack and prestack migration. He has received best paper awards at the 1994 SEG convention, 1995, 2003, and 2006 CSEG National Convention, and the Laric Hawkins Memorial Award at the 2001 ASEG Conference. He was elected an Honorary Member of the CSEG in 2005.
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ERIC BATTIG graduated with a BSc (1st Class Honours) in 2000 from The University of Queensland. He was employed by MIM Exploration where he worked on a wide variety of projects both within Australia and in Central and South America. There he was involved in all aspects of exploration and environmental geophysics from acquisition through to project management. In 2003 Eric spent 7 months working as a consultant Project Geophysicist to Xstrata Copper in Argentina and Northern Chile, responsible for ground and airborne geophysical surveys. In 2004 he joined the GRS team, supervising data acquisition and providing geophysical support to clients in many different geological environments.
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CRAIG J. BEASLEY holds a PhD degree in Mathematics and since 1981 has served in several capacities in the Computer Sciences, R&D and Data Processing Departments of WesternGeco including VP of R&D and VP of Data Processing. He has received 2 Litton Technology Awards, a Performed by Schlumberger Silver

Medal and the SEG Award for Best Presentation and served as the Esso Australia Distinguished Lecturer. He is an Honorary Member of the Geophysical Society of Houston and Foreign Member of the Russian Academy of Natural Sciences. He has presented papers and published widely on a variety of topics ranging from prestack imaging, migration, acquisition and the connections between acquisition, processing and imaging. He served as the 2001–02 SEG 1st Vice President and as the 2004–05 President of the SEG. Currently, he is Vice President for WesternGeco and a Schlumberger Fellow and is serving as the Chair of the newly formed SEG Committee for Geoscientists Without Borders.
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SERGEY BIRDUS currently works as a Depth Processing Supervisor with CGGVeritas in Perth. After receiving his PhD in Geophysics in Kiev University in 1986 he worked as a lecturer for Kiev University, a researcher in R&D departments of major Russian service geophysical companies and in several positions with Paradigm Geophysical in Moscow and Perth before joining CGGVeritas in 2006. Sergey is involved in challenging depth processing projects throughout Asia-Pacific region.
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ANDREJ BÓNA has been a senior lecturer at Department of Exploration Geophysics, Curtin University of Technology since September 2007. Before this he was assistant professor at the Department of Earth Sciences, Memorial University, Canada. He obtained his PhD in Applied Mathematics from the University of Calgary, Canada. His current main research interests include seismic imaging and inversion using ray theory and anisotropy.
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WILLEM BOTHA started his career as a Geophysicist at the Geological Survey of South Africa in 1970. In 1980 he completed his PhD in Exploration Geophysics at the Colorado School of Mines specialising in electromagnetic techniques. After 4 years in Canada, he returned to South Africa and accepted the Chair of Professor in Geophysics. After 16 years at the University, he took an early retirement and accepted a post as manager of Geophysical Exploration at a South African iron ore company.

Through his career he has been involved in base metal, iron ore, diamond, uranium, mineral sands, coal and ground water exploration in Canada, the USA, the DRC, Zambia, Namibia, Senegal, Mauritania, Madagascar, Botswana and South Africa.
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PETER BOULT gained his BSc in Geology from Leeds University in 1976. Worked in the mining for 2 years before moving to petroleum where he has over nearly 30 years of experience. He did his PhD at UniSA part time on seals. His current research interests are structural validation and seismic processing. He recently left his position as Chief Petroleum with PIRSA to start his own business.
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EDWARD BOWEN graduated from Macquarie University in 1970 with Honours in Geophysics and Structural Geology. As a Geophysicist, and later Chief Geophysicist for Amax Exploration he worked on a wide range of mineral and coal exploration projects throughout Australia, the South Pacific and South-East Asia. Subsequently, he joined Robertson Research as Chief Geophysicist and worked extensively on World Bank funded assessments of the petroleum potential of basins in Papua New Guinea and the Philippines. Later, he was invited to join the staff at Macquarie University where he held an Associate Professor's position for 6 years.

Currently, he manages the Southwest Margin Project within the Petroleum Prospectivity and Promotions Group of Geoscience Australia.
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STUART BREW graduated from Aston University in the UK in 1969 in Mathematics and Physics and has been involved in oil & gas exploration since that time. He has had roles in the Middle East, North Africa and West Africa where he specialised in seismic land acquisition and processing. He joined Santos' Operations Geophysics group in 1991 and is now involved with seismic activities in Australia and South East Asia.
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ROSS BRODIE works in the Onshore Energy and Minerals Division at Geoscience Australia. He graduated from the University of Queensland in 1990 with a BSc in Applied Geophysics. In 1991, after short stints logging chips and some seismic refraction processing at Velseis, he moved to Canberra to join GA to carry out airborne magnetic and gamma-ray data acquisition and processing. Since 1998 Ross has been closely involved with the uptake of AEM for salinity mapping. He has recently submitted a thesis resulting from PhD research work carried out at the Australian National University.
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TIM BUNTING is the WesternGeco Geophysics Manager for the Asia and South Asia region and a Schlumberger Principal Geophysicist. He has worked for WesternGeco, since graduating from Staffordshire University in 1990. Over this 18 year period he has held various technical roles, including six years offshore as a Field Geophysicst, 6 years in the Oslo technology Centre, and several technical support and survey design positions.
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NIGEL CANTWELL is a Senior Geophysicist working for Resource Potentials Pty Ltd, based in Perth, Western Australia. He graduated from Curtin University of Technology in 2003 with 1st Class Honours in Geophysics. He has five years of experience in the design, processing and interpretation of high resolution geophysical surveys for multi-national mining and exploration companies both in Australia and overseas. He is a current member of the ASEG.
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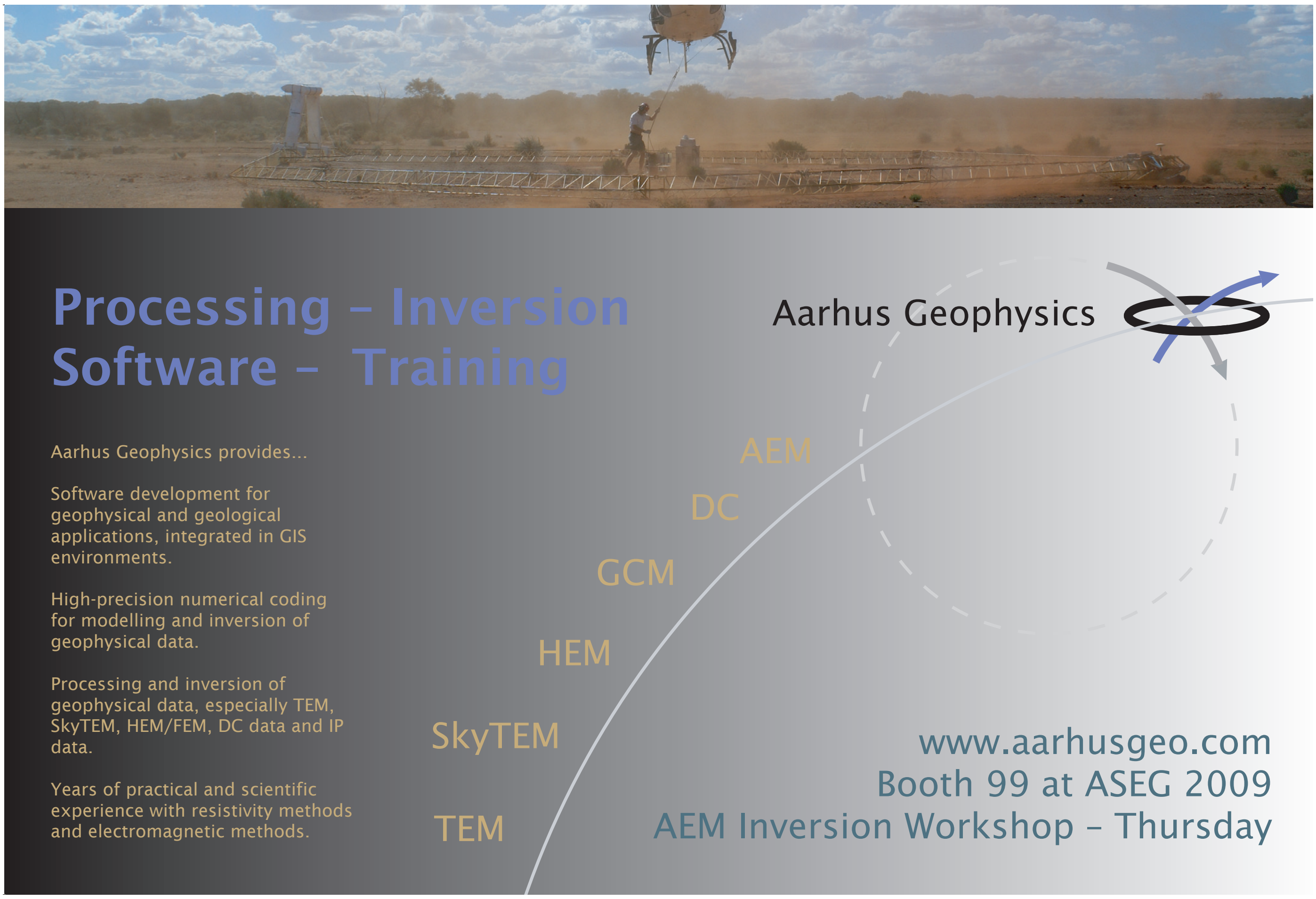
GERHARD ZACHER is application engineer at GE Sensing & Inspection Technologies GmbH, phoenix|x-ray, Wunstorf working on 2D and 3D x-ray inspection including CT measurements and interpretation. He's a geophysicist with more than 10 years experience in environmental and engineering geophysics, mainly 2D and 3D interpretation of EM data. Phoenix|x-ray is a leading brand in 2D microfocus and nanofocus® X-ray inspection and high resolution 3D computed tomography and the center of excellence for Computed Tomography, microelectronic and materials science applications of GE Sensing & Inspection Technologies.
gerhard.zacher@ge.co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Software – Training
Aarhus Geophysics
Aarhus Geophysics provides...
Software development for geophysical and geological applications, integrated in GIS environments.
High-precision numerical coding for modelling and inversion of geophysical data.
Processing and inversion of geophysical data, especially TEM, SkyTEM, HEM/FEM, DC data and IP data.
Years of practical and scientific experience with resistivity methods and electromagnetic methods.
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Setting the
PACE
in 2009
SOUTH AUSTRALIAN
RESOURCES & ENERGY INVESTMENT
CONFERENCE
4 – 6 MAY 2009
Hilton Adelaide
www.saresourcesconf.com
+
UNLOCKING SA'S
MINERAL WEALTH
(Technical Forum)
6 MAY 2009
Hilton Adelaide
www.minerals.pir.sa.gov.au
plan for accelerating exploration
HOT PROSPECTS
Government of South Australia
Primary Industries and Resources SA

SECTION 6

SOCIETY MEMBERSHIPS

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS
A.B.N. 71 000 876 040
PO BOX 8463, PERTH BUSINESS CENTRE WA 6849 AUSTRALIA
Phone: 08 9427 0838 (Intl: +618 9427 0838) Fax: 08 9427 0839 (Intl: +618 9427 0839)
Email: secretary@aseg.org.au Website: www.aseg.org.au

Application for Membership 2009

INSTRUCTIONS FOR APPLICANTS

1. Determine the membership level you wish to apply for, according to the eligibility criteria outlined in Section 2.
2. Fill out the application form. Note that applicants for Active Membership must nominate three referees who are Active members of ASEG. Student members must include a Supervisors Name and Signature. Under exceptional circumstances the Federal Executive Committee may waive these requirements. An active member of SEG does not need referees.
3. Attach the appropriate dues and submit the two pages of your application to the Secretariat at the address shown on the top of this page, retaining a copy of this page for your own records. If payment is to be made by credit card, the application may be sent by fax.

Section 1. Personal Identification

Surname		Date of Birth
Given Names		Mr / Mrs / Miss / Ms / Other
Address		
	State	Post Code
Organisation		
Phone (W)	Fax (W)	
e-mail		
Phone (H)	Fax (H)	
Mobile		

Section 2. Choice of Membership Grade (Tick one)

- ❑ Active — Please complete all sections except section 7
- ❑ Associate — Please complete all sections except section 7 (3 and 4 are optional)
- ❑ Student — Please complete the separate Student Membership Application Form

Active – an applicant must be actively engaged in practising or teaching geophysics or a related scientific field. The applicant's work must have been of a professional nature for **not less than eight years** and must have been of a responsible nature calling for exercise of independent judgement and the application of geophysical or geological principles during at least three years of the total eight years' professional experience. An applicant having worked toward a degree in a scientific field from a recognised college or university may count a portion of the time as a student toward the required eight years' professional experience, not to exceed the following: Bachelor's degree, four years; Master's degree, five years; Doctor's degree, seven years.

Associate – an applicant must be actively interested in geophysics.

Student – an applicant must be a full-time graduate or undergraduate student in good standing in residence at a recognised university or college.

Section 3. Academic and Professional Qualifications

Month / Year (From – To)	Organisation / Institution	Position / Degree (incl. Major)	Professional Record Only: Years of Independent Work

Section 4. Referees

Name	Postal or e-mail address	Phone/Fax

Section 5. Membership of Other Societies

Australian:

❑ Aus IMM Grade ________ ❑ AIG Grade ________ ❑ GSA Grade ________ ❑ PESA Grade ________

International:

❑ AAPG Grade ________ ❑ EAGE Grade ________ ❑ SEG Grade ________ ❑ SPE Grade ________

❑ Others ____

Section 6. ASEG Membership Directory Record

Please complete this section for the ASEG membership database.
The ASEG Membership Directory is published in April. The same information is included in the ASEG Web site (www.aseg.org.au)

Employment area:

❑ Industry ❑ Contract/Service Provider ❑ Government ❑ Student
❑ Education ❑ Consulting ❑ Other ____________________

Type of Business:

❑ Oil/Gas ❑ Ground Water/Environmental ❑ Coal ❑ Survey/Geotechnical/Engineering
❑ Minerals ❑ Petrophysics/Log Analysis ❑ Research/Education ❑ Data Acquisition
❑ Solid Earth Geophysics ❑ Archaeology/Marine Salvaging ❑ Computer/Data Processing ❑ Other ____________________

Section 8. Payment Details (This document will be an Australian Tax Invoice when you have made payment)

Membership Grade	Member Location	Number of Years	Membership Rates
Active / Associate	Australia / New Zealand	1	A$128.70 (GST inclusive)
		2	A$236.50 (GST inclusive)
		3	A$343.20 (GST inclusive)
	Rest of the world	1	A$117.00 + A$50.00⁺
		2	A$215.00 + A$100.00⁺
		3	A$312.00 + A$150.00⁺

⁺ Mailing surcharge

Amount Payable A$ ____________ ❑ Tick if you require a receipt Cheque No. __________________________

❑ MasterCard ❑ Visa ❑ AMEX

Name of Card Holder: ____ Card No. __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

Expiry Date: ______ / ______ Signature: __________________

(Note: Keep a copy for your record. A receipt will not be issued unless specifically requested.)

The above information is required for our records, but if you do not wish to be included in the ASEG directory or Internet search facility, please indicate by ticking appropriate box below:

❑ I ***do not*** wish to be included in the ASEG Directory. ❑ I ***do not*** wish to be included in the ASEG member search facility on the Web site.

The association produces a magazine call Exploration Geophysics; please indicate below how you would prefer to receive your copy:

❑ Paper/printed ❑ Electronic/CD

Section 9. Promotional Opportunities

The ASEG provides opportunities for special category listings (eg. Consultants, Contractors) in the Directory and a link from the ASEG Internet Web Page.

❑ I (or my business) would like to be included in a special category listing in the Directory.

❑ I (or my business) am interested in having a link from the ASEG Internet page. Rates will be advised when links are implemented. (Corporate and Corporate Plus members get a complimentary link.)

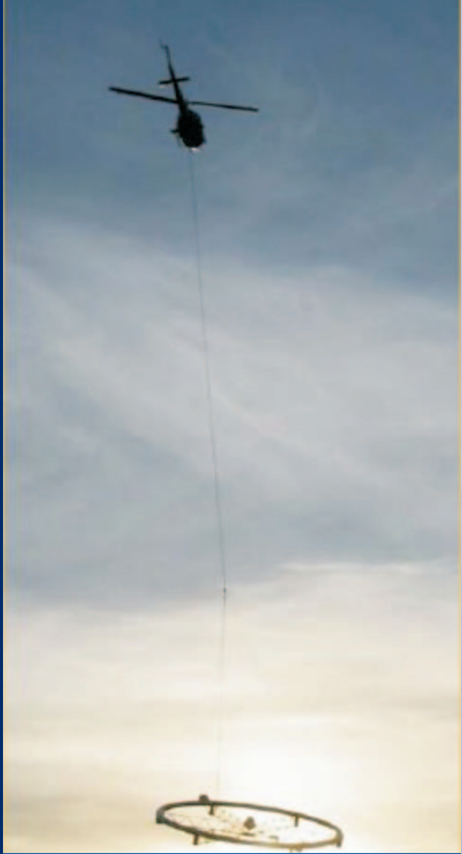
❑ I (or my business) am interested in advertising in the Directory, or other ASEG's publications. Rate details will be forwarded by our Publisher, CSIRO Publishing, elspeth.gardner@csiro.au or Ph +61 3 9662 7668. (Discounts available for Corporate Members and volume advertising.)

Section 10. Declaration

I, ____ (name), agree for the Australian Society of Exploration Geophysicists to make all necessary enquiries concerning my application and suitability to become a Member. By lodging this Application and upon being accepted in my membership, I agree to be bound by the Constitution of the Australian Society of Exploration Geophysicists, including its ethical and professional standards.

*Signature:*______________________________ *Date:*________________

SOCIETY MEMBERSHIPS




ZK-FNZ

INTERACTIVE DIGITAL FORM

MEMBERSHIP APPLICATION 2009 (Jan to Dec)

Petroleum Exploration Society of Australia Limited ABN 12 009 061 278

Note: Australian based Students must use separate Student Membership form

Photocopy acceptable. Please print clearly

Name ☐ Mr., ☐ Mrs., ☐ Ms., ☐ Dr., ☐ Other..........Initials: .... First Name:.............................. Surname: ....

Company Name/Affiliation: ....

Company adddress: .... Suburb: ....

State: .... Postal Code: .... Country: .... ☐ Use for mailing

Home address: .... Suburb: ....

State: .... Postal Code: .... Country: .... ☐ Use for mailing

Business Phone: .... After hours Phone: .... Mobile: ....

Fax: .... Email: ....

Branch Affiliation *(tick ☞ one only):* ACT ☐ NSW ☐ QLD/NT ☐ SA ☐ VIC/TAS ☐ WA ☐ Overseas ☐

Principal Profession *(Tick ☞ one box in each category)*

- Geoscience ☐
- Geology ☐
- Geophysics ☐
- Geochemistry ☐
- Biostratigraphy ☐
- Petrophysics ☐
- Computing ☐
- Engineering ☐
- Drafting ☐
- Finance ☐
- Law ☐
- Journalism ☐
- Clerical/Technical (Asst) ☐
- Other ________________

Principal Employment

- Exploration Company ☐
- Service Company ☐
- Government ☐
- Education ☐
- Legal Firm ☐
- Accounting Firm ☐
- Finance/Banking Inst. ☐
- Retired ☐
- Other ________________

Job Description

- Consultant ☐
- Staff ☐
- Researcher ☐
- Manager ☐
- Director ☐
- Retired ☐
- Other ________________

Tertiary Education/Record of Experience: ....

Class of Membership:

☐ **Active** (Voting) – A person involved in the petroleum industry, or who has professional experience or qualifications.

☐ **Associate** (Non-Voting) – A person interested in the objectives of the Society.

☐ **Overseas** (Non-Voting) – A person presently not resident in Australia but who otherwise would qualify for Active or Associate membership.

Young Petroleum Professional (YPP):

☐ Tick ☞ here if: You are in your first ten years in the Oil industry, see yourself as a Young Petroleum Professional (YPP) and would like to be informed of YPP career development and social events in your state.

Declaration: In applying for membership of the Petroleum Exploration Society of Australia Limited, I undertake that if admitted I will be bound by the provisions of the Memorandum and Articles of Association of the Society and also the Model By-Laws applicable to the State Branch with which I will be affiliated.

(Signature) .... (Date) ....

Sponsorship: Applications should be sponsored by two financial members of the Society. An applicant who does not know any Members or cannot easily obtain signatures, may attach additional personal information for the Committee to consider sponsorship.

Sponsor (1): ....
(Name) (Signature)

Sponsor (2): ....
(Name) (Signature)

NOTE TO APPLICANT:

Please select one of the following payment options:

☐ ***Credit Card**** (VISA, MASTERCARD, AMEX, DINERS)

☐ ***Cheque***** (made payable to PESA Ltd)

☐ ***Cash***

* Send credit card payments to PESA Membership Secretary in Perth by fax on **+61 8 9375 7636** or by mail to **PO Box 721, West Perth, WA 6872**

** A cheque covering your membership subscription fee plus nomination fee should be sent along with your application to: PESA Membership Secretary, **PO Box 721, West Perth, WA 6872**

MEMBERSHIP FEES (IN AUSTRALIAN DOLLARS)

	ACTIVE / ASSOCIATE (Inc. GST)	OVERSEAS
NOMINATION	$11.00	$10.00
MEMBERSHIP	$77.00	$90.00
TOTAL PAYMENT	$88.00	$100.00
TICK ☞ ONE ONLY	☐	☐

FREE PAPERS: As part of this year's PESA membership you are entitled to 20 free downloads of PESA / APPEA published papers from the Profdocs website (www.profdocs.com or use the 'Technical Papers Online' link on the PESA home page). To register for this entitlement please tick ☞ here. ☐

Type of card: VISA ☐ MASTERCARD ☐ AMERICAN EXPRESS ☐ DINERS ☐

Credit Card Number: ☐☐☐☐ / ☐☐☐☐ / ☐☐☐☐ / ☐☐☐☐ Expiry Date: ☐☐ / ☐☐

Name on Card: ____

Total Amount: $88.00 ☐ $100.00 ☐ Date: ________________ Signature: ________________________

Send application to PESA Secretary by email: **pesa.sec@bigpond.com** (for digitally completed form) or by fax: **+61 8 9375 7636** or by mail to: **PO Box 721, West Perth, WA 6872 AUSTRALIA**

SOCIETY MEMBERSHIPS