Australian
Society of
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Geophysicists
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Preview

February 1997

Issue No. 66

CONFERENCE HANDBOOK

Australian Society of Exploration Geophysicists
12th Geophysical Conference and Exhibition

co-hosted by:
The Society of Exploration Geophysicists
Petroleum Exploration Society of Australia

23-27 FEBRUARY 1997
SYDNEY ❖ AUSTRALIA

"ASIA-PACIFIC EXPLORATION"

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Editor's Desk – ASEG 12th Conference Edition of Preview

This issue of Preview serves as the Handbook for the 12th ASEG Conference and Exhibition in Sydney. I trust that all delegates will enjoy the ambience of Australia's premier harbour city as well as sharing with and learning from your colleagues the advances in geophysics since our last meeting in Adelaide.

The theme of this year's conference "Asia Pacific Exploration" has attracted a large of number papers from that region. Southeast Asia is particularly well represented while Canada and the USA., as usual, are great contributors. The result is a credit to the organisers and, perhaps, a trend that may develop further as we become less parochial here in Australia. Congratulations to all concerned and a special welcome to our visitors from the Pacific countries and around the world.

A first for our conference this year is a session on the application of geophysics in forensic detection, specifically looking for clandestine graves. It provides new insights into the meaning of physical property contrast which, after all, is the key to all our efforts. I am sure that the engineers and perhaps also the mineral explorers, will pick up some useful tips from attending this session. It reminds me of the 1983 conference in Brisbane at which we presented a couple of papers by medical practitioners who, for some of their work, apply the same physical principles to investigating their patients as we do in probing the earth for minerals and hydrocarbons.

During the past year *Preview* has continued to provide our membership with interesting and wide ranging topics. We have been lucky to continue a reasonably consistent flow of feature articles - perhaps a bit skewed towards the hydrocarbon side of our business. But this throws up a challenge to the mineral explorers, engineers and others to come up with a balancing act and to keep their own colleagues well informed on the latest developments. The year ahead is another challenge as we move towards making the ASEG publications a commercial operation which will continue to provide the membership with the high quality they've come to expect. Much of the routine work, particularly for *Preview*, will be taken over by a publisher leaving more time for your editorial staff to pursue new sources of instructive and interesting articles.

Your last *Preview* was the Silver Jubilee issue which I hope all of you enjoyed. I want to thank all of the contributors to that issue for their efforts in bringing you a slice of the past and putting on record the events surrounding the birth and early development of ASEG. The growth of our Society over those twenty-five years has been very encouraging and present trends auger well for the future. Unfortunately for the current issue, time has not permitted the inclusion of our regular Preview features. These will be held over until the next issue.

The *Preview* team this year welcomes a new Associate Editor, Geoff Pettifer (have we heard that name somewhere before?) Yes! Geoff was your last editor of Preview and, being something of a glutton for punishment, has volunteered his services again in the "Engineering, Environmental and Groundwater" department. This fits well with his recent change of employment to Geo-Eng Australia Pty Ltd. Thank you Geoff for this renewed effort for the team. I must also thank Derecke Palmer for his "Clean and Green" column since the inception of this department in 1994.

The current issue of *Preview* was put together with help from MIM Exploration Pty Ltd, BHP Exploration, Crusader Limited, Oil Company of Australia Limited and Henk van Paridon in Brisbane, also Ted Tyne and his team in Sydney. The Conference Volume of *Exploration Geophysics* is a little slimmer on this occasion as we have moved to contain the enormous cost of the conference publications. But this has not reduced the workload of Richard Facer and his team who have faced the additional problems of establishing the new format. Thank you all for your generous efforts.

Mike Shalley, Editor

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Conference Handbook

SECTION ONE

Chairmen's Welcome

It is our pleasure to welcome you to the 12th ASEG Conference and Exhibition in this great setting of Sydney. We are upholding the tradition of this event being the foremost geophysical conference in the region. Your **Conference Organising Committee**, listed below, has worked hard to provide you with the opportunity to have an enjoyable four days learning what's new in exploration geophysics from the 110 technical papers, 25 posters, 5 workshops and the biggest ever exhibition with 125 booths.

We are especially pleased to have had the cooperation and support from our **co-hosts**, SEG and PESA. SEG provided assistance in increasing our international presence and PESA helped to improve the petroleum balance to our technical content as well as providing financial backing.

As part of the technical programme we have a special session on the recent Government Initiatives to exploration which resulted in large airborne surveys in all the States and Territories. Another **innovation** this year is the incorporation into the programme of a special workshop on 'Future Trends and Directions in Mineral Exploration Geophysics' with presentations by several top scientists. At the Opening Ceremony we will honour some distinguished colleagues.

Specially invited **Keynote** speakers, some from overseas, are spread throughout the programme, talking on subjects ranging from 3D seismic to finding dead bodies.

Be sure to visit the **posters** and especially on the Tuesday after lunch when the authors will be present to answer questions. There are deliberately no other technical sessions at this time to give them worthy prominence.

To encourage and heighten awareness of our profession in high schools, we are continuing the successful event which was initiated at the last Conference, by holding a **Student's Day** on the Wednesday where 120 high school students and teachers will visit the exhibition. So please be on your best behaviour at least on that day!

None of these arrangements would have been possible without the generous financial support of all our **sponsors**. Once again Western Geophysical are our Principal sponsor and are closely followed by Digicon Geophysical Ltd and Schlumberger and other Major sponsors and supporters who are all listed in the programme. Please acknowledge this contribution to your Society when you meet their representatives.

Finally, don't miss the chance to renew old friends and make new ones at the many **social** functions starting with the Welcome Reception and including a Harbour Cruise, Conference Dinner, Conference Breakfast and Farewell Cocktail Party. The Conference Dinner should be especially entertaining with Professor Ian Plimer speaking on a topical and controversial subject.

Have a memorable time!

Roger Henderson Wes Jamieson
Co-Chairmen

1997 Conference Organising Committee

CO-CHAIRMEN Roger Henderson Wes Jamieson

SUB-COMMITTEE COORDINATORS AND ASSISTANTS

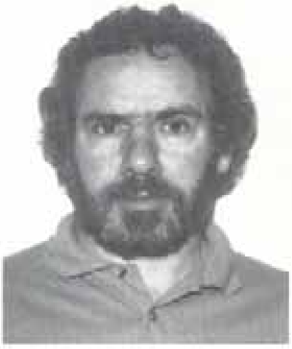
Technical Papers	*Coordinator*	Ted Tyne
	Assistants	Joe Odins
		James Macnae
		Jim Tayton
		Mike Smith
		Vince Robinson
Guest Editor		Richard Facer
Exhibition	*Coordinator*	Pat Hillsdon
	Assistant	Simon Stewart
Financial	*Coordinator*	Steve Webster
	Assistant	Katherine McKenna
Publicity	*Coordinator*	Peter Jackson
	Assistant	Mark Russell
Sponsorship	*Coordinator*	Roger Henderson

Workshops	*Coordinator*	Derecke Palmer
	Assistant	Michael Moore
Social Activities	*Coordinator*	Nigel Jones
Student's Day	*Coordinator*	Katherine McKenna
	Assistant	Derecke Palmer
PESA Representative		David Cliff
International & SEG Liaison		Roger Henderson
Event Manager	*Coordinator*	Mike Smith
	Assistant	Ted Bowen
Professional Conference Organiser	Conference Action Pty Ltd	
Meetings Secretary	Conference Action Pty Ltd	

ASEG President's Conference Address

Henk van Paridon

President, ASEG



Ladies and Gentlemen - Welcome to this the Australian Society of Exploration Geophysicists' 12th Conference and Exhibition. I don't think it is boasting to say that ours is the premier exploration conference in Australia.

I would like to thank our co-host societies the SEG and PESA. Their willingness to be involved is proof positive of the stature to which our conference is held.

I would also like to acknowledge the support of our principal sponsor, Western Geophysical and indeed all of our major sponsors. The ASEG has now developed a history of successful professionally organised conferences and I am sure that your ongoing support will be rewarded by yet another quality event.

The theme of this conference, Asia Pacific Exploration, is an attempt to broaden our normal focus. The conference organising committee has attracted papers from wide ranging geographical and geophysical areas. A special welcome is extended to our overseas presenters.

On behalf of the delegates and the ASEG membership at large, I would like to thank Roger Henderson, Wes Jamieson and the rest of their committee for the hard work they have put in. Those of us who have served on conference organising committees before are aware of the commitment required. I'm sure you will have an opportunity to talk with committee members throughout the conference and offer your support.

During the last year the Federal Executive has moved from Melbourne to Brisbane. The process of moving the executive serves two purposes, it allows new blood into the committee and it allows old blood to recover. This is my first time on a Federal Executive and there was, and still is a steep learning curve. From talking to former committee members it seems this move has been less hectic than before but maybe this just demonstrates how little we know. Earlier on, a lot of correspondence went into the "too hard" basket. Now that we know what we are supposed to be doing it actually takes longer to deal with issues.

The activities and business of our society is conducted by a range of committees. Some of these committees are very stable, people are happy to keep serving. The conference organising committee have a definite shelf life whilst other committees are ephemeral such as the Federal Executive. The wine tasting committee by contrast has a waiting list.

The constant changing of the guard is both a strength and weakness. The strength comes from having fresh enthusiastic people at the helm. The weakness comes from lack of continuity and from apparently contradictory positions adopted by us which sometimes makes it difficult for outsiders who wish to interact with us. But I would like to dwell on the strengths of this system. The best example is our conferences which are run according to a set of conference guidelines, put together by a standing committee. This provides necessary continuity but there is plenty of scope for the local COC to impart their own style on the event.

In another example new blood was found in Brisbane for the local branch committee when many of the regulars were seconded to the Federal Executive. I'm pleased to say that the local branch is as active as it ever was. The lesson here is that, despite being unbelievably shy, geophysicists will come forward if they are asked.

Membership of the society has continued to grow. Now at 1350 up by 8% since the last conference. There is no single area of growth. New members come from near and far, from highly experienced to inexperienced, and from growing mineral and petroleum industries. What does the ASEG offer? I believe that this conference and the publication of fully referenced papers are reason enough to be a member. But wait, there's more - further editions of Exploration Geophysics and six copies of Preview; and for capital city dwellers there's still more - local branch meetings and I could go on. It pays to belong! So if you know someone who would benefit from becoming a member, let them know. During the course of this conference there will be some standing committee meetings. You are welcome to attend and see how they work. I should add that I am also a member of SEG and PESA but they can find their own members.

The privileges of membership don't come without enormous effort from a lot of people. The standing committee, the local branch committees, the conference organising committee, the editors and my fellow executive members have all made contributions. Their efforts make this society tick. There is always a danger that I could forget to mention someone but I am going to take an even riskier approach by paying tribute to some outstanding contributions since the last conference - Geoff Pettifer for his pace-setting effort as preview editor, Norm Uren and Brian Spies for their notable achievements on the SEG executive.

This is also a good time to celebrate our 25th anniversary as a society. Twenty five year members will be recognised with a certificate. Whilst attending the SEG convention in Denver it was announced that one delegate was attending his 50th convention. This is my 6th convention and I don't think I will make 50. This is the society's 12th and it may very well reach 50. Nevertheless the ASEG can be proud of its record in the last 25 years and we look forward to the future.

The future is about begin. Once again welcome to the Australian Society of Exploration Geophysicists 12th Conference and Exhibition. The technical programme and the exhibition will make your trip worthwhile. I congratulate and thank all those who have made it happen.

General Information

Venue

Sydney Convention and Exhibition Centre
Darling Drive
DARLING HARBOUR NSW 2000
Telephone: +61-2-9282 5000 Facsimile: +61-2-9282 5041

Registration Desk

The Registration Desk is located on Level 1 of the Convention Centre, Main Foyer (see map) and will be open during the following times:

Sunday 23 February 1997	1600-1800 hours
Monday 24 February 1997	0730-1730 hours
Tuesday 25 February 1997	0630-1730 hours
Wednesday 26 February 1997	0730-1730 hours
Thursday 27 February 1997	0730-1700 hours

Speakers Preparation Room

Speakers using slides should leave them in the Speakers Preparation Room in the Southern Auditorium Lounge on Level 2 of the Convention Centre (see map). Slide preview facilities are available for speakers. Please lodge your materials if possible during the day prior to your presentation. The Speaker Preparation Room is open 0730-1730 hours daily.

Exhibition

The exhibition is located in Hall 5 of the Exhibition Centre. Hall 5 is the closest hall to the Convention Centre (see map). Opening hours are:

Monday 24 February 1997	1000-1800 hours
Tuesday 25 February 1997	0830-1800 hours
Wednesday 26 February 1997	0830-1800 hours
Thursday 27 February 1997	0830-1545 hours

Technical Sessions

All technical sessions will be held on Level 2 of the Convention Centre. Please refer to the Technical Programme for the session rooms.

Posters

Posters will be displayed in the exhibition area (Hall 5) from Tuesday 25 February 1997 at 1330 hours. A special exclusive poster session at this time will allow authors to explain their display.

Messages

A message board is located at the entrance to the exhibition. The telephone number to leave messages for delegates or exhibitors is +61-2-9282 6193.

Name Badges

All delegates and exhibitors are asked to wear their name badge throughout the Conference including all official social functions. Please note that entrance to all technical sessions and the exhibition is strictly limited to name badge holders only.

Refreshments

Morning and afternoon teas will be served in the exhibition area. Lunches will be available for purchase in the Restaurant area of Hall 5.

Car Parking

Car parking is available in the Exhibition Car Park, located underneath the Exhibition Centre. A special Conference rate is being offered to delegates and exhibitors at A$10.00 per day on presentation of your name badge. Entry is via Darling Drive, Darling Harbour.

Dress

Smart casual attire is appropriate for the Conference technical sessions.

Banking

Banks in Australia are open during 0930-1600 hours Monday-Thursday and from 0930-1700 hours on Fridays. Banks are closed on Saturday and Sundays but ATMs are available at most banks. Currency exchange facilities are available adjacent to the Convention Centre.

Credit Cards

Credit cards accepted at the Conference Registration Desk are Mastercard, Visacard and Australian Bankcard.

Safety and Security

Please do not leave bags or suitcases at any time either in or outside session rooms or the exhibition area. Please ensure you personalise your Conference satchel.

Smoking Policy

The Sydney Convention and Exhibition Centre's policy is that smoking is prohibited in all Conference sessions, exhibition area, registration area and in all areas where refreshments are being served during the Conference.

Disclaimer of Liability

The Australian Society of Exploration Geophysicists 12th Geophysical Conference and Exhibition including the Conference Secretariat will not accept liability for damages of any nature sustained by participants or their accompanying persons or loss or damage to their personal property as a result of the Australian Society of Exploration Geophysicists 12th Geophysical Conference and Exhibition or related events.

Conference Secretariat

Conference Action Pty Ltd

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NORTH SYDNEY NSW 2059, AUSTRALIA
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E-mail: confact@real.net.au

Social Programme

Tickets have been issued for all social functions.
Entry will be by ticket ONLY.

Monday, 24 February 1997

"Icebreaker" Welcome Reception 1800-2000 hours

Harbourside Room, Sydney Convention and Exhibition Centre

Sponsored by: Western Geophysical

All delegates, exhibitors and guests are welcome to attend the informal "Icebreaker" Welcome Reception, the opening social function to the Conference. The reception is complimentary for both fulltime delegates and exhibitors. Accompanying Persons/Guests can purchase tickets at the Registration Desk for A$35.00.

Tuesday, 25 February 1997

Conference Breakfast 0700-0800 hours

Skyline Terrace, Sydney Convention and Exhibition Centre

Dr Ian Lin has been invited to address this Conference Breakfast to offer a perspective of the future of this industry and it's position in the Asia-Pacific Region. Tickets are available for purchase from the Registration Desk for A$30.00.

Tuesday, 25 February 1997

Conference Harbour Dinner Cruise 1830-2200 hours

There is no better way to appreciate the world's finest harbour than from the decks of this spectacular evening of song, dance, comedy and fabulous dining afloat which has been organised for delegates and their guests. Tickets can be purchased at the Registration Desk for A$80.00. The boat will depart from the Festival Marketplace, Darling Harbour.

Wednesday 26 February 1997

Conference Dinner 1900-2300 hours

Banquet Hall, Sydney Convention and Exhibition Centre

Dress: Cocktail attire for women & jacket and tie for men

Sponsored by: Digicon Geophysical Ltd

The Conference Dinner is the main social function of the Conference and will include an entertaining address on scientific misinformation by Dr Ian Plimer, Australia's most talked-about geologist. All delegates, exhibitors and partners are invited to make it a memorable and enjoyable evening. Tickets may be purchased from the Registration Desk at A$70.00.

Thursday, 27 February 1997

Farewell Cocktail Party 1700-1900 hours

Harbourside Room, Sydney Convention and Exhibition Centre

Sponsored by: Schlumberger

The finale to the Conference - your last chance for farewells to friends, old and new-found. This function is complimentary for fulltime delegates and exhibitors. Additional tickets can be purchased at the Registration Desk for A$30.00.

Friday, 28 February 1997

Golf Day and Wine Tasting

Golf to be held at the Cypress Lakes Resort in the Hunter Valley wine-growing district. Please see the flyers in your satchel or ask at the Tour Desk for full details. Wine tasting at four popular vineyards.

Suggested Partner Activities

A Tour Desk is located at the entrance to the exhibition and will be open daily. They will be happy to assist with any arrangements you may like to make.

The ASEG 1997 Conference offers a marvellous opportunity to explore the delights of Sydney - host city to the 2000 Olympiad.

A selection of tours have now been designed especially for the Conference and coach tours will operate exclusively for delegates, their partners and accompanying persons (subject to minimum numbers being achieved).

Sydney Orientation Tour 0900-1200 hours

Cost: A$35.00

Including most of Sydney's main attractions in one tour - the Opera House, historic Rocks District, nightlife area of Kings Cross, famous Bondi Beach, trendy Paddington Village and fashionable Eastern Suburbs. There is also an introduction to the attractions in and close to Darling Harbour and the central shopping district and main department stores.

This tour will set down at Jetty #6, Circular Quay (for those joining the Sydney Harbour Luncheon Cruise) before proceeding directly to the Convention Centre.

Sydney Harbour Cruise 1230-1415 hours

Cost: A$42.00 per person (including buffet luncheon)

Sydney Harbour has been renowned for its spectacular beauty since it was first discovered by Captain James Cook. Now you will cruise on board one of the Captain Cook fleet and catch a seagulls view of the Opera House, Harbour Bridge, the Governors and Prime Ministers residences and many other magnificent homes along the foreshores. The cruise includes an international buffet luncheon and informative commentary from your cruise hostess.

This cruise departs from Jetty #6, Circular Quay.

The Blue Mountains (and Koalas!) 0830-1700 hours

Cost: A$60.00 per person

Once out of Sydney the first stop is the Wildlife Park with Australian animals and birdlife of all description - and including koalas and kangaroos. Mid morning you ascend to the mountain townships and the Blue Mountains, famous for stunning views of sandstone cliffs, valleys and waterfalls. A popular stop will be Echo Point to look out over the awe inspiring Jamieson Valley and take in the famous rock formation of the "Three Sisters". There is time for lunch in Leura (to your own cost) and the afternoon journey provides other viewing opportunities before you commence the descent and return toward the city. Always Sydney's most popular day tour experience!

Workshops

The following pre-conference workshops were held:

❶ **An Introduction to Geostatistics**
Brian Russell
Hampson-Russell Software Services

❷ **Interpretation of Regional Geophysical Datasets**
Peter Gunn
Australian Geological Survey Organisation

❸ **GIS for Geophysicists**
Derecke Palmer and Geoff Taylor
University of New South Wales

❹ **Surface and Downhole EM**
John Bishop, Mitre Geophysics
James Macnae, Macquarie University

Exploration Geophysics

ASEG Members will receive the Conference volume of *Exploration Geophysics*. Non-members may purchase a copy at the Registration Desk.

Student's Day

Sponsored by:
World Geoscience Corporation Limited

The 2nd ASEG Student's Day will be held on Wednesday 26th February 1997 in conjunction with the main conference programme. The aim of the student's day is to facilitate community understanding of the function of geophysics in the resources industry, to promote geophysics as an area of study, to highlight the development of non-invasive practices by the resource exploration industry, and to create a link between class room study and real life applications. A formal presentation to the students and teachers will include an overview of geophysics, experiences of a current geophysicist, prerequisites for studying geophysics at University and experiences of a current geophysics student at University. The students will also be taken on a guided tour of the exhibition area.

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"ASIA-PACIFIC EXPLORATION"

"ASIA-PACIFIC EXPLORATION"

23-27 FEBRUARY 1997
SYDNEY ❖ AUSTRALIA

TECHNICAL PROGRAMME

Sunday 23 February 1997

1200	EXHIBITION SET-UP
1600-1800	PRE-CONFERENCE REGISTRATION

Monday 24 February 1997

* Presenting author underlined

0730	**CONFERENCE REGISTRATION**
0900	**OFFICIAL WELCOME TO "ASIA-PACIFIC EXPLORATION" AND OPENING ADDRESSES BY THE PRESIDENTS OF ASEG, SEG AND PESA - AUDITORIUM SOUTH**
0930	**ASEG AWARDS CEREMONY - GOLD MEDAL AND HONORARY MEMBERSHIPS - AUDITORIUM SOUTH**
1000	**OFFICIAL OPENING OF EXHIBITION**

1000	*Morning Tea*	*Morning Tea*	*Morning Tea*
	STREAM 1 - AUDITORIUM SOUTH **Session 1 Petroleum Asia-Pacific** Chaired by H. van Paridon and D. Morton	**STREAM 2 - MEETING ROOM 3** **Session 1 Minerals Asia-Pacific** Chaired by E. Tyne and P. Gunn	**STREAM 3 - MEETING ROOM 4** **Session 1 Geotechnical/Environmental Asia-Pacific** Chaired by K. Frankcombe and S. Mudge
1030	*Exploration challenges and opportunities in the Far East* **KEYNOTE SPEAKER: Johnny Hall, Exxon Exploration** **Sponsored by: Ampolex Limited**	*The Vanuatu mineral exploration initiative* **P.J. Gunn, S. Temakon, J. N. Mitchell, P. Pieters**	*Site characterisation geophysics: experiences in South East Asia* **KEYNOTE SPEAKER: Dr Bob Whiteley, Coffey North America** **Sponsored by: West Australian Petroleum Pty Ltd**
1100	*Jackson 3-D seismic survey: a technical and commercial challenge* **H.R. Smith**	*Application of enhanced airborne radiometric data for geological mapping in Khanom area, southern Thailand* **P. Charusiri, W. Galong, S. Kosuwan**	*Geophysical indicators of controls on soil salinisation and implications, Longford Basin, Northern Tasmania* **N. Direen, M.J. Roach**
1130	*3-D prestack time migration: an application to the Ravva 3-D dataset, offshore India* **J. Montalbetti, P. Whiting, L. Brooks**	*Airborne geophysics and remote sensing as modern exploration tools in The Philippines* **M. Erceg, M.U. Papio, C. Nash**	*SALTMAP: a sound technical basis for catchment and farm plannin* **G. Street**
1200	*Lunch*	*Lunch*	*Lunch*
	Session 2 3-D Seismic Chaired by W. Jamieson and D. Cliff	**Session 2 Minerals Case Histories** Chaired by R. Smith and M. Smith	**Session 2 Geotechnical Environmental** Chaired by F.E.M. Lilley and R. Whiteley
1330	*A method for stacking 3-D swath data from a 3-D dipping horizon without the need for velocity analysis* **R. J. Evans**	*Exploration for Cu-Au deposits in the Sultanate of Oman* **S. Webster, A. Perry**	*A new resolution index for resistivity electrode arrays* **N. P. Merrick**
1400	*Some causes of artefacts in 3-D seismic surveys* **M. Galbraith, M. Hall**	*Second horizontal derivatives of ground magnetic data applied to gold exploration in the Yilgarn Craton, Western Australia* **N. R. Gyngell**	*A synthetic study on crosshole resistivity imaging using different electrode arrays* **Z. Bing, S.A. Greenhalgh**
1430	*Efficient 3-D imaging beneath complex water bottom topography* **C. Harris, M. Marcoux, P. Whiting**	*Exploration for Tertiary palaeochannels with geophysics, Mt. Keith area, Western Australia* **G. Jenke**	*The use of constraints in geophysical tomographic reconstruction* **J. Young**
1500	*Afternoon Tea*	*Afternoon Tea*	*Afternoon Tea*
	Session 3 3-D Seismic Chaired by D. Cliff and W. Jamieson	**Session 3 Minerals Case Histories** Chaired by M. Smith and R. Smith	**Session 3 Magnetotellurics** Chaired by W. Stasinowsky and F.E.M. Lilley
1545	*Imaging properties of modern 3-D seismic acquisition systems* **C. Beasley, E. Mobley**	*Finding sphalerite at Broken Hill with DHMMR* **J.R. Bishop, N. Carroll, M. Hatch, S. Macinnes, M. Asten**	*Advances in MT and CSAMT for deep and shallow ground conductivity imaging* **T. Asch, E. Nichols**
1615	*Accurate 3-D DMO for land and patch geometries: a practical approach and application to multi-fold field data* **R.G. Williams, N.J. Cooper, R. Wombell, C.D. Notfors**	*Geophysical signature of the Potosi Zn-Pb-Ag orebody, Broken Hill* **N. Hughes, N. Carroll, P. Leevers, J.R. Bishop**	*Processing magnetotelluric data with modern statistical and numerical techniques* **K.M. Edwards, L.M. Hastie**
1645	*A new dimension in 3-D* **B. Anderson, M. Weber**	*Airborne magnetic, radiometric and satellite imagery for regolith mapping in the Yilgarn Craton of Western Australia* **C. Dauth**	*Large-scale electrical conductivity structure of Australia from magnetometer arrays* **L.J. Wang, F.E.M. Lilley, F.H. Chamalaun**
1715-1800	Time for visiting Exhibition in Hall 5	Time for visiting Exhibition in Hall 5	Time for visiting Exhibition in Hall 5

1800	**"ICEBREAKER" WELCOME RECEPTION - HARBOURSIDE ROOM - Sponsored by Western Geophysical**

Tuesday 25 February 1997

* Presenting author underlined

0700 CONFERENCE BREAKFAST

0830 Exhibition Opens

	Stream 1	Stream 2	Stream 3
	STREAM 1 - AUDITORIUM SOUTH **Session 4 Seismic Processing** Chaired by S. Greenhalgh and P. Woods	**STREAM 2 - MEETING ROOM 3** **Session 4 Minerals Asia-Pacific** Chaired by D. Pratt and J. Bishop	**STREAM 3 - MEETING ROOM 4** **Session 4 Geotechnical Seismic Refraction** Chaired by J. Odins
0830	*The use of sensible velocities for migration* **S. Carrol, G. Beresford**	*Where has geophysics been and where are we headed?* **KEYNOTE SPEAKER: Dr Tom Whiting, BHP Minerals** **Sponsored by: BHP Minerals**	*Construction of the refraction time section by convolution* **D. Palmer, H. Zheng**
0900	*Model-based velocity analysis* **J. Dunne, G. Beresford**	*Integrated lithostructural mapping of the Rossing Area, Namibia, using high resolution aeromagnetics, radiometric and landsat data* **H. Anderson, C. Nash**	*Rapid automated determination of shallow velocity-depth structure using first breaks and the Generalised Reciprocal Method* **X. Xie, J. C. Macnae, D. Palmer**
0930	*DMO in the radon domain* **M. Hall, C-S. Wang, (M. Galbraith)**	*New algorithms for visually enhancing airborne geophysical data* **P.J. Gunn, D. Fitzgerald, N. Yassi, P. Dart**	*Joint application of seismic and electromagnetic methods to coal characterisation at West Cliff Colliery, NSW* **Z. Lin, K. Vozoff, G. H. Smith, P. Hatherly, O.G. Engels**
1000	*Morning Tea*	*Morning Tea*	*Morning Tea*
	Session 5 Seismic Processing Chaired by N. Uren and S. Greenhalgh	**Session 5 Magnetics and Gravity** Chaired by J. Bishop and D. Pratt	**Session 5 Gravity and Geoid** Chaired by D. Johnson and J. Odins
1030	*Seismic processing in areas of complex near-surface velocity fields: a case study* **P. Whiting, N. Hendrick, W. Muir, B. Suthers**	*Magnetic and gravity modelling of the Renison Tin Mine, Tasmania* **S. S-J. Roberts, S.T. Mudge**	*On the use of the geoid in geophysics: a case study over the Northwest Shelf of Australia* **W.E. Featherstone**
1100	*Computation of principal directions of azimuthal anisotropy from P-wave seismic data* **S. Mallick, L.J. Meister, K.L. Craft, R.E. Chambers**	*A semi-automated interpretation system for potential field data based on profile data* **Z. Shi, N. Sheard, R. Valenta**	*Fast combination of satellite and marine gravity data* **J. Kirby**
1130	*Processing through to stack in the tau-p domain* **J. Dunne, G. Beresford**	*The 3-D analytic signal: a creative solution or a waste of time?* **S. Rajagopalan**	*Gravity gradient tensor invariants for exploration* **M. Dransfield**
1200	*Lunch*	*Lunch*	*Lunch*
1330	**Session 6 POSTER PAPERS IN THE EXHIBITION HALL**	**Session 6 POSTER PAPERS IN THE EXHIBITION HALL**	**Session 6 POSTER PAPERS IN THE EXHIBITION HALL**
	New geophysical datasets for the Curnamona Olary area **N. Dunstan, D. Calandro**	*McArthur Basin architecture: a new perspective from geophysics and GIS* **M. Duffett, D. Leaman**	*Optimum XY determination for refraction analysis with the Generalised Reciprocal Method using image processing* **D. Palmer, H. Zheng**
	Geophysical modelling of structure and tectonostratigraphic history of the Longford Basin, Northern Tasmania **N. Direen, D.E. Leaman**	*Applications of airborne gamma-ray spectrometry: some Canadian examples* **R. Hetu**	*DIGHEM applied to salinity studies* **M. Hallett, S. Kilty, P. Jackson**
	Low-frequency seismic and transport properties of cracked and fluid-saturated crustal rocks: a laboratory study **C. Lu, I. Jackson**	*Spectral gamma-gamma logging in ore delineation and grade estimation* **C.J. Mwenifumbo**	*The application of radiometric data to soil mapping* **K. Slater, K.L. De Plater**
	Does the in-situ stress field control the orientation of open natural fractures in sub-surface reservoirs? **R.R. Hillis**	*Automatic depth estimation in regional magnetic surveys: a case study from North West Victoria* **D.H. Moore, R. Twyford, Z. Shi, A. Willocks**	*Magnetotelluric analysis: best 2-D strike direction and principal impedances* **F.E.M. Lilley**
	Basins of western Tasmania from shelf to abyssal plain: new geophysical data, new maps **P.J. Hill, N.F. Exon**	*Integrated geological and geophysical inversion* **S.M. Farrell, M.W. Jessell, T.D. Barr**	*Terrain corrections are critical for airborne gravity gradiometer data* **J. Chen, J. Macnae**
	Structural imaging around carbonate platforms: a case study **A.V. Strudley**	*An atlas of the potential-field response of geological structures* **M.W. Jessell**	*RINVERT for Windows software for the interpretation of resistivity soundings* **N.P. Merrick, E. Poezd**
	How to quantify the quality of seismic data **L. Peardon, I. Scott**	*Preliminary structural interpretation of aeromagnetic data, Maun, Botswana* **T.H. Ngwisanyi, W.E. Wightman**	*Palaeomagnetism, magnetic petrophysics and magnetic signature of the Porgera Intrusive Complex, PNG* **P.W. Schmidt, D.A. Clark, K.L. Logan**
	Offshore Southeast Asia: comparative regional assessment with modern non-exclusive seismic data **R. Fainstein, P. Davey**	*Inversion of controlled source EM apparent resistivity over layered earth* **I. G. Roy, U. C. Das**	*Seismic method application for gas field development: a case study in Pantai Pakam Timur area, Northern Sumatra Basin* **W. Sadirsan**
	Geophysics in water resource investigations **G. Humphreys, D. Chin, P. Jolly**	*Ground Infrared Thermometry (GIRT) in the determination of subsurface coal fire* **I. G. Roy, G. Sharma, K. Chakvabarty**	*Modern marine 3-D seismic acquisition: technical considerations* **C. Walker**
1445	*Afternoon Tea*	*Afternoon Tea*	*Afternoon Tea*
	Session 7 Non-Seismic Methods for Exploration Chaired by N. Moriarty and J. Montalbetti	**Session 7 Minerals Case Histories/Interpretation** Chaired by K. Logan and D. Robson	**Session 7 Coal Geophysics** Chaired by R. Huber
1530	*A new regional exploration method for hydrocarbon alteration plumes: the ALTREX method* **R. Smith, J. Rowe**	*The application of geophysics to iron ore mining in the Hamersley Basin, Western Australia* **A. Butt, M. F. Flis**	*Coalfield structure and intrusion mapping by helicopter magnetics* **M.J. Smith, R.J. Henderson, W. Stasinowsky**
1600	*High resolution aeromagnetic and gravity surveys used to highlight basin geometry and structure* **B. Mullard, D. Pratt**	*The application of ground electrical techniques to iron ore exploration* **P. Hawke, M.F. Flis**	*High resolution seismic survey for shallow coal exploration using a high frequency electromagnetic vibrator and high sensitivity geophones* **O. Nakano, E. Ishii, O. Dixon, Y. Ashida**
1630	*Application of magnetic methods to deep basin structures* **D.E. Leaman**	*Some geophysical applications for data classification* **K. Schmidt, D. Gamble**	*Shear-wave splitting analysis of multi-offset coal VSPs in the Bowen Basin* **B. Suthers, S. Hearn**
1700	*A regional gravity and magnetic study of the Malay Basin* **C. Foss, M.Ab. Ghani**	*Interpretation and modelling, based on petrophysical measurements of the Wirrda Well potential field anomaly, South Australia* **L. Vella**	*Application of GPR in open pit coal mines for mapping of overburden, seam thickness and guidance of continuous miners* **R. Yelf**
1730-1800	Time for visiting Exhibition in Hall 5	Time for visiting Exhibition in Hall 5	Time for visiting Exhibition in Hall 5

1830 CONFERENCE HARBOUR DINNER CRUISE

Wednesday 26 February 1997

* Presenting author underlined

	Stream 1	Stream 2	Stream 3
0830	Exhibition Opens		
	STREAM 1 - AUDITORIUM SOUTH **Session 8 Seismic Modelling/AVO** Chaired by B. Smith and J. Mebberson	**STREAM 2 - MEETING ROOM 3** **Session 8 Government Initiatives to Exploration Asia Pacific** Chaired by M. Smith and R. Rajagopalan	**STREAM 3 - MEETING ROOM 2** **Session 8 IP/Borehole Logging** Chaired by S. Webster and E. Tyne
0830	*2.5-D acoustic wave modelling in the wave number-frequency domain* **S. Cao, S. Greenhalgh**	*The role of government in the exploration kitchen: leavening the mix without spoiling the dough* **KEYNOTE SPEAKER: Dr Garry Lowder, Director General NSW Department Mineral Resources**	*New applications of borehole geophysical logging in mining and mineral exploration* **G.R. Selfe**
0900	*Poisson's ratio contrast and AVO indicators: model study* **B. Yang, J.K. Applegate**	*The NSW Government's Discovery 2000 Geophysical Surveys and their effect on exploration* **D.F. Robson, R. Spencer**	*Taking downhole EM underground, at Hill 50 decline, Mt Magnet, Western Australia* **L. Vella**
0930	*Fracture detection using P-wave AVO measurements* **S.V. Tadepalli, J.A. McDonald, K.K. Sekharan, R.H. Tatham**	*A new era: collaborative geological and geophysical mapping* **N. D. Watson, M. T. C. Leys, T. A. Macklin, D. F. Robson**	*Development of the IP tomography system and field testing in the Seta area, Hokkaido, Japan* **E. Arai**
1000	*Morning Tea*	*Morning Tea*	*Morning Tea*
	Session 9 Petroleum Exploration Chaired by J. Mebberson and B. Smith	**Session 9 Government Initiatives to Exploration Asia-Pacific** Chaired by S. Rajagopalan and E. Tyne	**Session 9 CRC-AMET Research Workshop** Chaired by B. Spies
1030	*Synchronous interval analysis - a possible approach to the seismic mapping of sequence bound lateral lithology changes* **J. W. Chiupka, L. Thomas, M. W. Wallace**	*Regional surveys in Victoria: experiences and lessons* **A. J. Willocks**	*CRC-AMET: The First Four Years* **KEYNOTE SPEAKER: Dr Brian Spies, Cooperative Research Centre for Australian Mineral Exploration Technologies**
1100	*Structural interpretation of a sedimentary basin using high-resolution magnetic and gravity data* **R.P. Iasky, A.J. Mory, S. I. Shevchenko**	*Eastern Victoria: a new exploration frontier ?* **B. Simons, A. Oranskaia, S. Haydon, P. McDonald, K Slater, R. Twyford, D. Bibby**	*CRC-AMET Research Programs: From Airborne to Ground Truth* **A. Raiche, J. Macnae, J.Slade, T. Munday**
1130	*Petroleum exploration in Proterozoic basins using potential fields data and stratigraphic coring* **G.M. Carlsen, S.I. Shevchenko**	*New data, new insights: an example from western Victoria* **D. Moore**	
1200	*Lunch*	*Lunch*	*Lunch*
	Session 10 Petroleum Exploration and Basin Structure Chaired by J. Mitchell and N. Jones	**Session 10 Government Initiatives to Exploration Asia Pacific** Chaired by A. Willocks and D. Howard	**Session 10 CRC-AMET Research Workshop** Chaired by B. Spies
1330	*The structure and evolution of the Bass Basin as delineated by aeromagnetic data* **P.J. Gunn, J. Mitchell, A.J. Meixner**	*Geological interpretation of high resolution airborne geophysical data in the Broken Hill region* **R. Haren, S. Liu, G. Gibson, D. Gibson, D. Maidment , P. J. Gunn**	*Future Trends and Directions in Mineral Exploration Geophysics* **Prof. Gordon West, Prof. Iain Mason, Dr Barry Drummond, Dr Ken McCracken, Prof. James Macnae, Mr Nick Sheard, Dr Tom Whiting, Mr Ken Witherly**
1400	*Structural style of the Warburton Basin and control in the Cooper and Eromanga Basins, South Australia* **X. Sun**	*Government sponsored geophysics in Tasmania* **R. G. Richardson**	**Other key scientists and explorationists**
1430	*Geophysical anomalies of the Central Belt in peninsular Thailand* **W. Lohawijarn, S. Phethuaiuk, S. Kaew-on**	*The basement elements of Tasmania* **T. Mackey, P.J. Gunn, R. Richardson, D. Seymour, D. McClenaghan, C.R. Calver, M. Roach, A.N. Yeates**	
1500	*Afternoon Tea*	*Afternoon Tea*	*Afternoon Tea*
	Session 11 Basin Structure and Depth to Basement Chaired by N. Jones and J. Mitchell	**Session 11 Government Initiatives to Exploration Asia-Pacific** Chaired by P. Gidley and A. Willocks	**Session 11 CRC-AMET Research Workshop** Chaired by B. Spies
1545	*Three-dimensional kinematic modelling of the magnetic field of the southern Joseph Bonaparte Gulf* **A. J. Meixner, P.J. Gunn**	*The contribution of airborne geophysics to mineral prospectivity in the New England Fold Belt* **P.R. Blake, C.G. Murray, M.A. Hayward, G.A. Simpson, R. Huber**	*Future Trends and Directions in Mineral Exploration Geophysics* **Panel Discussion and Workshop Summary**
1615	*Automatic interpretation of magnetic data using the Source Parameter Imaging method* **R. Smith, J. Thurston, D. Daggar, E. Tyne**	*Geophysical signatures of the South Australian mineral deposits* **M. Dentith, T. Crabb**	**Session 11a ARC-Funded Research: Support for Geophysics Research** **KEYNOTE SPEAKER: Prof. Norm Uren, Curtin University**
1645	*Automatic depth to basement analysis in modelled regions of complex structure* **E. Harris, M. Jessell, T. Barr**	*South Australian Exploration Initiative: Stardate 1997* **C. D. Cockshell**	**Panel Discussion**
1730-1800	Time for visiting Exhibition in Hall 5	Time for visiting Exhibition in Hall 5	Close of Panel Discussion
1900 for 1930	**CONFERENCE DINNER - BANQUET HALL - Sponsored by Digicon Geophysical Ltd**		

Thursday 27 February 1997

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0830 Exhibition Opens

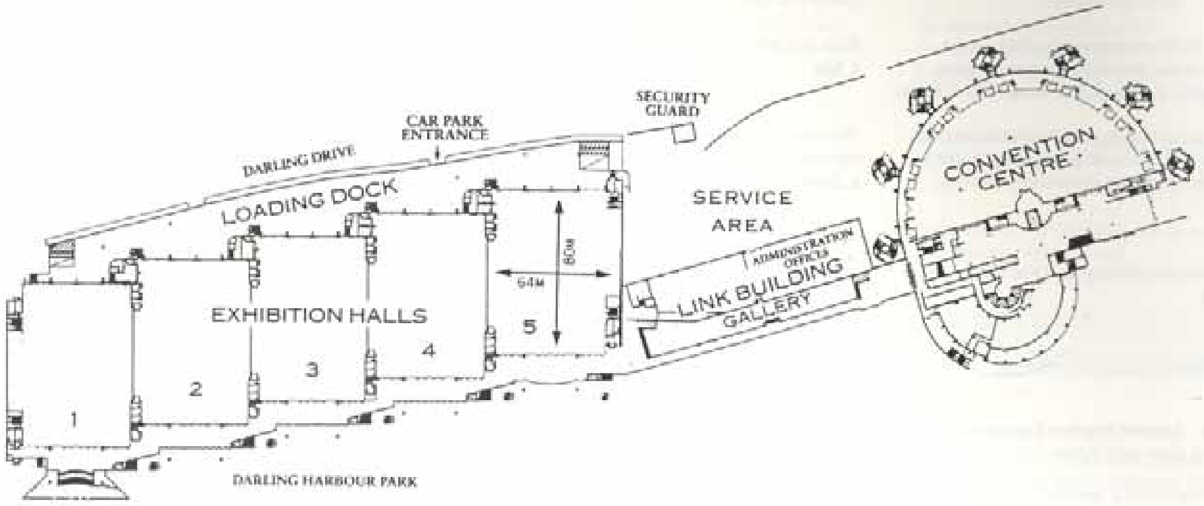
Time	STREAM 1 - AUDITORIUM SOUTH	STREAM 2 - MEETING ROOM 3	STREAM 3 - MEETING ROOM 4
0830	**Session 12 Regional and Basin Studies** Chaired by D. Palmer and S. Hearn	**Session 12 Airborne EM** Chaired by M. Asten and N. Sheard	**Session 12 Forensic Geophysics and Radar** Chaired by T. Pippett and R. Henderson
	The Otway Basin continental margin (OCM) transect: crustal architecture from wide-angle seismic profiling **D. Finlayson, L. S. Lukaszyk, E. C. Chudyk, C. D. N. Collins**	*Single pass airborne multi-sensor surveying using the DIGHEM system* **S. Kilty**	*Multi-disciplinary studies in the search for graves* **KEYNOTE SPEAKER: Clark Davenport, NecroSearch International** **Sponsored by: M.I.M. Exploration Pty Ltd**
0900	*The Maastrichtian breakup of the Otway Basin margin: a model developed by integrating seismic interpretation, sequence stratigraphy and thermodynamic studies* **C. Lavin**	*The effect of uncertain or changing system geometry on airborne transient electromagnetic data* **A. Green, Z. Lin**	*The application of GPR to large scale production mining of alluvial gravels, bauxite and laterite deposits* **R. Yelf**
0930	*Regional geophysics and geology of King Island* **M.J. Roach**	*GEOTEMDEEP - Technical advances in deep exploration: Australian case studies* **S. Jaggar, S. Thomson, S. Collins**	
1000	*Morning Tea*	*Morning Tea*	*Morning Tea*
	Session 13 Specialist Petroleum Exploration Tools Chaired by S. Hearn and D. Palmer	**Session 13 Airborne and Ground EM** Chaired by M. Flis and M. Asten	**Session 13 Petrophysical Studies** Chaired by P. Hatherly
1030	*STRATDAT and RESFACS: relational databases as tools in petroleum exploration* **G. Moss, D. Rowland**	*Display of airborne electromagnetic data as multispectral images* **A. Green**	*Scale-dependent electrical phenomena in sulphide rocks- new methods and techniques* **M. Roach, R.J.G. Lewis, W. Jablenski**
1100	*Fluid inclusion record of early oil preserved at Jabiru field, Vulcan sub-basin* **S. George, M. Lisk, P.J. Eadington, F.W. Krieger, R.A. Quezada, P. Greenwood, M.A. Wilson**	*Fast approximate inversion of TEM data* **E.M. Stolz, J. C. Macnae**	*Magnetic petrology of granitoids: implications for exploration and magnetic interpretation* **D.A. Clark**
1130	*Modelling the contemporary stress field and its implications for hydrocarbons* **R.R. Hillis, M. Sandiford, D.D. Coblentz, S. Zhou**	*Time domain EM for environmental targets* **T. Pippett, B. Bulman**	*An iterative method to calculate self-demagnetisation for 3-D magnetic bodies, with application to the Osborne Cu-Au deposit* **K. Logan, R. Angus**
1200	*Lunch*	*Lunch*	*Lunch*
	Session 14 Porosity Determination Chaired by G. Gumley	**Session 14 EM and Electrical Modelling** Chaired by P. Fullagar and L. Vella	**Session 14 Geophysical Software Developments** Chaired by D. Pratt and M. Russell
1330	*Velocity/porosity transforms in gas bearing sandstones: field data versus empirical equations* **A. Khaksar, C. M. Griffiths, (M. R. Rezaee)**	*3-D EM modelling in mining geophysics: when, where and how do we want it?* **M. Asten**	*Management of software for geophysical exploration* **K. Witherly**
1400	*Estimation of effective porosity: Tirrawarra Sandstone, Cooper Basin, South Australia* **M. R. Rezaee, N.M. Lemon**	*Fast and stable method for 3-D modelling of electromagnetic data* **B. Sh. Singer, E. B. Fainberg**	*A case study on geophysical gridding techniques: INTREPID perspective* **D. FitzGerald, N. Yassi, P. Dart**
1430	*Determination of permeability transforms from geophysical logs using statistical pattern recognition* **Y. Zhang, P.A. Lollback, H.A. Salisch**	*The electrical potential arising from a point source in an arbitrarily anisotropic half-space with regolith cover* **P. Li, N. Uren**	*A method for calculating equivalent layers corresponding to large aeromagnetic and radiometric grids* **P.J. Gunn, R. Almond**
1500	*Afternoon Tea*	*Afternoon Tea*	*Afternoon Tea*

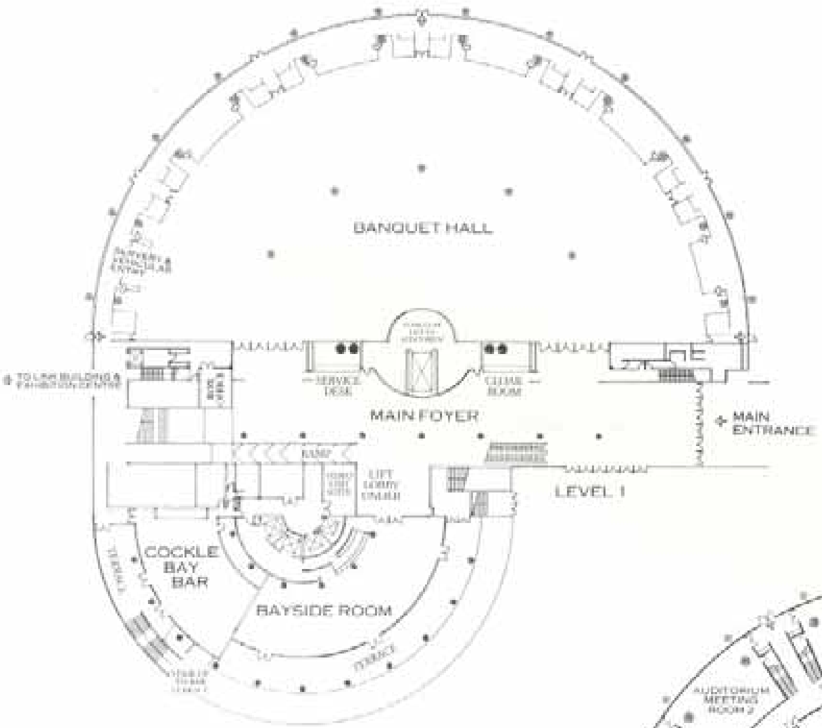
1545 **EXHIBITION CLOSES**

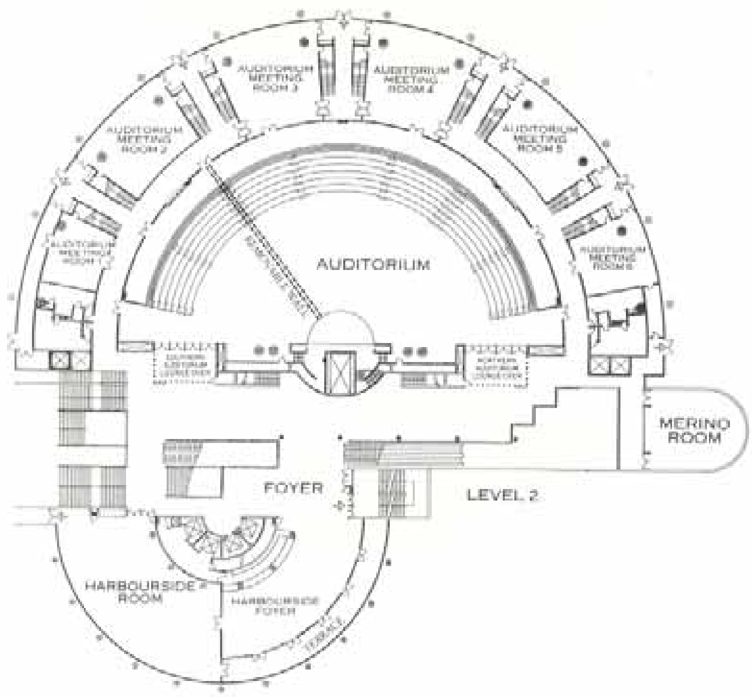
1630 **CLOSING CEREMONY AND AWARDS FOR BEST PRESENTATION, BEST POSTER AND BEST EXHIBITOR - AUDITORIUM SOUTH**

1700 **FAREWELL COCKTAIL PARTY - HARBOURSIDE ROOM - Sponsored by Schlumberger**

Sydney Convention & Exhibition Centre Floor Plans







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Calendar Clips

March 7, 1997
Downhole Geophysics in mining
Kalgoorlie WA
Contact Corene Haffner Public Relations
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March 12-14, 1997
The AusIMM Annual Conference
Ballarat VIC
Contact R.M. Croggon, Univ. of Ballarat
Tel: +61-53-279 113

April 6-9, 1997
Sinkholes and Environmental Impacts of Karst
Springfield, MO. USA
Contact Dr. Barry F. Beck
P. E. LaMoreaux and Associates Inc.
Tel: +1 423 483-7483

April 7-10, 1997
Optimizing and Whittle
Optimization of Mine Design and Planning
Hyatt Regency, Perth WA
Contact David Whittle
Whittle Programming Pty Ltd,
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July 7-10, 1997
Istanbul '97 International Conference and Exhibition
Istanbul, Turkey. Sponsored by SEG, Chmb. of Geoph. Engineers of Turkey and EAGE
Contact Oz Yilmaz, Paradigm Geophysical Corp.
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Notice of Annual General Meeting – ASEG

The Annual General Meeting of the Australian Society of Exploration Geophysicists will be held at Oxley's on the River, Coronation Drive, Brisbane on 29th April 1997 at 6.00 pm.

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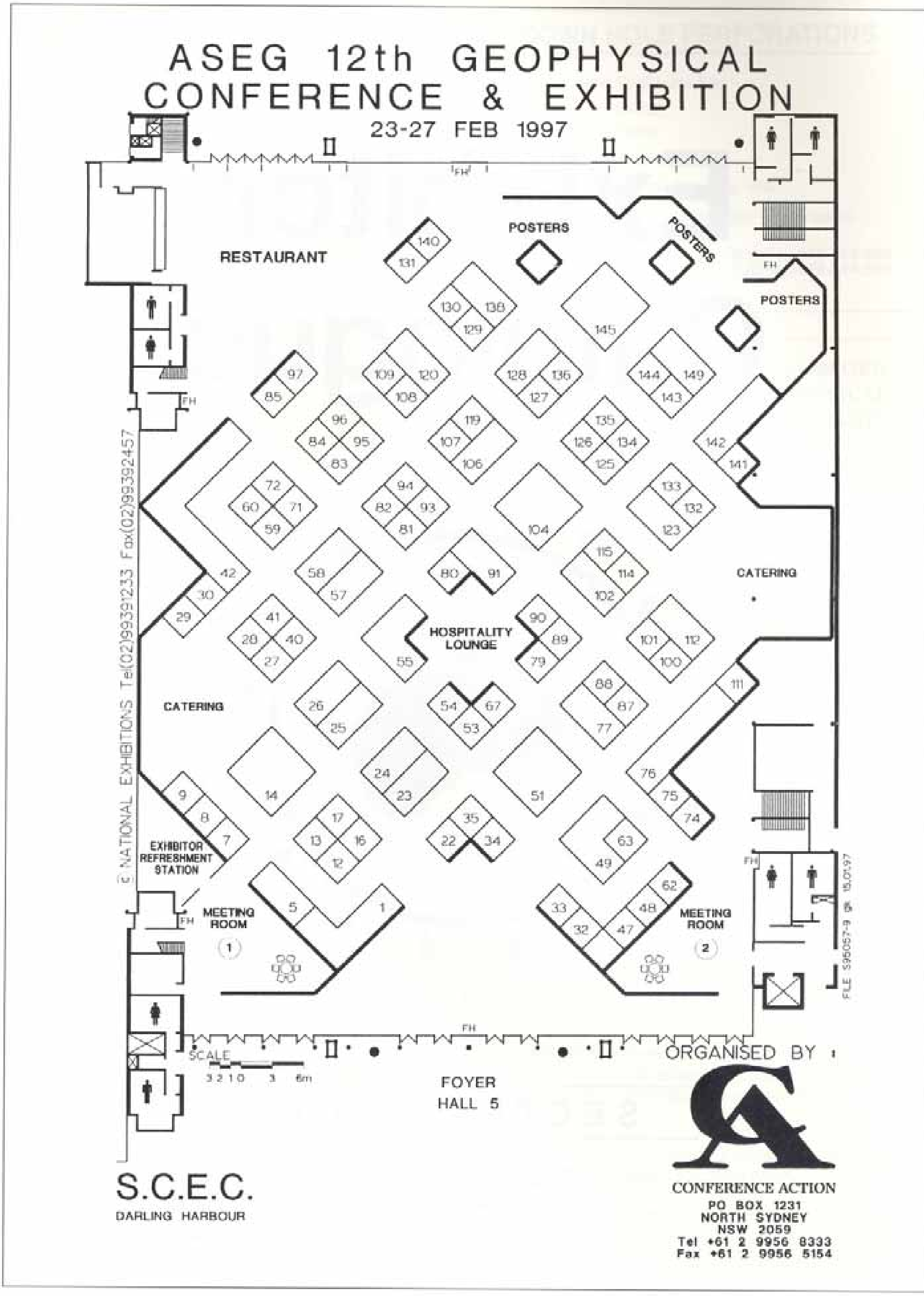
Exhibitor Catalogue

SECTION TWO

Trade Exhibition and Floorplan



ASEG 12th GEOPHYSICAL CONFERENCE & EXHIBITION
LIST OF EXHIBITORS AND BOOTH NUMBERS

Organisation	Booth Number
ABEM Instruments	48
ACIRL-DMT	72
Aerodat Inc	7
Auslog Pty Ltd/Velseis Pty Ltd	142
Australian Geological Survey Organisation	1
Australian Geophysical Surveys	95
Australian Mineral Foundation	100
Australian Society of Exploration Geophysicists	100
C Vision Pty Ltd	63
Carson Services Inc, Aerogravity Division	108
CGG Borehole Services Division	32
CogniSeis Development	138
CSIRO - Division of Exploration & Mining	28
Curtin University ot Technology	131
Dept of Mines and Energy QLD	143
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Engineering Computer Services Pty Ltd	125
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MALA Geo Science	47
Marschall Acoustics Instruments Pty Ltd	115
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Exhibition Hours

Monday 24 February 1997	**0830-1800 hours**
Tuesday 25 February 1997	**0830-1800 hours**
Wednesday 26 February 1997	**0830-1800 hours**
Thursday 27 February 1997	**0830-1545 hours**

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Fax: 61 9 479 7361
Contact: Neil Goodey

UTS Geophysics provide a specialised service in the acquisition of ultra-detailed airborne surveys.

The unique approach of UTS has been to use specialised aircraft in providing the highest detailed data to ensure the greatest benefit to the mineral exploration programme is achieved.

The company operate two specialised low level survey planes and two helicopter systems providing both magnetic and radiometric data.

The specialised service is complemented by high levels of operational safety and quality control.

Data acquisition is complemented by quality mapping and image processing facilities. UTS encourage an interactive approach to survey design and selection of the correct processing products

WORLD GEOSCIENCE CORPORATION LTD BOOTH 54
65 Brockway Road, Floreat,
WA, 6014, AUSTRALIA
Tel: (09) 273 6400
Fax: (09) 273 6466
Contact: Dr Michael Jones

The WGC Group is the world's largest airborne geophysical survey operator with companies in Perth (WGC headquarters), Sydney (Austirex), Toronto and Vancouver, Canada (Questor), Houston, USA (UK)), Bhubaneswar, India (Crown Technical Services) and Santiago, Chile. Overseas offices and agencies exist in Botswana, Oman, Malaysia, Philippines, Indonesia and Bolivia and more are planned as the international scope of operations expands. In 1994/95 WGC had a turnover in excess of $45 million and employs approximately 250 people world-wide.

Services are provided in earth resource mapping, principally using high resolution magnetic, radiometric and electromagnetic measurements taken from low flying aircraft (and helicopter) mainly for mineral and hydrocarbon exploration but encompassing groundwater and geothermal exploration, coastal resource mapping and environmental studies.

Other Sponsors

GEO INSTRUMENTS PTY LTD. **BOOTHS 16, 23**

348 Rocky Point Road, Ramsgate, NSW 2219
Tel: +61 2 9529 2355
Fax: +61 2 9529 9726
E-mail: geoins1@ibm.net
Contact: Roger Henderson

Geo Instruments is a leader in the Australian and Asia-Pacific regions in the sales, rental and servicing of geophysical equipment and software. A large number of overseas manufacturers are represented, in order to provide a wide range of different geophysical equipment. Geo Instruments also manufactures hand-held, magnetic susceptibility and conductivity meter's, and is currently designing new models of the SIROTEM™ TEM system for which it has the worldwide marketing rights. These instruments can be seen on our booth. Geo Instruments also operates a helicopter geophysical division providing surveys in magnetics and radiometrics.

GEOTERREX PTY LTD **BOOTH 49**

7-9 George Place, Artarmon (Sydney), NSW, 2064
AUSTRALIA
Tel: (02) 9418 8077
Fax: (02) 9418 8581
Contact: Peter Jackson

Geoterrex Pty Ltd is an Australian-based world leader in airborne and ground geophysics providing a fast and cost effective service from data acquisition and processing through to sophisticated image processing and interpretation.

Our services include both fixed wing and helicopter EM systems. The new addition to the GEOTEM system, $GEOTEM_{DEEP}$ has been designed to explore beneath conductive cover whilst the DIGHEM heli-EM system provides both excellent conductor detection as well as high resolution resistivity mapping capabilities. Other systems include aeromagnetics and radiometrics, and a wide range of ground geophysical services including GPS positioned Gravity, EM, IP/Resistivity, Surveying and downhole surveys.

Geoterrex is the exclusive agent in Australia for the following instrument and equipment manufacturers: GEONICS, Abem Instruments, and MALA Geoscience.

KEVRON GEOPHYSICS PTY LTD **BOOTH 22**

PO Box 6325, East Perth 6822
Tel: (09) 325 2877
Fax: (09) 481 0323
Contact: Kevin Radford

Kevron Geophysics Pty Ltd, specialising in the acquisition and processing of high resolution aeromagnetic and multi-channel radiometric data, is one of Australia's foremost airborne geophysical survey companies.

Three of the company's four Aero Commander "Shirke" 500S aircraft are configured as magnetic gradiometer systems with wingtip sensors measuring the horizontal gradient of the earth's magnetic field. Proprietary software incorporates the gradient measurements into the gridding algorithm, providing significantly improved resolution over single sensor data presentations.

Based in Perth, Western Australia, Kevron Geophysics has operational experience throughout Australian and internationally. Kevron Geophysics has developed an enviable reputation as a supplier of high quality airborne geophysical surveys at very competitive rates. Its impressive client list includes the major exploration companies as well as Federal and State government departments.

NSW DEPARTMENT OF MINERAL RESOURCES **BOOTH 102**

P O Box 536 St. Leonards, NSW, 2065, AUSTRALIA
Tel: (02) 9901 8356 or (02) 9901 8342
Fax: (02) 9901 8256
Contact: Jamie McIntyre or Dave Robson

During the first two years of this Department's 6 year DISCOVERY 2000 programme, around $9 million has been spent on high-resolution airborne magnetic, radiometric and gravity surveys, over both mineral and petroleum prospective areas. Seismic reflection work has also been carried out over some of the petroleum prospective areas. World-class data packages are now available over the 26% of the State covered by this work.

Close tie line spacing and the use of GPS satellite positioning have helped ensure the very tight noise envelope and the high positional accuracy of the airborne data sets.

The mineral prospective areas chosen are areas with shallow cover, which particularly benefit from high quality regional geophysical coverage. These areas were flown with a 250 metre interline spacing and a terrain clearance of 60 metres.

The petroleum prospective areas were flown with a 400 metre interline spacing and a terrain clearance of 80 metres. Images from all the data sets are on display in the Department's booth, and workstations are available for manipulation and display of the data sets on screen.

TESLA-10 PTY LTD **BOOTH 55**

3 Fox Close, Kariong, NSW, 2250, AUSTRALIA
Tel: (043) 400 122
Fax: (043) 400 155
Contact: Brett Merritt

Tesla-10 Pty Ltd is the core company of the Tesla Geophysical Group. We offer a complete range of ground survey, equipment rental and quality data processing services.

Tesla's airborne acquisition is by Tesla Airborne Geoscience Pty Ltd, Australia's only Quality Assured airborne survey company (ISO 9002). Tesla's products include fixed-wing and helicopter acquired: low-noise magnetics, high-quality 256-channel radiometrics and detailed terrain models.

Tesla has offices in Western Australia, New South Wales, London and Jakarta. We employ eight geoscientists and three programmers, keeping us at the leading edge of geophysical data acquisition and processing.

Exhibitors

ACIRL/DMT **BOOTH 72**

1 Acirl St, Riverview (PO Box 242), Booval,
Qld. 4303 (4304) AUSTRALIA
Tel: 3282 2011
Fax: 3816 1107
Contact: Terry O'Beirne / Ulrich Ruppel

DMT-GeoTec, established 130 years ago, is one of the largest private geo-scientific facilities in Germany. It specialises in development and production of geotechnical systems and geophysical services.

DMT-GeoTec is active in the following:

- Seismic exploration including shall marine seismic analysis
- Geology and Borehole Geophysics
- Potential Methods and Monitoring
- Geo-Information Systems and Cartography
- Geo-Instruments

Our range of products include:

- GYROMAT-2000 gyrotheodolite
- ROTLEVEL inclinometer
- SUMMIT Seismic Telemetry Acquisition System
- MoSDaS seismic monitoring system
- Borehole Shuttle for deviated boreholes
- RESECS DC-Resistivity and Electrode Control System
- DMT-CoreScan System for digital optical core image analysis

DMT-GeoTec can provide a full range of products and services in Australia through its representative ACIRL and its partners.

AERODAT INC. BOOTH 7

6300 Northwest Drive, Mississauga, Ontario, L4V 1J7, CANADA
Tel: 1 905 671 2446
Fax: 1 905 671 8160
Contact: Mario Steiner

Aerodat was founded in 1969 to provide airborne geophysical surveys to the mining exploration industry. Today, Aerodat is a world leader in airborne geophysics with world wide operations in mineral, hydrocarbon, environmental and engineering applications. A strong commitment to research and development has kept Aerodat on the leading edge of sensor and data processing technology.

Surveys are carried out from helicopter or fixed wing platforms. Helicopter survey systems include frequency domain electromagnetics (HEM), total field and gradient magnetics, radiometrics and VLF-EM. Fixed wing systems include magnetics, gravity, radiometrics and VLF-EM.

Aerodat has developed and implemented the software required for the processing, presentation and interpretation of all types of geophysical data.

AUSLOG PTY LTD, BOOTH 142
VELSEIS PTY LTD,
VELSEIS PROCESSING PTY LTD

PO box 125, Sumner Park, Qld., 4074, AUSTRALIA
Tel: (07) 3376 5188
Fax: (07) 3376 6626
Contact: Bill Smith

The VELSEIS GROUP provides a large range of services and products to the mining and oil industries in Australia and overseas. The group operates from its own office and factory facility situated in Sumner Park, Brisbane and has a regional office in Thailand.

VELSEIS PTY LTD offers high resolution seismic data acquisition services and designs and manufactures specialised instrumentation.

AUSLOG PTY LTD manufactures and sells geophysical logging equipment and provides logging and rental services.

VELSEIS PROCESSING PTY LTD processes seismic data by utilising the latest workstation based, interactive seismic data processing techniques.

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION BOOTH 01

GPO Box 378, Canberra, ACT, 2902, AUSTRALIA
Tel: (06) 249 9263
Fax: (06) 249 9982
Contact: Stephen Ross

AGSO's primary mission is to build a vigorous, client-driven national geoscientific mapping effort to encourage economically and environmentally sustainable management of Australia's minerals, energy, soil and water resources. It is the national leader in geoscientific mapping and information services.

AGSO provides the geoscientific knowledge base to underpin government, industry and public decision-making, by satisfying customer needs for high quality geoscience information and innovative research, in relation to sustainable management of Australia's natural resources and environment.

AGSO, which was established in 1946 as the Bureau of Mineral Resources, Geology and Geophysics (BMR), is part of the Commonwealth Department of Primary Industries and Energy.

AUSTRALIAN GEOPHYSICAL SURVEYS PTY LTD BOOTH 95

3 Baron Way, Jandakot Airport, WA, 6164, AUSTRALIA
Tel: (09) 414 1266
Fax: (09) 414 1277
Contact: Yoke or Martin

Australian Geophysical Surveys currently operates two twin engined aircraft and a Bell-206 helicopter from their base at Jandakot Airport, Western Australia. Their PC based data acquisition system utilises a CS2 Caesium magnetometer with real-time compensation and an Exploranium spectrometer system.

The company has built up a steady base of customers who appreciate the expertise and reliability of a small but dedicated team who provide data quality well above the industry standards.

This ongoing demand for excellence has influenced the company's decision to establish and maintain a BVQI certified quality system in accordance with AS/NZS/ISO 9002 : 1994 - Quality Systems (Accreditation October 1996).

AUSTRALIAN MINERAL FOUNDATION BOOTH 100

3 Conyngham Street, Adelaide, SA 5065, AUSTRALIA
Tel: 08 8379 0444
Fax: 08 8379 4634
Contact: Maureen Blake

Australian Mineral Foundation
Celebrating 25 years as Australia's premier provider of applied training and information to the mining and petroleum industries.

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AESIS - the national database of Australian published and unpublished literature. Free searches at the Conference.

The AMF Bookshop - Australia's leading technical bookshop. Huge range of industry books on display - come and buy or browse

C VISION **BOOTH 63**
Suite 320, 185 Elizabeth Street, Sydney, NSW 2000
AUSTRALIA
Tel: +612 9283 4000
Fax: +612 9261 4854
Contact: Shenny Bhanji, Mr. Noel Merrick

C Vision specialises in commercial software development that integrates new and emerging technologies for the scientific and engineering industry. Our mission is to provide scientists, engineers and technocrats with exciting new software products and services that are practical, innovative and economical. We use object technology for development and undertake research into the design of GUI's that are intuitive and provide enhanced visual learning environments. C Vision's software catalogues currently consists of one of the largest collection of commercial scientific and engineering software in Australia.

C Vision also specialises in the provision of consulting services for water resource development, and modelling solutions for environmental and ecosystem management. International experience of the C Vision team includes consultancies, projects, research, software development and training in Australia, Papua New Guinea, Thailand, Tanzania, Russia, USA, Canada, India, Pakistan, and Middle East with extensive experience working with government and private sector companies.

CARSON SERVICES INC. AEROGRAVITY DIVISION **BOOTH 108**
32H Blooming Glen Rd., PA, 18944, USA
Tel: 1 215 249 3535
Fax: 1 215 249 1352
Contact: Michael P. Mueller

Airborne gravity and magnetic data acquisition, processing and interpretation services. Airborne three-axis gravity meters. Twin Otter fixed-wing aircraft and helicopters are survey platforms.

CGG BOREHOLE SERVICES DIVISION **BOOTH 32**
Unit 3,9 Sheen Place,Bayswater, WA 6053, AUSTRALIA
Tel: 09 377 2028
Fax: 09 377 2737
Contact: D J Thorne

CGG Borehole Services Division has the reputation for being the experts in acquiring and processing borehole seismic data - from simple checkshot surveys to Vertical Seismic Profiles (VSPs),Vertical Incidence surveys and walkaway surveys. Dual-string geophones are now standard for most offshore wells which has resulted in rig time savings of approximately 45%. In-field processing means that results are available within 30 minutes of completing acquisition. New innovations are the soon to be released 12 string SST-500 system and the Pipeseis technique of running a geophone inside drillpipe to record data inside horizontal wells. Visit stand 32 for more details.

COGNISEIS DEVELOPMENT, INC **BOOTH 138**
35 Jalan Pemimpin,
#05-02 Wedge Mount Industrial Bldg.
SINGAPORE 577176
Tel: (65) 258-3414
Fax: (65) 258-3077
Contact: Gareth Taylor

CogniSeis develops geoscience software for the exploration and production industry. Products include Focus3D/2D, Geosec3D/2D, VoxelGeo, SeisX, WellSystems, TerraCube and the ULA. CogniSeis integrates and sells systems consisting of processing and interpretation software together with special computing equipment. CogniSeis provides these systems to oil companies, geophysical contractors, universities, and governmental agencies. Geophysicists and geologists use these systems to process and interpret various kinds of data in order to arrive at a consistent model of the subsurface. The subsurface model is used to find new oil and gas deposits and to improve production from known oil and gas reservoirs. In addition to system sales, CogniSeis also provides complete software and hardware support, installation, training, consulting, and on-site personnel.

CSIRO DIVISION OF EXPLORATION AND MINING **BOOTH 28**
PO Box 136, North Ryde, NSW, 2113, AUSTRALIA
Tel: (02) 9887 8757
Fax: (02) 9887 8921
Contact: Judy Thomson

The CSIRO Division of Exploration and Mining addresses the research and development needs of the Australian mining industry across the spectrum from exploration, through resource delineation and mining, to minesite rehabilitation. The Division works closely with industry to identify opportunities and deliver innovative solutions through outstanding science and engineering.

In exploration geophysics, the Division is a major participant in the Cooperative Research Centre for Australian Mineral Exploration Technologies. The focus of CRC AMET is to develop dramatically improved electromagnetic methods for use by the Australian mineral exploration industry. The main emphasis of this work is on cost-effective airborne systems for geological and regolith mapping and for detection of deeply-buried ore deposits.

DEPARTMENT OF MINES AND ENERGY, QUEENSLAND **BOOTH 143**
61 Mary Street, Brisbane, Qld. 4000, AUSTRALIA
Tel: (07) 3237 1420
Fax: (07) 3229 7770
Contact: Jim Beeston

GEOMAP 2005 is a **Department of Mines and Energy** (DME) program designed to ensure that all maps of significant prospective areas of Queensland will be upgraded within a short time frame, with the year 2005 set for completion. Airborne geophysical data acquisition is an important contributor to the GEOMAP 2005 program, involving funding of $1.5 million a year over the next three years.

Under the Geophysical Data Initiative (GDI), the Department is extending data acquisition to cover the Drummond Basin in central Queensland; scheduled to begin in April this year.

320 000 line kilometres of data from the recently-completed AIRDATA airborne magnetic and radiometric survey project are now available.

DESMOND FITZGERALD AND ASSOCIATES **BOOTH 129**
Unit 2, 1 Male St. Brighton Vic. 3186, AUSTRALIA
Tel: +61 3 9593 1077
Fax: +61 3 9592 4142
e-mail: sales@dfa.com.au or www.dfa.com.au
Contact: Des FitzGerald, James Heywood

Desmond Fitzgerald and Associates (DFA) have been providing specialist services to the mining and exploration industry for approx. 20 years. In 1992 DFA released a world class geophysics processing and interpreting tool, Intrepid. The system was developed in conjunction with local and international industry partners.

The Intrepid software is a system that combines image processing with line, point and polygon processing. The system provides data integration, analysis and display, and is built with modern object oriented portable technology.

DFA's Geophysical Data Processing services utilise the advanced capabilities of Intrepid and include processing of aeromagnetic, magnetic and gravity raw data, and calibration of 256 channel radiometric data.

DESTINY DRILLING OVERSEAS LIMITED — **BOOTH 41**

#525 700 6th Ave. S. W. Calgary, Alberta, T2P 0T8, CANADA
Tel: 1 403 237 6437
Fax: 1 403 233 8714
Contact: Howard Jackson

DESTINY is a seismic drilling contractor that specialises in remote area shot hole drilling services. The company designs and builds a wide variety of speciality drills that include man portable and helicopter portable units. With emphasis on safety, these drills have a proven track record for efficiency and productivity. In business since 1976, Destiny has a significant number of experienced personnel who have completed successful programs in Papua New Guinea, The Middle East, South America as well as Canada and the USA.

DOWNHOLE SURVEYS PTY LTD — **BOOTH 71**

11 Dugan St., Kalgoorlie, WA 6430, AUSTRALIA
Tel: (090) 218 015
Fax: (090) 912 012
Contact: Michael Ayris

Established in October 1989, **Downhole Surveys Pty Ltd** is a dynamic Western Australian based company utilising the latest technology in drill hole deviation and wireline logging equipment to provide a unique and essential service to the mineral exploration and geotechnical industries.

The services available include:

- Digital electronic multishot borehole surveying with surface readouts.
- Non magnetic MAXIBOR borehole surveys inside drill rods in magnetic formations or for directional steering during drilling.
- Triaxial magnetometer logging and offhole magnetic modelling packages.
- Sale of REFLEX surveying instruments and software.
- Physical property wireline logging including formation density, natural gamma, calliper and dual induction (formation conductivity).
- Acoustic televiewer data acquisition, data processing and interpretation.
- Log interpretation including dry density index and gross tonnage index.

EARTH RESOURCE MAPPING — **BOOTH 145**

Level 2, 87 Colin Street, West Perth, WA 6005 AUSTRALIA
Tel: (09) 388 2900
Fax: (09) 388 2901
Contact: Karen Stuart

ER Mapper is an advanced digital image processing and remote sensing system created to help earth scientists integrate, enhance, visualise, and interpret their geographic data. In contrast to conventional "disk-to-disk" image processing products, ER Mapper features a breakthrough that allows truly interactive "real time" integration and processing of data. The point-and-click graphical user interface streamlines complex image processing tasks to provide a fast, flexible "what if" tool for earth scientists in all application areas. ER Mapper is available for SGI, Sun, Windows 95 and Windows NT.

ER Mapper 5.5 introduces multiple surfaces and 3D functionality on all platforms. Please check out http://www.ermapper.com.

EARTHWARE SYSTEMS (AUSTRALIA) PTY LTD — **BOOTH 12**

PO Box 704, Macquarie, ACT, 2614, AUSTRALIA
Tel: (06) 251 3511
Fax: (06) 251 3581
Contact: Dave Johnson

EarthWare Systems (Australia) Pty Ltd provides consultancy services in the application of computing techniques to the geoscience community. Dave Johnson, Director of EarthWare Systems, has specialist expertise in the areas of three-dimensional visualisation, metadata directory applications and web-based information systems.

Australasian ImageNet Pty Ltd is a joint venture of Core Software Technology (Pasadena, USA) and EarthWare Systems which has been recently formed to promote ImageNet services and products. ImageNet provides a global distributed system for locating and acquiring geospatial data.

EarthWare Systems is the Australian distributor for Facet Decision Systems spatial spreadsheet software used in complex stakeholder modelling and decision support applications. EarthWare Systems also distributes the Fortner Research suite of visual data analysis software.

Further information can be found on the web at http://www.w3c2.com.au/earthware/ and http://www.ainet.com.au/.

ELECTROMAGNETIC INSTRUMENTS, INC. — **BOOTH 130**

1301 South 46th Street UCRFS #300 Richmond, California 94804, USA
Tel: 510 232 7997
Fax: 510 232 7998
e-mail: www.emiinc.com
Contact: Bob Osmond

ElectroMagnetic Instruments, Inc. (EMI) is a world leader in the development and manufacture of instrumentation utilised in imaging below the surface of the earth. Our instrumentation is employed in mineral, geothermal, petroleum and groundwater exploration.

The company specialises in ultra-sensitive magnetic sensors; magnetotellurics (MT); crosshole and single borehole electromagnetic systems; and custom R&D projects.

Products include: BF series of highly sensitive magnetometers and the MT-24, the world's first 24 bit magnetotelluric system.

ENCOM TECHNOLOGY PTY LTD — **BOOTH 106**

PO Box 422, Milson's Point, NSW, 2061, AUSTRALIA
Tel: (02) 9957 4117
Fax: (02) 9901 3121
Contact: Dave Pratt

Melbourne Office: PO Box 727, Richmond, Vic., 3121 Tel: (03) 9428 4088, Fax: (03) 9428 0470
Perth Office: PO Box 1572, West Perth, 6104
Tel: (09) 321 1788, Fax: (09) 321 1799

Encom Technology provides software, hardware and services to the mineral and petroleum exploration industry from its offices in Sydney, Melbourne and Perth. Our business units provide:
Software: ModelVision, EM Vision, NODDY, GPINFO, Earth Map
ER Mapper: distributor in NSW, ACT, VIC
Tape Services: Tape archiving, reformatting, rehabilitation, CD ROM writing and media
Data Services: petroleum and mineral permits, mineral deposits of Australia, ACRES, AUSLIG, SPOT, AGSO
Mapping: digitizing, colour scanning, data Reformatting, imaging, plotting
Encom Geoscience: integrated geological and geophysical interpretation projects

Computer Hardware: Silicon Graphics, PC, Novell, peripherals
Communications: multi-platform network and hardware support.

Encom's experienced team of geophysicists, geologists and software developers will complement your team.

ENGINEERING COMPUTER SERVICES PTY LTD **BOOTH 125**

PO Box 160, Bowral, NSW, 2576 AUSTRALIA
Tel: (048) 61 2122
Fax: (048) 61 3902
Contact: P. R. Hillsdon

ECS International Pty Ltd (ECSI) has recently been formed to continue the services of Engineering Computer Services Pty Ltd (ECS) to the Australian and international minerals and energy industries. ECS has been in business for over 30 years, and ECSI will build on this long history and associated client base. ECSI provides:

1. Processing of airborne geophysical data.
2. In-house consulting - from feasibility studies through to mine planning and scheduling.
3. Direct software sales and technical support of AGP and MINEX V.4.0.

ECSI support all these activities with offices in Bowral (Head Office), Denver (USA) and agents worldwide.

EXPLORANIUM **BOOTH 127**

264 Watline Avenue, Mississauga Ontario L4Z 1P4 CANADA
Tel: +(905) 712 3100
Fax: +(905) 712 3105
Contact: Ed McGovern

Exploranium designs and manufactures radiation detection systems for geophysical, environmental and industrial applications. The GR-820 Airborne Gamma-Ray Spectrometer is internationally recognised as the state of the art spectrometer for geophysical and environmental surveying. The company's geophysical product line also includes portable and vehicle mounted spectrometers, scintillometers and magnetic susceptibility meters. Exploranium's latest product, the GR-320 Spectrometer, designed for portable, land vehicle and small fixed and rotary wing aircraft applications, is one of the instruments being demonstrated at the company's booth.

FUGRO SURVEY PTY LTD **BOOTH 90**

18 Prowse Street, West Perth,
WA 6005, (PO Box 329, West Perth, WA 6872)
AUSTRALIA
Tel: +61 9 322 5295
Fax: +61 9 322 4164
Contact: Dianne Studman

Fugro Survey Pty Ltd is a high technology service company, with over 100 technical staff in the Perth headquarters.

Fugro's marine division specialises in geophysical, geotechnical and hydrographic surveys for pipeline and cable routes, port and harbour development, site surveys for rigs and seabed structures, marine minerals research, debris clearance and wreck search and environmental surveys.

OmniSTAR is a division of Fugro Survey that offers a range of differenential GPS products for it's clients, including OmniSTAR, OmniSTAR*plus*, GPSNet and AUSNAV*Gold*. The broadening of OmniSTAR's DGPS product line has allowed Fugro to offer subscribers more flexibility in choice of accuracy and application requirements.

Fugro Perth is part of the Fugro Group of companies, with over 3,400 employees in more than 150 offices worldwide.

GEO-X SYSTEMS LTD ARAM24 DIVISION **BOOTH 120**

900,425 First Street, South West, Calgary, Alberta, T2P3L8, CANADA
Tel: (403) 298 5690
Fax: (403) 298 5655
Contact: Kevin Pelletier

Manufacturer of Aram seismic recording instruments. Aram24-CMP 24 bit Delta-Sigma Conventional cable recorders, and Aram24 24bit Delta-Sigma telemetry systems for land and transition zone acquisition.

GEOIMAGE PTY LTD **BOOTH 67**

13/180 Moggill Road, Taringa, Qld 4068, AUSTRALIA
Tel: 07 3871 0088
Fax: 07 3871 0042
Contact: Sylvia Michael

Geoimage Pty Ltd is an independent Australian image processing consultancy specialising in the sale and production of satellite and geophysical imagery.

Our background is in the mineral and petroleum industries and we have expanded our expertise into the land use and land management markets.

Our existing client base extends throughout Australia, South East Asia, North and South America and Africa.

Geoimage has existing offices in Brisbane and Darwin and during January-February 1997 will be opening an office in Perth.

Information on our company, services and products can be found on our web page at www.geoimage.com.au.

GEOLOGICAL SOCIETY OF AUSTRALIA INC **BOOTH 144**

1203 Wynyard House,
301 George Street, NSW
2000, AUSTRALIA
Tel: 02 9290 2194
Fax: 02 9290 2198
Contact: Mrs Misha Frankel

The Geological Society of Australia is a learned society of scientists, formed in 1952 to facilitate the exchange of ideas and information and to encourage and support advancement of the geological sciences. The Society has over 3000 members representing all sections of the geoscience profession. There are Divisions in each State capital and ACT and meetings are held monthly. The Society has 12 specialist interest groups who also hold meetings, symposia or field trips. An Australian Geological Convention is held biennially. Members are drawn from the minerals and petroleum industries, government departments, research and education institutions and consultancy groups. The Society publishes the Australian Journal of Earth Sciences, The Australian Geologist, convention abstracts, Divisional and Specialist Groups proceedings and field guides.

GEOLOGICAL SURVEY OF VICTORIA **BOOTH 77**

P O Box 2145, MDC Fitzroy, Victoria, 3065
AUSTRALIA
Tel: (03) 9412 7862
Fax: (03) 9412 7803
Contact: Alan Willocks, Manager Geophysics Section

Minerals and Petroleum Victoria (MPV) is a division of the Department of Natural Resources and Environment. MPV is dedicated to providing appropriate geoscientific information and services to support the increasing levels of mineral and petroleum exploration in Victoria.

The Victorian Government is currently undertaking a $16.5 million dollar initiative to support the exploration industry. State-of-the-art techniques such as image processing and GIS are used to interpret data for release as geological and geophysical packages covering various mineral commodities and regions across Victoria. Examples of recently acquired aeromagnetic, gravity and other exploration data are on display at our booth.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA **BOOTH 149**

Mineral House, 100 Plain Street, East Perth,
Western Australia, 6004, AUSTRALIA
Tel: (09) 222 3423
Fax: (09) 222 3633
Contact: Alex Forbes

The role of the **Geological Survey of Western Australia** is to record and interpret the geology of the State and provide information to Government, industry and the general public to assist with exploration, development and conservation of the State's petroleum and mineral resources.

Our strengths are in field-based research especially geological mapping, structural geology, basin studies, carbonate sedimentology, mineralisation studies, geochemistry, regolith studies, geochronology, geoscientific computer applications palaeontology and petrology. Through the application of these skills for over a century, the Geological Survey has become the premier pool of geoscientific expertise in Western Australia.

GEONICS LIMITED **BOOTH 33**

8-1745 Meyerside Drive, Mississauga, Ontario,
L5T 1C6, CANADA
Tel: 905 670 9580
Fax: 905 670 9204
Contact: Frank B. Snelgrove

Geonics is the world's leading manufacturer of electromagnetic surface geophysical instrumentation covering a wide range of applications from mapping soil salinity, groundwater contamination and environmental site investigation to deep groundwater, geothermal and mineral exploration.

The Geonics PROTEM system is the transient electromagnetic system most widely used throughout the world for mineral exploration. The newest addition is the BH43-3D borehole probe measuring x y and z components. A simple primary field or gravity reference algorithm corrects for the probe rotation. Tests carried out in Canada and Australia have demonstrated the superior data quality and signal-to-noise ratio over competitive systems.

See us in Booth 33 for further information.

GEOPHYSICAL TECHNOLOGY LIMITED **BOOTH 123**

P O Box U9, "Woodland Hill", Rowlands Road, Armidale,
NSW 2350 AUSTRALIA
Tel: +61 (0)67 73 2617
Fax: +61 (0)67 73 3307
Contact: Andrew Davis

Geophysical Technology Limited was formed in 1996 to combine the 20 years of operational experience, assets and intellectual property of the Geophysical Research Institute (University of New England) with the capability and technology of specialist instrument manufacturer, Geophysical Technology Pty Ltd. GTL specialises in the provision of high definition, sub-surface mapping services to the mineral exploration; explosive ordnance detection; industrial decontamination; geotechnical investigation; and archaeological investigation markets. This service capability is founded on its proprietary and award-winning technologies and systems, the TM-4 magnetometer; Sub-Audio Magnetics; the TM-4s EM system; the dual-sensor GRI-Helimag system; and TL ground probing radar system.

GEOSOFT INC. **BOOTH 34**

Address: Please see Business Cards at booth for details.
Perth, WA, AUSTRALIA
Tel, Fax: Please see booth
Contact: Mr Nick Valleau, Managing Director

Geosoft specialises in professional software solutions for data processing and analysis, along with a high level of service and support. We provide a comprehensive suite of PC-based tools for managing, processing, visualising, imaging and presenting all types of earth science data, particularly in geophysical, geological and geochemical applications.

In 1996, Geosoft released OASIS **montaj**, an integrated environment for data processing and analysis using Windows 95 or NT.

Geosoft is pleased to announce the opening of an Australian office in Perth, WA, in February 1997. This office will improve access to technical support, training and custom development services for our Australian customers.

GETECH **BOOTH 82**

C/o Dept. of Earth Sciences, University of Leeds,
Leeds, L52 9JT, UNITED KINGDOM
Tel: 44-113-233-5240
Fax: 44-113-242-9234
Contact: Ian Somerton

With offices in the UK, Houston and Beijing **GETECH** has grown into a major geophysical contractor providing potential field geophysics services and products to the international oil and mining industry.

From a history of continental-scale gravity and magnetic compilation projects, GETECH has developed leading-edge software products, spec survey products, and advanced processing and interpretation services. Current projects include:

- GETdbase - the industry's leading database software solution for gravity and magnetic data
- CHAMP - over 7 million kms of Chinese aeromagnetic data are currently being digitised and compiled into the first country-wide 1km grid of magnetic data
- SEAGP - Gravity compilation of SE Asia including China, will become commercially available in April 1997
- Specialised satellite gravity processing and research

GMA INTERNATIONAL **BOOTH 114**

700, 736 - 6th Ave SW, Calgary, Alberta T2P 3T7,
CANADA
Tel: (403) 261 4025
Fax: (403) 263 6493
Contact: Bonnie Robinson, Marketing Assistant

A world leader in the exploration software industry, today, **GMA** supports over 3000 software systems spanning 40 countries worldwide.

GMA has developed an integrated exploration system designed to save time and increase productivity by coordinating the activities of geophysicist, geologist and now petrophysicist in a seamless integrated system environment.

GMA's integrated system performs: petrophysical analysis, synthetic generation, log editing, seismic modelling, X-section generation with geological features, 2D and 3D seismic interpretation, structural modelling, wavelet extraction and AVO analysis. All GMA tools have the flexibility to dynamically share information between modules.

GMA tools are supported on multiple platforms including: DOS, Windows, Windows NT and UNIX environments.

Visit GMA in Booth #114 at the ASEG to discover just how efficient life can be!

GREEN MOUNTAIN GEOPHYSICS INC **BOOTH 59**
1800-38th Street, Suite 100, Boulder, Colorado, 80301, USA
Tel: 303-444-6925
Fax: 303-444-8632
Contact: Schelly Olson

Green Mountain Geophysics set the industry standard in 3D survey design with MESA, the complete acquisition planning system. Now we're leading the way into the future with even more high quality 3D design and refraction statics applications. GMG products are developed using an advanced C++ architecture and run on both PCs and workstations (Windows, '95 & NT, Sun, IBM, Silicon Graphics, and Hewlett Packard), ensuring users of an advanced set of features well into the next millennium.

Since 1979, GMG has been a leading geophysical software developer for the petroleum industry. Every leading energy company in the world uses GMG software in offices and on field systems worldwide. Since over half of our sales are international, we have sales and support offices around the world. We employ software engineers and geophysicists who are experienced in dealing with the issues and challenges encountered in oil and gas exploration.

GUARDIAN DATA **BOOTH 5**
Unit 2, 72-74 Gibbes Street, Chatswood, NSW 2067
AUSTRALIA
Tel: 61-2-94176144
Fax: 61-2-94170297
Contact: Bryan Robertson

Guardian Data is a leading geophysical data transcription and archiving company established in 1984 and now with offices in Sydney, Melbourne, Perth, Brisbane, Jakarta, Brunei, Miri, K.L. and London.

Guardian Data offers a suite of services which include:-

- Pre-processing demux, correlation and shot record or Seg Y displays,
- Field tape copy and compaction
  9trk, 21trk, 3480, 3490, 3590, D2, CD
  all formats, all densities
  analogue to digital conversion
- High Density Archiving
  the transcription of geophysical libraries to HDM such as D2 or 3590
  database creation
  RODE format
- Workstation Support
  data loading services available in Perth.
- Recovery of Data from deteriorated tapes
  a combination of software, hardware and tape preservation methods.

GX TECHNOLOGY **BOOTH 126**
Level 3, Legal and General Bldng,
261 St. Georges Tce, Perth, WA 6149, AUSTRALIA
Tel: (09) 261 7776
Fax: (09) 261 7720
Contact: J. W. Hooper

GX Technology Corporation is a geoscience software and services company with headquarters in Houston, Texas. The company has offices in London, Paris, Calgary, Beijing, and Perth. GX Technology is recognised as a leading independent technology supplier of 2D/3D seismic modelling and depth imaging software and services to the exploration and exploitation segments of the oil and gas industry. These products and services are used worldwide to assist geoscientists in the search for oil and gas.

GX Technology Corporation 5847 San Felipe, Suite 3500, Houston, Texas 77057 US
Tel: 713 789 7250 Fax: 713 789 7201

HAMPSON-RUSSELL SOFTWARE SERVICES LTD. **BOOTH 27**
Suite 510, 715-5 Avenue SW, Calgary, CANADA
T2P 2X6
Tel: (403) 266-3225
Fax: (403) 265-6651
Contact: Brian Russell

Hampson-Russell Software Services Ltd. is a Calgary based software developer specialising in seismic inversion and analysis applications for the petroleum industry. The company also has regional support and sales offices in London, Houston and Hong Kong. Key products include STRATA, a 3D post-stack inversion program; AVO, an amplitude variations with offset modelling, analysis, and inversion program; GEOSTAT, a comprehensive geostatistic package; and GLI3D, a 2D/3D refraction analysis package. The founders of the company, Dan Hampson and Brian Russell, were winners of the 1996 SEG Enterprise Award.

HIGH-SENSE GEOPHYSICS LIMITED **BOOTH 17**
47 Jefferson Avenue, Toronto, Ontario, M6K 1Y3
CANADA
Tel: 416 588 7075
Fax: 416 588 9789
Contact: Vera Weller

High-Sense Geophysics provides spectrum of contract airborne geophysical surveys with systems and software of its own design. Mounted in either locally available helicopters, fixed wing aircraft, or on special function fixed wing platforms, they produce industry-leading high definition data for detailed geological mapping and natural resource detection. Applications include precious metals, gem, base metal and uranium exploration, and detailed or regional high sensitivity aeromagnetic, stratigraphic and basement mapping for petroleum. Systems include multi-frequency HEM, 2056 channel gamma radiation spectrometry, digitally compensated helicopter and fixed wing total field magnetics, and VLF-EM, all supported by precision DGPS navigation.

INPUT/OUTPUT, INC. **BOOTH 128**
11104 West Airport Boulevard, Stafford, Texas 77477
USA
Tel: 281/933-3339
Fax: 281/879-3500
Contact: Diana Galindo-Walker (or Marsha Krohn)

Input/Output, Inc. is the leading designer and manufacturer of seismic data acquisition systems and equipment. It is the only independent supplier of seismic acquisition systems for use in every exploration environment - on land, in the transition zone (marshes, swamps and tidal zones) and in the deepwater marine environment.

Founded in 1968 and headquartered in Stafford, Texas, Input/Output has facilities in Alvin, Texas; Houston, Texas; Calgary, Canada; Norwich, England; Kanturk, County Cork, Ireland; and Voorschoten, the Netherlands.

Input/Output is dedicated to providing its customers seismic equipment that delivers better seismic data, faster and cheaper.

JASON GEOSYSTEMS ASIA **BOOTH 26**
Level 36, Hong Leong Building, 16 Raffles Quay,
Singapore 048581
Tel: +65 3221465
Fax: +65 3228558
Mobile +65 96374987
E-mail: paul@jason.nl
Contact: Paul Vrolijk

Jason Geosystems Asia - "Teamware" for finding Oil & Gas - the smart way
Jason Geosystems is specialised in Advanced Reservoir Characterisation software and services.

With the Jason Geoscience Workbench, 30 reservoir models (in time and depth) can be generated which honour all the available seismic, interpretive, well and geological information. Because best possible use is made of the available data, better exploration and development decisions can be made.

The software consists of a complete range of modules for geological modelling, velocity modelling, wavelet estimation, seismic inversion (including a number of different methods) and geostatistical analysis.

LANDMARK GRAPHICS INTERNATIONAL INC. **BOOTH 24**

57 Havelock Street, West Perth, Western Australia, 6005, AUSTRALIA
Tel: (09) 481 0277
Fax: (09) 481 1580
Contact: Kylie Jones

Landmark Graphics Corporation is the leading supplier of exploration and production information systems to the worldwide petroleum industry. The company launched a revolution in computer-aided exploration (CAEX) with the introduction of our first product in 1984. Today, as the petroleum industry focuses on more efficient production, Landmark is leading the way in creating a new era of computer-aided reservoir management (CARM). Through innovative products and integrated information solutions, we bring dramatic business value to our customers by allowing them to reduce risk, cut cycle times, and boost productivity. Our expanding portfolio of unparalleled technologies and services helps approximately 90 percent of the worlds largest oil and gas companies transform vast amounts of data into better decisions.

MAGELLAN GPS SYSTEMS **BOOTH 94**

10-12 Main Street, Osborne Park
Western Australia 6915, AUSTRALIA
Tel: (09) 444 0233
Fax: (09) 443 2598
Contact: Kerry Kennedy

PHM Magellan GPS Systems, now with head offices in Perth and Sydney, is the largest supplier of GPS receivers in Australia. The product range includes low cost receivers from $418, through to the NovAtel GPS based RT2 System, which provides 1-2cm real time accuracy, and sub-centimetre post processed accuracy. Using a dual frequency GPS with multipath elimination firmware, the system can output the RTK correction to distances within a 10-30km range.

Another product in the range is the GPS MAGPAK - an RTK GPS integrated with a Scintrex magnetometer. The MAGPAK can provide selected accuracies from 5m to 1-2 cm, over a 10-30km range.

In the communications field we will show the Magellan microCOM-M - the world's smallest, lightest satellite phone. Working via the international Inmarsat M system the microCOM-M can send and receive voice, fax and data transmissions from anywhere in the world.

MALÅ GEOSCIENCE **BOOTH 47**

Skolgatan 11 Malå, S-93070,
SWEDEN
Tel: 46 953 10710
Fax: 46 953 10225
Contact: Mr Bòrje Niva

MALÅ GeoScience is a Swedish equipment manufacturer with more than 70 years of experience. The company is a worldwide supplier of Geophysical Instruments for Geotechnical, Groundwater, Mineral Exploration and Mining applications.

The advanced RAMAC Borehole Radar, RAMAC/GPR Ground Penetrating Radar, WELLMAC Slimhole Logging System, EMAC SLINGRAM and JH-8 Magnetic Susceptibility Meter are well-known systems used worldwide.

The surface radar system RAMAC/GPR is now reaching new user groups thanks to its flexible and lightweight design in combination with easy operation.

At this ASEG Meeting MALÅ GeoScience exhibits the RAMAC/GPR Ground Penetrating Radar system with software.

MARSCHALL ACOUSTICS INSTRUMENTS PTY LTD **BOOTH 115**

Suite 13, 9-11 Abel Street, Penrith, NSW 2750
AUSTRALIA
Tel: 61-47-32-3208
Fax: 61-47-31-4323
Contact: Richard A Marschall, PhD

Marschall Acoustics Instruments Pty. Ltd. (MAI) is a high technology company that designs, supplies and supports acoustic and geophysical instrumentation and software to the mining, geophysical exploration and defence sectors.

A world leader in acoustics and sonar modelling, MAI has the capability to optimise sonars and geophysical arrays for maximum signal fidelity and minimal noise. MAI also has considerable mechanical and electronics design capabilities to support geophysical systems design and installation.

Locally in the Australia-Asia Pacific region, MAI is the sole authorised representative for: OYO Geosciences Corporation; Geophysical Survey Systems Inc; Marimatech ApS ; OmniTech AS.

MINES AND ENERGY SOUTH AUSTRALIA **BOOTH 30**

191 Greenhill Road, Parkside
PO Box 151, Eastwood 5063 South Australia
Contact: Gary Reed

MESA administers all legislation covering exploration and mining activity in South Australia. Its other activities include:

- undertaking detailed geophysical surveys
- support of exploration activity and issue of relevant licences
- identification of new prospective terrains including ongoing geological and geophysical survey programmes funded by supportive governments and industry
- regulation of mining activity
- ensuring environmental standards are maintained throughout exploration and mining operations
- encouraging indigenous people and their support for mineral and oil activities
- encouraging resource processing and ensuring adequate infrastructure is in place

NEURAL MINING SOLUTIONS **BOOTH 83**

Level 3, Gold Fields House, 1 Alfred Street,
Sydney, NSW 2000
Tel: (02) 9252 2011 Fax: (02)9241 2465
Contact: Gavin Daneel

Prospect Explorer: A Geophysical Mineral Exploration Neural Analysis Tool

Exploration data analysis plays a vital role in acquiring, mapping, targeting, prioritising and management of mineral prospects.

Neural computers analyse large amounts of data to identify relationships, recognise patterns, associations and anomalies, and make predictions automatically. Applied to the various forms of exploration data, they provide a powerful analysis tool.

This exploration tool, "Prospect Explorer", takes an alternative approach to data analysis and visualisation, automating the detection and prioritisation of anomalies and the relationships between their components.

Prospect Explorer has been proven to find economically viable mineral deposits in blind tests - the Girilambone Copper Mine is just one example.

OYO INSTRUMENTS INC **BOOTH 92**

c/- Seismic Supply International Pty Ltd,
12 Archimedes Street, Darra, Queensland, 4076
AUSTRALIA
Tel: (07) 3375 3300
Fax: (07) 3375 4027
Contact: Rodger Quick

OYO Instruments specialises in the design and manufacture of systems used for acquiring, processing and presenting geological and geophysical seismic data.

OYO Instruments is a supplier of high-resolution thermal plotters, designed for continuous and unattended operation. Recent improvements include a sophisticated new controller that automatically adjusts printhead energy levels. This feature improves plot contrast and with the zig-zag plotting feature greatly extends the printhead life expectancy.

The DAS-2 seismic data acquisition continues the development of cutting edge seismic technology established by the DAS-1. DAS-2 is a multi-purpose land or marine seismic data acquisition system. It records data from both impulsive and vibrator sources for 2D and 3D seismic surveys. DAS-2 incorporates a Pentium CPU as its main system controller. All system operation and acquisition functions are managed by menu driven software.

PANTHER SOFTWARE CORP. **BOOTH 107**

Suite 700, 703 - 6th Avenue SW, Calgary,
Alberta T2P OT9, CANADA
Tel: +1 403 234 9060
Fax: +1 403 234 9190
Contact: Bev Berze

Panther Software Corp. is a rapidly growing private Canadian company that is successfully developing and marketing data management software and services solutions to the petroleum industry.

Panther's products include: SDMSTM the seismic Data Management System that delivers seismic data seamlessly to desktop applications and between applications; SDL, a Seismic Data Loader that quality controls and moves data to major applications; and App Track, software that monitors application usage across UNIX and PC networks.

Panther's products are distributed by Integrated Solutions Australasia Pty Ltd, in Australia, New Zealand, Indonesia, Malaysia, Thailand, Brunei and Singapore.

Visit Panther at booth #107.

PARADIGM GEOPHYSICAL PTE LTD. **BOOTH 58**

100 Beach Road #15-05/06, Shaw Towers, 189702
SINGAPORE
Tel: (65) 297 9250
Fax: (65) 297 9251
Contact: David C. Cox

Seeing in depth is the key to successful exploration! In the early 90s, **Paradigm Geophysical** introduced GeoDepth® a product based on our depth/velocity model building and depth imaging technology. It is an exploration technology uniquely capable of uncovering subsurface structures where time-based seismic approaches have failed. Since then, our depth paradigm has been helping leading majors and independents to better explore and exploit reservoirs, reducing risk and shortening production cycles. Today, Paradigm Geophysical offers a comprehensive, integrated and field-proven suite of exploration software products and global services using 2D and 3D tools to see through the exploration and exploitation process, from depth imaging and velocity analysis to depth mapping and model-building.

PATERSON GRANT & WATSON LIMITED **BOOTH 35**

204 Richmond Street West, Fifth Floor, Toronto, Ontario
M5V 1V6, CANADA
Tel: (416) 971 7343
Fax: (416) 971 7471
E-mail: stephen.reford@prw.on.ca
web: http://www.pgw.on.ca
Contact: Stephen Reford, Vice-President

Paterson, Grant & Watson Limited (PGW) is a Toronto-based geophysical consulting firm, which has been providing services worldwide to the mineral and hydrocarbon exploration industries since 1973. PGW provides geophysical and geoscience data compilation, processing, enhancement and interpretation services to both the public and private sector. PGW has worked for most of the world's major mining and petroleum companies, as well as a wide variety of junior mining companies.

PGW's work for government agencies in developing countries has incorporated formal and hands-on training programs, involving airborne and ground data acquisition, data processing, interpretation, ground truth, and installation and operation of geophysical and computer hardware and software. PGW also provides services in digital cartography, satellite image processing and distribution of geophysical and image processing software (Geosoft, ER Mapper, Gipsi, GM-SYS).

Contact: Stephen Reford, 204 Richmond Street West, Fifth Floor, Toronto, Ontario M5V 1V6. Tel: 416-971-7343,
Fax: 416-971-7471.
Email: stephen.reford@pgw.on.ca.,
WWW: http:\\www.pgw.onca

PETROCONSULTANTS / ASB **BOOTH 112**

Level 4, 39 Chandos Street, St Leonards, NSW 2065
AUSTRALIA
Tel: (02) 9901 3599
Fax: (02) 9901 3636
Contact: Helen Linha

The Geneva-based **Petroconsultants** group is represented in Australia by Petroconsultants Australia (PAUS) and Petroconsultants Digimap (Digimap), with a 50% interest in Australian Seismic Brokers (ASB). Digimap and ASB have compiled the most comprehensive collection of SEGY and seismic location data within Australia and complement this with well completion reports, digital well logs and synthetic seismograms. The SEGY data includes reprocessing and spec survey data as well as open file surveys, and is augmented with scanned and reconstituted seismic data using Digimap's REDEEM technique. The international E&P GIS PetroWorld, the seismic GIS SeiSearch, and the Australian FSS are all produced locally.

PETROLEUM GEO-SERVICES (PGS) **BOOTH 14**

Level 4,1060 Hay Street, Perth, WA 6005, AUSTRALIA
Tel: (09) 3215126
Fax: (09) 3215197
Contact: Michele Rinaldi or Nicky Turich

Petroleum Geo-Services ASA is a holding company offering a range of marine oilfield services through its subsidiaries. The group was established in 1991.

It's largest service segments are the acquisition and processing of contract seismic surveys and the planning, completion and marketing of multi-client seismic surveys. The group operates a fleet of 13 advanced 3D seismic vessels and two ocean bottom seismic crews on a world-wide basis. Onshore data processing centres are located in the USA, Europe, Middle East, South America and Asia. Other services include development and sales of geoscience applications software, petroleum data management systems and services, and reservoir consultancy.

PGS employs approximately 1400 people in 15 locations around the world. In 1995, the company's net revenues were approximately USD 320 million, with a net income before tax of USD 52 million.

PETROSYS PTY LTD **BOOTH 25**

Suite 11 / 15 Fullarton Road, Kent Town, SA 5067
AUSTRALIA
Tel: (08) 8363 0922
Fax: (08) 8362 1840
Contact: Michael Brumby

Petrosys is an established supplier of computing systems for the petroleum industry, with the main office in Adelaide, South Australia and subsidiary offices in Ayr, Scotland and Houston, USA. Petrosys' major products include: Petrosys Mapping A mapping system designed to create drafting quality style maps of

geophysical data, including shotpoint and posted basemaps, contour maps and sun-shaded or colourfill grid displays. A range of display option allow you to post text; draw lines, curves and boxes; to display polygons and to post cultural and well data. Petrosys supports a number of projections and spheroids.

PGC/3: Gridding and Contouring of seismic data, contours and XYZ files, with or without faults; grid arithmetic operations; grid and contour based volumetric calculations; editing of grids, contours, faults and polygons.

DBMAP: An industry standard petrotechnical database systems with a mapping front end. Enables you to query a database (e.g. Oracle) by graphically pointing and clicking on an object such as a seismic line, well or lease. Reports details such as the line processing history or the well production history.

Digitising: Digitising of sections, contours, faults, seismic line locations and cultural information (such as wells).
PEP: Well log Database and Display.
Petrosys software is supported under SUN (4.1.3 and Solaris), SGI and Windows 3.1.1, NT and 95 platforms.

PITT RESEARCH PTY LTD **BOOTH 89**

45 Hackney Road,
Hackney (PO box 110, Kent Town) SA 5071, AUSTRALIA
Tel: (08) 83629966
Fax: (08)83629977
Contact: Anne Treloar

Pitt Research Pty Ltd is an independent geophysical data processing company specialising in high-quality aeromagnetic and radiometric data processing, image processing, mapping and interpretation services to the global exploration community. Experienced processors for new helicopter, ultra-detailed and conventional fixed-wing surveys, as well as re-processing for older surveys.

The company is a key facilitator of the current SA mineral exploration boom and has established an extensive magnetic coverage of the state through its MAGMAP and Gawler Craton map series.

Pitt Research has recently established the WANT airborne geophysics database, a scheme whereby companies can contribute and purchase survey data for WA and the NT from a centralised database

PROSPECTORS EARTH SCIENCES **BOOTH 81**

4/195 Prospect Highway, SEVEN HILLS, NSW 2147
AUSTRALIA
Tel: 02 9838 7890
Fax: 02 9838 7073
Contact: Bill McArd

Dear Client

1996 was a year of change and in keeping with this we changed our name to Prospectors Earth Sciences. After 24 years in business we felt that the change was necessary to properly reflect our client base. Our stand (81) features many items which we hope will be of interest to all people who have an involvement in the earth sciences.

We have attempted to make our company as "User Friendly" as possible by giving you the uncomplicated options of telephone, fax or mail to place your order. The rear section of our catalogue provides full details of these options. One fact that became very noticeable in 1996 was the mobility of earth scientists resulting in a dramatic increase in exports to "Far away places with strange sounding names".

Our 1997 catalogue is now available at our stand.

Bill & Alison McArd

RESOURCE INDUSTRY ASSOCIATES (R.IA.) **BOOTH 132**

538 Brunswick Street ,North Fitzroy, Vic. 3068 AUSTRALIA
Tel: 03 9482 4945
Fax: 03 9482 4956
Contact: Jeff Bailey

MapPad and TerraScan ProGPS have been developed by Resource Industry Associates and Geospatial Solutions to provide "State of the Art" data capture and image processing tools for portable computing.

MapPad DGPS enables field data to be collected digitally in any customised format including AGSO standard fieldbook format then easily downloaded to a GIS such as MapInfo or ArcView for analysis.

TerraScan offers high functionality yet is easy to use by explorationists. It has smart links to GPS, MapInfo and ArcView.

R.I.A. distribute the technology while Geospatial Solutions provide the GIS training and implementation in the mining industry.

Further details at: www.ria.com.au

RMS INSTRUMENTS **BOOTH 53**

6877-1 Goreway Drive, Ontario, L4V 1L9, CANADA
Tel: (905) 677-5533
Fax: (905) 677-5030
E-mail: rms@rmsinst.com
Home Page: http://www/rmsinst.com
Contact: Onorio Rocca

RMS Instruments is a Canadian company specialising in the research, development and manufacturing of ruggedized data recording equipment, test and measurements instruments, and geophysical exploration systems.

Graphic Recorders, Chart Recorders, Data Loggers, Data Acquisition Systems, Magnetic Tape Recorder, Removable Hard Disk, Automatic Aeromagnetic Digital Compensator, Totem-2A VLF EM Receiver with Gradiometer option.

Airborne geophysical exploration systems integration and engineering.

ASSISTANCE, SALES, RENTAL, SERVICE

ROBERTSON RESEARCH AUSTRALIA PTY LTD **BOOTH 93**

69 Outram Street, West Perth, WA, 6005, AUSTRALIA
Tel: (09) 322 2490
Fax: (09) 481 6721
Contact: Steve Smith

Robertson Research Australia Pty Ltd specialises in land, marine 2D and 3D, and transition zone seismic data processing services on either an exclusive or non-exclusive basis. Interpretative Processing services (AVO analysis, inversion, petrophysical log analysis and pre-stack depth migration) are also provided at our Perth based office. Our team of loyal and dedicated geoscientists are our main asset, offering the Oil and Gas companies their expertise and experience to solve the many problems associated with this industry.

The Robertson Group supplies innovative and integrated services to the oil and gas industry throughout the world. Robertson's expertise is unparalleled in the industry. Its staff of geologists, geophysicists, engineers and technical specialists provide cost-effective solutions for the increasingly complex tasks associated with hydrocarbon exploration and exploitation today.

Visit us at stand 93 for full details of the services offered by the Robertson Group.

SAGEM AUSTRALASIA PTY LTD **BOOTH 88**
Unit 2, 44-48 O'Dea Avenue, Waterloo, NSW 2017,
AUSTRALIA
Tel: +61 (2) 315 3500
Fax: +61 (2) 315 3555
Contact: Peta Groves

SAGEM Australasia Pty Ltd is part of the SAGEM Group, a French group of high technology companies totalling over 14,000 employees, with an annual turnover of more than $3 billion US dollars. SAGEM Australasia represents Ashtech Inc (USA) in the Australian/Pacific region. Ashtech (USA) is the market leader in applications of the high accuracy satellite position systems known as GPS and GLONASS. The new G-12 and GG24 series systems provide real time accuracies of 10 metres (standalone) and sub-metre (differential). Other systems provide real time and post-processed centimetre differential positioning. Ideal for all geophysical applications, visitors to the stand will be able to see the equipment and application software demonstrated.

SCINTREX PTY LTD **BOOTH 57**
1031 Wellington Street, West Perth, WA, 6005 AUSTRALIA
Tel: (09) 321 6934
Fax: (09) 481 1201
Contact: Dr Graham Linford

Scintrex, a world leader in geophysical instrumentation, provides instrument sales, rentals and contract surveys for ground and airborne applications that include mineral, groundwater, environmental site characterisation and oil and gas exploration. The survey methods include IP, MIP, SIROTEM, gravity, magnetics and the new HELIGRAV, a fully integrated, helicopter-borne gravity mapping system. Scintrex instrumentation includes the world renowned CG-3 Automated Gravity Meter, the ENVIMAG proton magnetometer, the SMARTMAG high resolution cesium vapour magnetometer, the IPR-12 Multipole IP Receiver, and the HELIMAG lightweight airborne mag system, as well as a wide variety of customised instrumentation to meet almost all specified geophysical requirements.

SEISMIC IMAGE SOFTWARE LTD **BOOTH 101**
1700, 444 5th Avenue SW, Calgary, Alberta, T2P2T8
CANADA
Tel: 403 233 2140
Fax: 403 266 2685
Contact: M. Hall

Seismic Image Software Ltd is recognised world-wide as a leading developer of 2D and 3D Seismic Processing Software. They distribute their software products through 18 agents to over 300 customers in over 40 countries around the world. Courses are offered world-wide in processing of seismic data.

Seismic Image Software Ltd, has been developing and marketing software from their headquarters in Calgary, Alberta, Canada for over nine years. Their products include:

VISTA for DOS is a PC-based 2D seismic processing and interpretation system for those geophysicists who require a full-function and cost effective system.

VPTAPE is a cost-effective PC based tape copy and demultiplex system capable of handling formats SEG-A, B, C, D, X, Y from/to media such as 9 track, 3480, and Exabyte.

Our new multi-platform system VISTA for Windows is a full 3D/2D processing system. VISTA is set to revolutionise the geophysical industry in terms of cost and functionality.

CAM120 is a ruggedized PC and high speed thermal plotter for the I/O System Two, a new version of this with much expanded capability is to be launched at the 1996 SEG convention.

GEOSYN is a cost effective, user friendly PC Windows based synthetic seismogram and log modelling program that everyone can afford to have on their desk.

For more information contact us at
Tel: +1 403 233 2140; Fax: +1 403 266 2685
or e-mail: ron@sisimage.com.

SEISMIC SUPPLY INTERNATIONAL PTY LTD **BOOTH 91**
12 Archimedes Street, Darra, Queensland, 4076
AUSTRALIA
Tel: (07) 3375 3300
Fax: (07) 3375 4027
Contact: Rodger Quick

Seismic Supply International's participation in the 12th Australian Society of Exploration Geophysicists Conference and Exhibition features the latest in Seismic Data Acquisition Systems and Peripherals, Geophones, Seismic Source and Source Control Equipment, TGhermal Plotters, Sub-Bottom Profilers, Side Scan Sonars, Marine Magnetometers, Seabed Classification and Differential Global Positioning System (DGPS), Survey, Positioning and Tracking.

Seismic Supply International Pty Ltd represents the manufacturers of today's leading Geophysical Geotechnical, Bathymetric and Precision Positioning Systems including the following organisations:

Datasonics, Dassault Sercel Navigation and Positioning, EPC Labs, Gem Systems, Geo Acoustics, GeoSpace, Hydroscience, Klein Associates, Macha International, Mertz, OYO Corporation, OYO Instruments, Quester Tangent, SeaBeam Instruments, Seismic Systems, Sercel and Triton Technology.

SURPAC SOFTWARE INTERNATIONAL **BOOTH 136**
Level 7, 344 Queen Street, Brisbane, Qld. 4000,
AUSTRALIA
Tel: 3211 2077
Fax: 3211 2185
Contact: Tony Harvie

SURPAC2000 has tools for all mining disciplines - Engineers, Geologists and Surveyors. SURPAC2000 has standard file formats allowing seamless flow of information between departments ensuring productivity is maximised.

Surpac's R & D Team has been developing new software and enhancing our current products to provide SSI customers with the most sophisticated mining and exploration available.

Drill Pad:	Windows based bore hole logging system for Exploration Geologists.
XPLORpac:	Exploration data management and resource modelling.
SURPAC2000:	A sophisticated mine production system used by all mining professionals.

Some of the features of our software which are contributing to it's world wide popularity are:

- Surpac Software runs on Win 95, Win NT and a variety of Unix platforms.
- Surpac Software is compatible with popular database tools.
- Surpac Software is a fully integrated system.

Call for more information Brisbane 3211 2077.

TOTAL RECALL TECHNOLOGIES PTY LTD — **BOOTH 40**

PO Box 423, Artarmon, NSW, 2064, AUSTRALIA
Tel: (02) 9967 2644
Fax: (02) 9967 2808
Contact: Eric Swarbrick

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Abstracts

SECTION THREE

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ASEG 12th Conference and Exhibition - Keynote Papers (Abstracts)

Exploration Challenges and Opportunities in the far East

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The dramatic political events of the late 1980's and early 1990's have globalised today's petroleum industry. Many regions with substantial hydrocarbons have become accessible for the first time to private investment. With the emergence of these new opportunities, industry is facing significant technical, commercial and competitive challenges. These opportunities tend to be capital intensive and often include a greater level of risk. Frequently these resources are found in hostile environments and are often remote from existing infrastructure. Many of the countries in newly accessible areas are developing economic, legal and fiscal regimes necessary to attract and support private investment initiatives

This paper will focus on the technical, economic and political challenges encountered in exploring new emerging opportunities while continuing operations in established, hydrocarbon rich areas within the Far East region.

Site Characterisation Geophysics: Experiences in South East Asia

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Abstract

The objectives of geotechnical and environmental geophysics are to characterise the subsurface in a manner that is useful for civil and mining works, agricultural planning or to satisfy legal regulations or requirements. Site characterisation geophysics (SCG) is an appropriate term which encompasses these activities.

If specific buried targets are sought then SCG seems to share many similarities with exploration geophysics. This apparent similarity is illusory since characterisation of the spatial variability of a geophysical parameter, particularly at a contaminated urban site, as opposed to bump detection in a "green fields" site is not simple or straightforward. SCG places considerable pressure on a geophysicist because many targets are shallow. A site characterisation geophysicist must also be familiar with a variety of other geotechnical and environmental testing methods and must be capable of relating geophysical information to these tests.

In recent years SCG has developed rapidly throughout the world in conjunction with the discipline of environmental engineering. The dramatic growth in Asian economies, their resource demands and the pressures on urban environments has also generated increased demand for SCG. Some recent experiences using SCG in a number of Asian countries demonstrate the scope and variety of the projects which are underway in the region.

In most Asian countries, including Thailand, groundwater is a major concern. Within the greater Bangkok area groundwater withdrawal from shallow aquifers has lead to land subsidence and massive wet season flooding. SCG using high resolution seismic reflection enables the aquifer system to be effectively mapped and assists the design of groundwater injection programs to slow the subsidence rates. In central Thailand electrical geophysics is applied to shallow aquifer mapping and dam leakage problems.

In Yunnan Province of China TEM located a deep source of potable water for a major resort development which could not proceed without an assured water supply.

Significant parts of Kuala Lumpar, Malaysia's largest city are underlain by karst limestone which creates many foundation problems. Seismic tomographic imaging between geotechnical boreholes is used to map the limestone bedrock beneath a school which was subsiding to assist the siting of supporting piles. At another site in this city, proposed for a multi-story building, a new method of Radiowave Diffraction Electromagnetics (RDEM) was use to map the irregular limestone bedrock to depths of 20m.

Major mining development is proceeding in Kalimantan, Indonesia. At one mine a major river diversion was required through a large hill in order to expand the available reserves. Seismic refraction and tomographic imaging was used to assist route selection and in the characterisation of excavation conditions.

Large Petroleum refineries are located throughout South East Asia. At Manila, Philippines RDEM was used in a refinery site to screen for hydrocarbons plumes and their potential for off-site migration.

Australian geophysicists have significant opportunities to work in conjunction with the rapidly growing local geophysical industries in South East Asia for the sustainable development of the region if they are prepared to meet the technical demands of SCG and make the necessary cultural adjustments.

Where has geophysics been and where is it headed?

Dr Tom Whiting

Manager Exploration Australia
BHP Minerals

Abstract

We have made great strides in our application of exploration geophysics in Australia over the last 30 years. Early attempts at transplanting Canadian electrical geophysical techniques into the deeply weathered landscape and highly conductive regolith of Australia proved quite disastrous to their early development. Since then the struggle to effectively apply geophysical

methods to exploration has progressed slowly, recovering lost credibility from those early setbacks. Progress gathered pace with experimentation during the late 1970s and early 1980s using new transient electromagnetic (e.g. SIROTEM) and induced polarisation systems. A major leap was made in the early to late 1980s with the innovative application of high resolution aeromagnetics coupled with image processing techniques. For the first time, this combination clearly demonstrated, through stunningly geologically intuitive images, the geological mapping capability inherent in potential field geophysical techniques. This application and its associated power in discriminating exploration targets is now expanding to most geophysical techniques (e.g. Airborne Electromagnetics). In short, the initial barriers to the application of geophysical methods in Australia have become a catalyst for innovation and progress in modern geophysics.

What have we learnt from these challenges and the evolution of techniques to meet them? We have gained a depth of understanding of the application of exploration geophysics in deeply weathered and covered terrains probably unequalled anywhere in the world. This has been gained through several processes; firstly, incremental research and experimentation with a wide range of techniques resulting in vastly improved instrumentation and acquisition; secondly, the documentation of extensive geophysical case histories covering a wide range of commodities and deposit styles, including rock properties and resultant geophysical signatures; finally, integration of this data with an improving knowledge of ore deposits, in particular their structural and lithostratigraphic settings. The latter has resulted in an increasingly integrated, geologically meaningful, interpretation approach. Most important of all has been the willingness of the Australian Exploration Industry to collaborate through various research organisations (AMIRA, CSIRO) and professional associations (ASEG) to progressively break barriers to more effective exploration. The scale at which this collaboration has happened is possibly unique in the minerals exploration industry. At the same time, Government has recognised the economic benefits of continuing to support research (through CSIRO) and data collection (through AGSO and State Mines Departments) at a continental scale with state of the art techniques. This has provided new insights into technique development, data processing and the geodynamic framework of the Australian continent which has in turn maintained the momentum for technical progress and resultant discovery.

A consequence of the hard fought gains of the past is that we are becoming better empirical explorers. We understand better the structural and stratigraphic criteria important in describing **where** major deposits may be located. We have improved knowledge of the physical properties and geophysical signatures of both their host rock assemblages and the deposits themselves. This is true at both regional and local scales. Therefore we are getting better at discriminating what a **target** is compared to what is simply an **anomaly**. We aggressively apply search techniques that work (whether they be geophysical or geochemical) on ore deposit styles that we empirically understand. The aggressive and systematic use of airborne magnetics to map prospective greenstone belts in the Yilgarn Block, accompanied by sophisticated surface and downhole geochemistry to discover new Archaean, shear hosted, gold deposits is a good example of this. This is very successful when looking for clone-like deposits, but unfortunately, most deposit styles are not clones (e.g. Century). This approach will not work for unconventional styles of mineralisation occurring in terrains currently perceived as unprospective (e.g. Voisey's Bay). Our blanket coverage exploration behaviour reveals **how** little we know about how these deposits form. Our lack of understanding about mineralising processes forming world class deposits means our ability to truly predict ore location is limited. Consequently, the geological interpretation of geophysical data is largely limited to ore location by searching for similar geophysical signatures or geological settings to known deposits. As discussed recently by Oliver Warin in his address "Mineral Exploration into the Millennium" (in The Geoscience), the arena of location of world class deposits through conceptual geological thinking based on the process of ore formation is still in its infancy. Some of you may ask "Does this really matter?" If we wish to focus our efforts and do things smarter not harder, it is important for orebodies which are not clones.

What are the challenges for the future? In Australia, it is essential to continue to break the technical barriers to exploration success. Geophysics is at the forefront of this battle as exploration moves increasingly to the search for blind deposits. We increasingly rely on the innovative use of geophysical and geochemical techniques integrated with empirical and conceptual geological thinking. To be successful it will be essential to stay at the leading edge. There are several challenges involved. We must continue to improve the number, range and effectiveness of acquisition techniques through improvements in instrumentation. New geophysical methods applied at regional scale are excellent at providing new insights into **why** deposits are **where** they are and possibly **how** they came into being. They often provide totally new geological maps through totally new sensors ("new eyes"). This adds impetus leading to discovery. Research alliances between exploration companies and contracting companies targeted at improved acquisition and processing techniques are an effective way of achieving this aim. We must continue to improve geophysically based geological mapping techniques (which we should attempt to extend to all geophysical techniques). We must enhance their ability to **discriminate**, often subtle signatures due to mineral deposits as opposed to signatures simply due to geology. This will require advances in data processing to accompany better acquisition systems. It will also require continuing commitment by industry and government to improve the national geophysical database and documentation of geophysical signatures of known deposits. Finally, to move from empirical description of ore location to prediction, we need to improve the interpretation of geophysical data via better integration with geological concepts. Progress will depend on improved understanding of key mineralising processes important in the formation of world class deposits. This is a long term goal and should involve collaboration between government and industry.

Where does Australia fit into the global exploration scene and what are the implications for exploration geophysics coming into the new millennium? Globalisation is the catch phrase of the 1990s and the hope for growth and prosperity into the new millennium. In the Australian minerals exploration industry we are feeling its effects daily. Major mining companies are increasingly taking advantage of attractive opportunities available as countries around the world open their doors to investment. Since the end of the cold war, countries around the world are seeking foreign investment and expertise to grow prosperous. There are many excellent models (e.g. Chile). The dust is being blown off decades old mining laws, in some cases they never existed and are being drafted from modern mining codes. On the positive side, many of these countries are highly prospective and have had no modern exploration. Existing exploration techniques work well leading to the rapid identification of prospects. On the negative side many don't have a history of mining, its associated skills requirements or fully understand or accept its social impacts. Different cultural rules and expectations can make mining operations risky for those companies not able to deal with differing social perspectives and aspirations. Australia itself is no exception to changing social expectations (e.g. Native Title and environmental pressures) .

We are in the early stage of global expansion where mining investment opportunities are still being analysed and the host countries adjusting to new philosophies of economic growth. Mistakes are being made and will continue to be made on both sides. It seems we are in for a generation long period of experimentation and adjustment before new trends will emerge. Several trends are however already apparent. Major mining companies are spreading their budgets across the world and increasingly devolving authority for those budgets internationally. This means Australia is receiving a reduced proportion of these exploration dollars. There is also a growing trend for the majors to contract out everything from exploration to mining. This raises interesting questions as to how they will evolve in the future. Junior companies are aggressively focused on gold in regions of proven prospectivity, where they have effective search techniques. With their ability to raise money on stock markets and their nimble, entrepreneurial flair they are currently a major force in the global minerals exploration business. Exploration companies big or small will eventually focus on prospective countries where investment policies and people skills exist to profitably and responsibly operate.

What are the implications of globalisation to the future development and application of exploration geophysics? There is currently a phase of exploration in under-explored countries using effective, proven techniques (e.g. stream geochemistry). Operational and technical difficulties associated with government policy, work practices, mountainous or jungle covered terrain, poor weather and new styles of mineralisation are the main challenges. This work has a reduced emphasis on geophysical techniques when compared to exploration in Australia In more mature or topographically difficult regions there is a progression towards solving barriers to effective exploration and an associated need for more sophisticated geophysical techniques, just as in Australia. For example the need for high altitude airborne geophysical surveys. This need will grow in all world class provinces as they mature resulting in new impetus for geophysical research. Another force is the increasingly international spread of exploration budgets and reduced exploration focus on purely Australian exploration problems. Research from both majors and juniors is becoming more targeted on short term problems. In the case of the former companies this is increasingly being carried out through internal research or one-to-one collaboration with contractors seen to be expert in their field. There is a threat to longer term research in areas important in progressing toward being more predictive explorers. Australian based research institutions must find a way of aligning themselves with the global aspirations and associated exploration problems of exploration companies. This may be a problem with government funding if a benefit to Australia cannot be demonstrated. The basis for highly successful collaborative research in Australia is shifting. On the positive side, a sizeable section of the worlds mining exploration geophysics expertise is to be found in Australia and will need to be accessed as a part of future research initiatives.

The trend of globalisation is extremely positive for the minerals exploration business and for exploration geophysics. The industry has never been so buoyant. The adjustment pains of the Australian exploration industry as it seeks its new place in the world scene have a way to go. This is yet to flow fully into the R&D section of the industry. The challenge is to be able to see the new world order, its challenges and to quickly adjust to those challenges. History shows it is notoriously difficult to judge future trends from the perspective of our own time. However, we as geophysicists have much to offer in meeting these challenges. The lessons we have learnt from the past can help us adapt to the future. We must continue to push leading edge geophysical exploration in Australia. We must be willing to spread this knowledge into the world to meet the challenges associated with applying exploration geophysics to new environments and targets. This especially applies to our growing ability to integrate geology, geophysics and geochemistry leading to more geologically intuitive geophysical products and interpretation. If we take an international perspective, we will have much to teach, much to learn and will find the journey both professionally and culturally exciting and rewarding.

The Role of Government in the Exploration Kitchen: Leavening the Mix Without Spoiling the Dough

Dr Garry G. Lowder

Director-General
NSW Department of Mineral Resources

Abstract

There is a long though somewhat chequered history of association between the mining industry and government in Australia. This goes back at least to 1851, when the discovery of gold at Ophir, near Orange in NSW, was first officially recognised and rewarded. That reward was the result of a government incentive to encourage exploration in this country and stem the flow of people, and exploration, offshore to the mother lode country of California. Over the next 100 years or so, as the Australian mining industry grew, governments of the day continued to play a key role in encouraging that growth, though commonly in a rather paternalistic manner. Today, mining is Australia's most internationally competitive industry and as a new millennium approaches, it is appropriate to ask what now is the proper role for government and should it have a role at all? Nowhere are these questions more pertinent or more hotly debated than in the exploration sector of the mining industry, where competition is keenest and opportunity for wealth creation greatest.

To consider the role of government in mining and especially in mineral exploration properly, it is necessary to look first at the nature of mineral resource ownership and regulation in Australia. For the most part, minerals are owned by the Crown, which has a custodial role on behalf of the community. That custodianship is managed in each state by a mines department, which in effect contracts out to the private sector, that is to the mining industry, the process of finding, developing and

producing minerals from each state's natural endowment of resources. This is done through a system of mineral titles that assign property rights in return for certain undertakings, including the payment of royalty, given by title holders.

As custodians, governments are both financial and political stakeholders in the mining business and therefore government regulation can be seen as protection of self interest rather than unwarranted interference in private sector enterprise. The problem is that many potential hazards lie in the need for government to be accountable to the community for the way in which it manages its resource custodianship, including its regulatory role. Over-regulation in response to community pressure is a constant threat, especially in the face of agitation from those with anti-mining agendas. State mines departments have a critical role to play in providing timely and factual advice to both the community and government about the nature and value of mining to the community and the nation's economy. They need to act as advocates, not so much for the mining industry as such, but as advocates for mining itself as an essential and valuable part of the Australian economy.

In today's highly competitive world, where many jurisdictions are competing with one another for resource investment, governments can not afford to remain passive towards the mining industry. The political imperatives of job creation and economic growth require governments to provide direct incentives for private sector investment and to remove disincentives wherever possible. Such incentives could include financial inducements by way of subsidy or tax concession, but these are very subject to political whim and can be taken away as easily as they were given. Far better is the provision of pre-competitive, high quality regional geoscience data, by way of geological, geophysical or other resource related spatial information. The provision of such data is irreversible and represents a true level playing field for all participants in the industry, whether large or small.

Fortunately, this is the direction chosen by most states in recent years as they have developed their various exploration initiatives and the expenditure of around $100 million over five or six years in the generation of new, state-of-the-art geoscience mapping has created a once-in-a-generation opportunity for explorers across Australia.

World's best practice is a term often used in relation to the way the mining industry goes about its business. Governments, too, need to recognise that they are required to demonstrate world's best practice in terms of their own role in resource development, achieving a balance between regulatory zeal and unbridled promotion that delivers the greatest good for the greatest number over the longest term.

Multi-disciplinary Studies In The Search For Graves

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Abstract

One task of criminal investigations concerns searching for and locating clandestine evidence, often buried. This task is traditionally undertaken based on information provided by informants, witnesses and psychics. Resultant searches are time consuming and may be destructive to crime scenes. Any non-destructive methods capable of reducing time spent on searches are of prime interest to the law enforcement community. Remote sensing methodologies, including geophysical surveys, are currently being applied with great success in archaeological and environmental investigations. These methodologies, with minor modifications, are also being applied to forensic investigations and have shown promising results.

In 1986, Colorado law enforcement officials were presented with the following situation; according to rumour and a confidential informant, approximately a dozen bodies, allegedly interred over the course of several years, were buried over several square kilometres on a large ranch. How could law enforcement best approach the problem of locating these clandestine graves and associated evidence while preserving the evidence to maximise its eventual use in a court of law? The above incident was a catalyst for the formation of Project PIG ("Pigs In Ground"), because of the limitations found with the traditional law enforcement methods used to locate clandestine graves.

Since 1987 approximately 20 pigs have been buried under controlled conditions in an area south of Denver, Colorado. Remote sensing data has been continually acquired since prior to burial to the present time. This data consists of aerial photography, airborne and ground-based thermal and colour infrared, MAG, EM and GPR surveys. Additional data consisting of soil gas and self potential (SP) surveys was also obtained during the initial years. The remote sensing data is supplemented by geological, entomological, biological and meteorological surveys.

Monitoring with MAG surveys after interment demonstrates that these surveys can be used to detect areas of excavation, even when ferrous materials are not present. This effect, a MAG anomaly, appears to be directly related to a reorientation of magnetic soil particles upon backfilling the graves. EM surveys have proven more useful than MAG, as ground conductivity changes over graves due to increased porosity of the backfill materials. A number of EM anomalies have been recorded in proximity to some of the graves, in areas of scrub oak. These anomalies, which are time-variant, appear to be a function of moisture transportation and retention by the scrub oak root systems. GPR surveys have proven very useful in mapping soil changes and/or excavation patterns. Initial work at site demonstrated that standard soil gas and SP surveying have limited applications.

Abstracts

Jackson 3d Seismic Survey - Technical And Commercial Challenge

Ms Hege Rogno Smith

Abstract

The Jackson 3D Survey was acquired in 1993 and covers three producing oil fields in Naccowlah Block, Queensland.

A total of 58 wells had been drilled within the survey limits prior to the 3D seismic acquisition. The aim of the programme was to identify remaining development and enhanced oil recovery opportunities in these mature oil fields. A detailed geological study and reservoir engineering review were integrated with the 3D seismic interpretation.

The Jackson field is one of the largest onshore oil fields in Australia with 43 wells in production. The bulk of the oil comes from the Jurassic Westbourne Formation and Hutton Sandstone which occur at depths between 1100 - 1350m below MSL (860 - 1060ms two way time).

In addition to the improved structural definition the survey was able to resolve significant stratigraphic complexities at reservoir level.

The 3D seismic amplitude variation of a continuous peak reflector in the Late Jurassic Westbourne Formation is interpreted to be associated with fluvial channel development. A set of time markers established from well control demonstrates that the mapped reflector corresponds to a lithological change following onset of reservoir sand development. This Westbourne Formation reflector represents a progressively younger section from west to east and an eastward-stepping, transgressive stacking pattern was established within this fluvial/lacustrine setting.

Furthermore, the bright amplitude events showed good correlation with both Kh product and cumulative production and it is postulated that strong peak amplitude is indicative of good sand quality within the Westbourne reservoir section. Two well locations based on this model are anticipated to be completed prior to presentation of this paper.

The 3D data also proved useful in identifying Birkhead Formation scour channels in the upper part of the Hutton Sandstone. These scour channels are generally not productive and had not previously been recognised. The mapping of these features is vital in the understanding of the Upper Hutton Sandstone reservoir behaviour.

Keywords: Eromanga Basin, Jackson oil field, 3D seismic amplitude, sequence/seismic stratigraphy, production data integration, seismic forward modelling.

3-D Prestack Time Migration - an Application to the Ravva 3-D Dataset, Offshore India

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Abstract

The Ravva oil and gas field is located offshore eastern India in the Krishna-Godavari Basin. Command Petroleum (India) Pty. Limited was granted operatorship of the field in October 1994 by the government of India, on behalf of a Joint Venture consortium that includes Oil and Natural Gas Corporation (ONGC) Ltd, the Indian national oil company, Videocon Petroleum Ltd and Ravva Oil Ltd (Marubeni). The Joint Venture is developing the Ravva field with the immediate aim of increasing daily production from the present level of 3000 bbl of oil per day to approximately 35 000 bbl of oil per day by the end of 1996.

One of the first geophysical projects to be initiated in the development plan was reprocessing of the Ravva 3-D seismic dataset, acquired in early 1990 using a single streamer/single source configuration. The geography of the coastline and the shallow water depths in the area (<20 m) required a shooting direction that was predominantly in the strike direction but somewhat oblique to the main structural elements of the field.

This reprocessing project was initiated to achieve an optimum dataset for siting of the development/exploration wells over the next two to three years. Recent developments in computer hardware and the applications to 3-D seismic data processing have allowed the implementation of 3-D prestack migration to develop into a usable process for the practising explorationist.

The reprocessing project is described, with particular emphasis on the testing and analyses that led to use of 3-D prestack time migration to image the data volume. Examples show the improvements in stacking velocity definition and seismic imaging that have been achieved using 3-D seismic processing techniques that were not practicably available when the dataset was initially processed in 1990.

The Vanuatu Mineral Exploration Initiative

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Abstract

The acquisition and release of airborne magnetic and radiometric data and digital elevation data acquired over the Republic of Vanuatu during 1994 has significantly increased mineral exploration in this island nation which

has a recognised potential for significant copper and gold deposits. The geophysical database will also provide a basis for long term studies of geology, groundwater resources, geohazards, geothermal and hydrocarbon potential and landuse capabilities.

Application of Enhanced Airborne Radiometric Data for Geological Mapping in Khanom Area, Southern Thailand

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Abstract

The Khanom area (255 sq km), Nakhon Si Thammarat province, southern Thailand, which is mainly covered by inferred Precambrian gneissic (and/or granitic) complexes, was chosen for a systematic detailed study by airborne radiometric method due to its uneasy accessibility. Airborne radiometric (K, eU & eTh) data of the study area were processed, enhanced and interpreted on a scale of 1:100,000. Since various rock types yield different values of radio-concentration depending upon their mineral compositions, therefore, several kinds of multicoloured radiometric maps are produced. It is quite cleared that felsic igneous rocks yield higher radio-concentration than those of the mafic ones. In addition, the other factor that controls the distribution of radioactive elements is their properties on mobility in different environments. Hence, ratios of radio-elements have to be applied for the map production. The results clearly indicate that different phases of granitoid rocks can be distinguished according to the radiometric parameters. This method can be, therefore, an essential aid for detailed mapping in granitic terranes.

Airborne Geophysics & Remote Sensing as a Modern Exploration Tool in the Philippines

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1. *Chase Minerals (Philippines) Corp.*
2. *World Geoscience Corporation, Jakarta*

Abstract

A detailed helicopter-borne geophysical survey was flown in March 1996, over the entire Chase Minerals - BHP Batangas Financial and Technical Assistance Agreement (FTAA) permit area in South Luzon, Philippines.

Investment from the private sector in detailed surveys of this type, and the Integration of remote sensed data, has been encouraged by the change in the mining laws with the promulgation of a new Mining Act in 1995, which has allowed foreign ownership of large Individual permit areas up to 81,000 hectares.

The Batangas FTAA permit area covers the Taysan porphyry hosted copper and gold deposit that has a calculated resource of 403 million tonnes at a grade of 0.29 % copper and 0.23 g/t gold at a 0.2% Cu cutoff. The deposit is located on the margins of a large dioritic batholith approximately 20 km x 12 km in size, and elongated in a NW direction. Mineralisation as chalcopyrite and lesser bornite occurs as disseminations and in fractures associated with sericite + chlorite alteration that overprints an earlier biotite and orthoclase and magnetite zone, localised around porphyritic quartz diorite stocks. The stocks, alteration and mineralisation have a strong NW trending structural control.

Regional broad spaced fixed wing aeromagnetic data had been acquired over Batangas as part of the 1980's pan Philippines study and in 1995, a trial helicopter borne survey was conducted at the deposit itself. This helicopter survey clearly delineated the orebody as a magnetic and radiometric anomaly, as expected. The 1996 survey should permit rapid evaluation over the entire permit area and assist in the identification of repetitions of the known orebodv - particularly in areas mantled by recent ash, where conventional surface techniques are inadequate.

The 1996 survey was conducted by world Geoscience Corp. Ltd (WGC) of Perth, Australia, using a state of the art stinger mounted magnetometer - the first time a helicopter stinger-mounted magnetometer system has been used. The helicopter was a twin bladed Bell 206 L3 Longranger, operated by A. Soriano.

The geophysical equipment mounted on the helicopter included the stinger, carrying a Scintrex VIEW 2321/CS-2 caesium vapour magnetometer, and within the fuselage a PGAM spectrometer interfaced to two NaI crystal packs with a volume of 33.5 litres, for radiometric data. Navigation was via GPS.

Data generated from the survey includes total magnetic field (including reduction to pole transformations) radiometric data, and topography from a digital terrain model. The airborne geophysical data has been integrated with remote sensed data collected from the latest generation Radarsat from Canada.

A satellite image was programmed over the location and the resulting image rectified to ground control by reference to GPS stations. The data have been interpreted for structural information and drainage, and further integrated with the results from the airborne geophysical programme.

Geophysical Indicators of Controls on Soil Salinisation and Implications, Longford Basin, Northern Tasmania

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Abstract

A SIROTEM survey and experimental petrophysical data from drill cores have enabled a study of apparent conductance anomalies in and around the Longford Basin of northern Tasmania. Within the basin depocentre, conductance anomalies due to thickness irregularity of highly conductive layers reflect stacking and migration of

fluvial systems. Outside the basin margins, conductance anomalies reflect changes in the conductivity of drainage bedload which is a function of watershed lithology.

The anomalously conductive Tertiary sediments have three possible sources for stored salt: inheritance from erosion of conductive Triassic red bed sequences in the Tertiary basement; relict meteoric salt from proximity to a drowned estuary; or ions released from extensive lateritisation of lavas after a period of Eocene to Miocene basaltic volcanism.

Keywords: TEM; soil salinisation; Tertiary sequences; onshore basins; Tasmania

SALTMAP a sound technical basis for catchment and farm planning

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Abstract

Salinisation of agricultural lands is the largest environmental problem in Australia. In Western Australia alone around 9% of once productive land is now salt-affected and this will grow to around 15% in 15 years. The degradation of farming land has spawned the Landcare movement in Australia, a unique development to alert the community on the problems and their solutions. The growth of this movement has created a call for better information. Salt is concentrated in the landscape over geological time scales and the mapping of these salt concentrations (salt storages) requires geological exploration techniques.

SALTMAP. A new airborne electromagnetic system was developed specifically to map conductivity variations in the near surface. The data collected by the system can be directly related to the concentrations of salt in the regolith. When used with other datasets such as satellite images, airphotos, magnetic data, radiometric data and topography the SALTMAP conductivity gives an insight into the processes that lead to areas becoming saline. Remedial measures can then be designed with a sound technical basis.

Surveys using airborne electromagnetics have been carried out in 20 areas prone to salinity using the QUESTEM and SALTMAP systems. At Broomehill in the south west of Western Australia. The farmers have developed farm plans for sustainable agriculture based on the results of a SALTMAP survey.

The Broomehill Project was a joint research and development project carried out by World Geoscience Corporation in conjunction with the farmers of the West Wadjekanup and Byenup Hill Catchment Groups and with Department of Land Administration, Department of Agriculture and Landmark Resources.

At the commencement of the project it was recognised that airborne geophysical data including SALTMAP conductivity was not sufficient to develop new farm plans. Therefore around 14 datasets all well located were collected as part of the project. These included data which reflects many influences such as cadastre and the extent of remnant vegetation and surface information such as rectified airphoto mosaic, SPOT satellite data, digital topography, soils maps etc. These are the datasets which are commonly used in land management planning throughout Australia. At Broomehill however information was also collected using the SALTMAP airborne electromagnetic system which indicates geophysical datasets such as magnetic survey maps which reflect geology and radiometrics which allows the skilled interpreter to determine the type weathering process that formed the landscape.

When combined with surface information these data can then be used to formulate farm plans on a sound technical basis with a high degree of confidence in their success in combating land degradation.

The challenge for land management planners of the future and for surveyors is to create paddock farm catchment and possibly district plans based on better technical and better located data than has been available in the past. Integral to this kind of planning in salinity-prone areas is a good understanding of where the salt is stored in the surface. Only SALTMAP can provide this on an economic scale for catchment groups.

A method for stacking 3-D swath data from a 3-D dipping horizon, without the need for velocity analysis

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Abstract

The Generalised 3-D Normal Moveout (GMO) equation has been developed for a single, three dimensionally dipping horizon, in which the velocity term has been separated from the dip term. The velocity term is the medium velocity above the chosen horizon whereas the dip term is partitioned into orthogonal dip directions. If a method could be found to establish the dip terms in the equation, then a single velocity term could be used to stack 3-D swath data, without the need for velocity analyses.

Firstly, a 3-D field method was devised in which the true dip of a reflecting horizon and its azimuth could be measured within a survey area. The method required a single horizon whose velocity was known, assuming a constant dip throughout the area. Two orthogonal swath surveys were then recorded, generating two orthogonal Common Midpoint (CMP) lines. The GMO equation then corrected data to a zero-offset coordinate origin point. An optimum value of dip and strike provided the best reflection line-up at the origin, producing the value of true dip and its azimuth for that horizon.

A physical model was used to demonstrate the method, which was able to predict dips and their azimuths to within half a degree. The two orthogonal CMP lines were then correctly stacked using the variable 3-D dip information only, without a need to perform a velocity analysis, and the method shows potential for use in stacking low-fold data.

Keywords: seismic, dip, NMO, GMO, 3-D, swath, CMP, moveout.

Some Causes Of Artefacts In 3-D Seismic Surveys

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Abstract

Artefacts in final processed 3-D seismic data volumes are becoming more frequently reported because such datasets are used increasingly in reservoir management projects. These artefacts commonly take the appearance of amplitude variations which are not due to geology. This leads to confusion and some loss of detectability when using data in amplitude studies, as in stratigraphic plays. They may also demonstrate structural features, usually small-scale, which again do not depict geology. In this paper, a description of some causes of such artefacts are complemented with suggestions made on methodologies for minimising, if not eliminating, their effects. Practical examples of artefacts are shown to demonstrate these effects. Guidelines are given with respect to aspects of field survey design such that these designs will have minimal effect on data interpretability.

The implications of recent techniques on survey design are also investigated, in particular, the introduction of DMO in the Radon domain has considerable impact on survey designs as it allows the use of wide azimuths and irregular offset sampling. Also certain processing-induced artefacts are described, with suggestions given as to means of reducing or eliminating them

Keywords: artefacts, 3-D seismic surveys, survey planning

Efficient 3-D imaging beneath complex water bottom topography

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Abstract

Complex overburdens are a common feature in many regions of exploration interest. In such regions the shallow velocity field may have severe lateral velocity gradients, even though the underlying structure is often relatively simple. Time imaging is inadequate due to the large temporal distortion of the overburden on the deeper reflections. Thus depth migration is necessary to produce a useful image.

Depth migration requires an accurate velocity-depth model. 3-D velocity field estimation remains a topic of intense interest and research. Established 2-D iterative techniques based on post-migration offset consistency have been extended to 3-D. However, for areas in which a structurally regular region underlies a well-defined complex overburden, such general methods can be replaced by a more efficient technique.

We have developed a 'single pass' approach to the problem. The data is initially prestack depth migrated with an accurate shallow model and an approximate deep model. Residual moveout is picked from the migrated gathers, and the data is moveout corrected and stacked. The dependence of these picks on the deep model error is the basis for our model updating algorithm. Using a derived relationship between residual moveout and model error, the residual moveout picks are globally inverted with a constrained least squares algorithm to obtain an accurate deep model. Any additional information, such as well velocities, may also be included in this inversion scheme. The stacked data below the base of the shallow model is demigrated with the initial model, and then remigrated with the updated model. The result approximates that which would have been obtained by prestack depth migrating with the updated model, but at a greatly reduced cost, since the prestack migration was not repeated.

A second pass of prestack depth migration is useful, however, to validate the accuracy of this model updating technique, and to demonstrate the effectiveness of the post-stack imaging step described above. For this reason, we have applied the single pass method to both 2-D synthetic and field datasets, and have compared our results with those obtained from a second prestack migration. In addition to these results, the conference presentation will consist of an overview of the method in 2-D, and a discussion of the applicability of the technique in 3-D.

Exploration For Copper-Gold Deposits In The Sultanate Of Oman

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Abstract

Copper mining has occurred in the Sultanate of Oman since the third millennium BC in sporadic episodes. Current mining operations and exploration have resulted from recent (post 1970) recognition of gossans and ancient mining centres plus the economic benefits of modern concentrator and smelting processes.

Copper-gold deposits in Oman are inherently low grade and small tonnage in nature, however, they occur in clusters along predictable structural zones at or near to specific volcanic horizons. The accumulated tonnages, from numerous deposits in close proximity, impacts on mining economics and is the reason why initial exploration was focused near known mineralised zones.

Airborne magnetic (and radiometric) surveys were contracted, by the Ministry of Petroleum and Minerals to World Geoscience Corporation, to map the geology and structure of prospective terrains in Oman and to recommend anomalous zones for ground follow-up. Several magnetic anomalies, close to the Hayl-As-Safil deposit, were chosen for exploration using modern transient electromagnetic (TEM) and induced polarisation (IP) techniques. Orientation fixed-loop TEM surveys were conducted over known deposits to calibrate the methods and determine typical response parameters.

Near Hayl-As-Safil several TEM anomalies, of relatively low - moderate conductivity, were delineated by the surveys and tested by drilling. The programme produced three new copper/gold zones (in excess of 4 million tonnes) of higher than usual grade (greater than 1.5% copper and 1g/t gold) which almost doubled the shallow ore reserves in the vicinity.

The largest of these deposits, Al Bishara (2 million tonnes of 1.19% Cu and 0.83g/t Au) was detected as a broad (225m diameter) TEM anomaly that was not detailed prior to drilling in the 1994/5 season. Quantitative interpretation of the in-loop TEM data indicated an additional deeper source and other zones of interest, within the anomaly closure.

A gradient array IP survey was conducted, in the 1995/6 season, and showed at least three discrete mineralised zones within the area of the broad TEM closure:

1. a broad chargeability anomaly defining the Al Bishara mineralisation
2. a linear trend (of high chargeability) outlining a Au-bearing gossan zone that included 500,000 tonnes of 5g/t Au at shallow depth
3. a fault off-set continuation of the Al Bishara mineralisation.

These mineralised zones, and other anomalies from the gradient array survey, are still being evaluated by diamond drilling. The resistivity and chargeability data provided additional mapping information to help define the sub-crop extent of volcanic and sedimentary rocks.

The results vindicated the exploration efforts of the Ministry of Petroleum and Minerals and confirmed the application of modern airborne and ground geophysics to cost effectively locate new zones of mineralisation.

Second Horizontal Derivatives of Ground Magnetic Data Applied to Gold Exploration in the Yilgarn Craton of Western Australia

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Abstract

Ground magnetic surveys for gold exploration in the Archaean Yilgarn Craton of Western Australia are rapidly being replaced by low-level, high-resolution, fixed-wing and helicopter aeromagnetic surveys for detailed geological mapping of large areas. However, for exploration of areas that are either small, or where the buried magnetic sources are located near the surface, or where the magnetic response of the regolith is of interest, ground magnetic surveys are required in order to measure the high-frequency magnetic responses associated with these environments. Surface and subsurface geological features are often of interest when exploring for near-surface gold mineralisation.

Earlier work, by S. Mudge, has shown that bipole plots of second horizontal derivatives of aeromagnetic data are effective in resolving detail in aeromagnetic data. These have been applied to ungridded ground magnetic data and are effective in resolving high-frequency detail in the magnetic responses of subsurface rocks and the regolith. The large high-frequency component of ground magnetic data acquired from maghemite-rich regolith areas presents different and often difficult data processing and presentation problems compared with data acquired from higher-level aeromagnetic surveys. Despite this, second horizontal derivatives of ground magnetic data resolve important detail of magnetic subsurface rocks and the regolith that would otherwise be lost in images and contours of the gridded data.

For an area in the Kalgoorlie district of Western Australia, data from a ground magnetic survey and a low-level aeromagnetic survey were transformed with the second horizontal derivative filter to reveal different degrees of resolution of magnetic sources located in the regolith and the subsurface. Line profiles, and images and contours of the gridded data, from both surveys resolved subsurface sources which have assisted with the identification of drill targets. Importantly, however, magnetic features in the regolith were only resolved in the enhanced ground survey data which has assisted with geological mapping of the regolith.

Keywords: aeromagnetic data, bipole map, gold, ground magnetic data, horizontal derivative, maghemite, regolith, Yilgarn

Exploration for Tertiary Palaeochannels with Geophysics, Mount Keith Area, Western Australia

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Abstract

The supply of water to mining operations in arid areas is critical to their viability. The Mount Keith nickel mine occurs in such an area of the Archean Yilgarn craton about 400km north of Kalgoorlie in Western Australia. It is a large, low grade, open pit mine commissioned in late 1994 with a mill capacity of 6 million tonnes per annum, and a planned life of 20 years. The main sources of process water are sand aquifers at the base of Tertiary palaeochannels beneath 80 - 100m of cover, and two borefields extending over total channel length of 60km supply the operation currently.

Several phases of exploration for a suitable water supply have been carried out since the deposit's discovery in 1959. Early programmes used resistivity, gravity, seismic refraction and traverse drilling with limited success.

WMC acquired the deposit in 1993 to establish a mining operation and proving an adequate supply of water became an immediate priority. In the Albion Downs basin to the west and South Lake Way to the east, extensive gravity surveying with followup drilling allowed the channel axis to be traced progressively as a local gravity low. However, the gravity data were not diagnostic in some areas where the channel meandered significantly, where its valley was less incised, and where lithological contrasts in the basement complicated the response.

To expedite work here, a Dighem helicopter electromagnetic survey was flown to map the clays which overlie the sand aquifers and fill the valleys. This method was particularly successful in the South Lake Way basin where there were no modern, saline drainages to mask the palaeochannel's response.

The history of this programme shows that exploration efficiency increased significantly when appropriate geophysical techniques were applied, and that a single technique is often not appropriate to all the geological settings encountered along the length of a pelaeochannel.

A New Resolution Index for Resistivity Electrode Arrays

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Abstract

Historical arguments about the "sensitivity" of an electrode array to different volume elements in the subsurface have been satisfied by the concept of signal contribution sections, although they address only homogeneous earths. Similar arguments on the "depth of investigation" of various electrode arrays have been put to rest by the concept of effective depth. The effective depth is a well-defined characteristic of the vertical response function of an electrode array obtained by integrating horizontal planes of the corresponding signal contribution section. Debate on the "resolution" of various electrode arrays has not reached a firm conclusion. The ranking of arrays in order of resolution power varies according to the definition of resolution. A new resolution index is proposed here. It builds on the successful effective depth concept by introducing new concepts called effective thickness and extended depth. The index is quantified by formulating the cumulative vertical response function of a general electrode array. The dipole-dipole arrays are found to have the best vertical resolution, and the Schlumberger array is found to be better than the conventional Wenner array.

Keywords: resistivity, effective depth, resolution

A Synthetic Study on Crosshole Resistivity Imaging Using Different Electrode Arrays

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Abstract

By means of numerical simulations, the possibilities of crosshole resistivity imaging with different survey geometries are investigated for three- and four-electrode arrays. The sensitivity variation for the different arrays and the effectiveness in crosshole resistivity imaging with such data are examined. A comparative analysis was carried out by computation of the sensitivity function and anomaly effect, and a synthetic model was used to test the image reconstructions. It is shown that for crosshole resistivity imaging, some specific three- and four-electrode configurations, such as AM–N, AM–B and AM–BN, can be employed. These configurations, compared with the pole(pole survey, have quite different sensitivity patterns in the detection area and anomaly effects to the target between the boreholes. The sensitivity and the anomaly effect can be adjusted by choosing the separation of the electrodes of the array and conducting scanning observations. The synthetic imaging experiment demonstrates that data from these configurations can be used to reconstruct the image of the target between the boreholes. These kinds of measurement configurations yield greater flexibility in crosshole resistivity imaging.

The Use of Constraints in Geophysical Tomographic Reconstruction

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Abstract

A significant problem with geophysical tomography is that the image reconstruction problem does not usually have a unique solution, given the measured data. A number of tomograms can be consistent with the measured data because of the limited access available for taking measurements. It is necessary to introduce additional information into the reconstruction process in order to find a unique solution.

A common approach is to choose the solution that optimises some objective function. However, such criteria (e.g., minimum norm and maximum entropy) are not necessarily consistent with the geology. Other prior information is usually available which is consistent with the geology, much of which can be expressed in the form of constraints which define sets of images, called property sets. The intersection of the property sets contains feasible solutions. Set theoretic estimation finds solutions in this feasibility set which are consistent with the measured data and all prior information.

A number of tomography algorithms used in geophysics fit into the category of set theoretic estimation techniques. This paper gives an introduction to some of the concepts that are common to these techniques and compares several reconstruction algorithms, using straight-ray synthetic data.

Keywords: tomography, tomographic reconstruction, tomographic imaging

Imaging Properties Of Modern 3-D Seismic Acquisition Systems1

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Abstract

Significant cost reductions in data acquisition have resulted in widespread use of 3-D seismic data. Improved technology, economies of scale, and innovative 3-D survey designs have all contributed to cost reductions. Perhaps the most important of these innovations has been the efficient use of sources and cables in land, marine, and transition zone acquisition for increased productivity. Indeed, the number of CMP lines acquired per shot line generally is just the product of the number of source liens and the number of cables or receiver lines. Thus for reasons of productivity, the seismic industry strives for more receiver lines and/or source lines within the basic acquisition layout, which in turn generally implies wide configurations.

While the advantages of wide geometries are sometimes clear from an economic standpoint, the geophysical properties of the resulting seismic data are not always well understood. Wide acquisition geometries are not inherently either good or bad; the answer depends on the particular aspect of the data in question. We will

concentrate on the subsurface illumination and imaging quality of a 3-D survey design. Imaging quality generally depends on many factors, not the least of which is the actual subsurface geology. However, in practice certain geometries, for example wide marine geometries, can have very irregular subsurface illumination patterns and serious sampling deficiencies in the form of dip and azimuth-dependent shadow zones (Beasley, 1993; Varmeer, 1994). In this paper we examine several acquisition geometries including marine, land and transition zone in light of their subsurface illumination properties. This comparative study shows that the typical 3-D geometries, wide-tow marine geometries suffer from significant shadow zones while much wider land and transition zone geometries generally do not.

Accurate 3D DMO for Land and Patch Geometries: A Practical Approach and Application to Multi-fold Field Data

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Abstract

Recent work by Vermeer et al (1995) has provided a clear theoretical basis for the application of 3D DMO to data with varying shot-receiver azimuths. They show that, for the cross-spread geometry, the locus of contributing midpoints for a given output point is a hyperbola in the (x,y) plane passing through the output point. They further demonstrate that, in practice, the input traces will not generally be located exactly on the appropriate hyperbola, implying that the DMO operator will not be correctly sampled at the output point. This gives rise to poor cancellation of DMO smiles, leading to distortion of signal amplitudes, loss of frequency and a reduction in the signal-to-noise ratio.

Conventional 'input-orientated' 3D DMO techniques operate by 'smiling' an input trace along the direction of the shot-receiver azimuth. The DMO operator is discretely sampled at regular intervals along the azimuth and the 'smile traces' collected into their respective CMP bins.

Since the input points do not, in general, lie along the required hyperbola in the (x, y) plane the operator at each output point is not well sampled and this results in DMO-generated noise and distortion of signal amplitudes.

The ideal solution to this problem would be a fully output-orientated DMO implementation, computing input traces along the appropriate (x, y) hyperbola, for each output point (Vermeer, 1996). The output-orientated approach is the more correct because it ensures that input traces contribute exactly to a given output location (not merely to the output bin, as would be the case with the input orientated approach), and that the operator at the output point is well sampled. The drawback of this approach is that every output point requires different input points so that a near continuum of recordings is required.

Our approach to this problem is to pre-condition the input data so that it more closely matches the correct hyperbolic loci as described by Vermeer (1995, 1996). By recognising the pattern of the geometry in this way, an accurate 3D DMO can be achieved for many multi-azimuth geometries. Results will be shown for synthetic and field data.

Keywords. 3D DMO, Land geometry, Patch shooting, Cross-spread.

A New Dimension in 3-D

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Abstract

Using new interpretation case studies from the Ship Shoal area of the Gulf of Mexico and offshore Europe, it is possible to gain insights into enhancing and constraining the interpretation of 3D seismic data. Using digital horizons interpreted from a 3D seismic volume and high resolution gravity and magnetics data, an integrated and constrained 3D model can be quickly built and interpreted.

The acquisition of high resolution gravity and magnetic data in conjunction with 3D seismic surveys is now an accepted norm in Europe and is gaining acceptance in the gulf of Mexico. Over 300 OCS blocks of 3D-acquired gravity and major areas of high resolution aeromagnetic data have been recently recorded in the Gulf of Mexico or are now being acquired. The use of high resolution gravity in seismic velocity analysis, and the use of velocity grids for localised, focused density input to gravity models are now possible. A detailed example of a localised conversion of a velocity cube to a well tied density volume is provided from the South Additions, offshore Louisiana.

A brief review of instrumentation, processing techniques, costs and integrated workstation software applications is provided to set the framework for the interpretation case studies. Instrumentation has decreased in size and increased in sampling and resolution power. Processing of the data using high quality DGPS positioning data has resulted in a dramatic increase in resolving power for shipborne gravity, particularly at the high frequency end of the power spectrum. Workstation applications are now in use which facilitate the direct transfer of data and models between seismic and gravity/magnetic modelling software systems.

Finding Sphalerite at Broken Hill with DHMMR

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Abstract

The lode horizons north and south of the Broken Hill orebody contain several zones rich in sphalerite and poor in galena. One example is the new open-cut Potosi Mine on Pasminco Mining's Northern Leases, which averages

8.5% Zn and 2% Pb with little other sulphide. Such mineralisation is similar to the Zinc Lodes in the main Broken Hill orebody, which petrophysical testing has shown to be only weakly conductive.

The mineralisation at the Potosi Mine has been well defined by applied potential and IP surveys, but different techniques are required for deeper, down-plunge exploration. DHEM is routinely used but may miss those zones where sphalerite is almost the only sulphide. It was therefore decided to trial a series of drillhole magnetometric resistivity (DHMMR) surveys, since this method responds to contrasting, rather than absolute, conductivity. The results were very successful with all of the known sulphides (and some previously unsuspected zones) responding to the DHMMR surveys, at distances approaching 200m from the drillhole.

Several examples are presented which show that although the method has less resolution than DHEM, it is capable of locating bodies not seen by that technique at depths in excess of 1000m below the surface and unambiguously placing them above or below the drillhole. The results also suggest that the magnetic field, which responds to changes in resistivity has a much larger search radius than the phase angle which measures the IP effect.

DHMMR is expected to play a wider role in the Broken Hill district and elsewhere, in the search for sphalerite-rich orebodies.

Geophysical Signature of the Potosi Zinc-Lead-Silver Orebody, Broken Hill

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Abstract

The recently opened Potosi orebody is the first significant mine to be developed in the Broken Hill District since the discovery of the main Broken Hill orebody in 1883. A study of the geophysical characteristics of the Potosi mineralisation has been undertaken to assist in the search for further occurrences of this style of mineralisation in the Broken Hill district.

The Potosi zinc-lead-silver deposit occurs 2 kms along strike from the Broken Hill orebody and immediately below the main lode horizon within a sequence of amphibolite to granulite grade, altered metasediments and felsic and mafic gneisses of the Early to Middle Proterozoic Willyama Supergroup. It is a narrow, elongate, folded, stratabound lens which plunges shallowly top the north and is comprised of stringy to massive zinc-rich mineralisation hosted by psammitic, pegmatitic and siliceous gahnite-altered rocks. The million ton deposit, AT 8.9% Zn and 2.1% Pb, is being mined by open cut methods. Exploration for down dip potential is continuing with favourable results.

Extensive IP surveying during the 1960's utilising multiple dipole spacings appears to have detected the mineralisation with the smaller dipoles. However these responses were typical along the whole of the lode horizons on the northern mine leases. Although historic drilling intersected patchy high grade zinc mineralisation, its stratigraphic position and the lack of a clear IP response from the larger dipoles led to the area being given a low priority.

An applied potential survey was successful in outlining the orientation and strike extent of the sulphides. Hole to hole applied potential has been useful in confirming electrical connectivity between drill intersections as well as confirming no connectivity across fault structures.

Downhole EM surveying has had variable results with both well developed responses and little or no response being recorded close to mineralisation. The better developed responses are invariably due to galena rich zones. However, application of DHMMR has proved very successful in detecting zinc-rich as well as lead-rich mineralisation.

Other techniques that have been applied include aeromagnetics, high resolution ground magnetics and gravity. None of these surveys have a recognisable response. A sub audio magnetic/magnetometric resistivity survey showed subtle response in the MMR results which may be related to mineralisation and structure.

The pencil-like shape and physical characteristics (poorly conducting, non magnetic) makes this style of mineralisation a difficult regional exploration target. However, once intersected by drilling both applied potential and downhole MMR and EM can be utilised to successfully delineate its shape and extent.

Airborne magnetics, radiometrics and satellite imagery for regolith mapping in the Yilgarn Craton of Western Australia

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Abstract

The integrated use of airborne magnetic and radiometric data, and SPOT Panchromatic and LANDSAT Thematic Mapper satellite data has proved effective for regolith mapping in the Yilgarn Craton of Western Australia. They can form the basis for designing appropriate soil sampling and regional exploration drilling in gold exploration programs.

Horizontal derivative filters have been applied to airborne magnetic line data to enhance short wavelength magnetic responses of maghemite-rich lateritic weathering products within the regolith profile. Magnetised maghemite-rich pisolites often occur in buried Tertiary palaeo-drainage channels or within residual laterite horizons, and their distribution can be delineated with these filters. A new filter for magnetic data (REGMAG) is described that maps the distribution of short-wavelength responses and has proved effective in mapping magnetic structures in the regolith.

Ratios of airborne radiometric potassium and thorium channels, and ternary images of potassium, thorium, and uranium, are useful in highlighting the radiometric

signatures of various weathering products in the regolith. A new ratio normalisation algorithm improves the resolution of ratioed data.

Combined SPOT Panchromatic and LANDSAT Thematic Mapper satellite data are useful for landform mapping. Ratios of LANDSAT Thematic Mapper bands provide discrimination of various weathering products such as saprolite, pisolitic/nodular goethite and hematite-rich laterite, quartz and kaolinite rich alluvial cover, and red-earth calcareous clays.

Examples from the Archaean Yilgarn Craton of Western Australia show how these processing techniques can reveal valuable information from remotely sensed data which can assist with regolith mapping.

Keywords: aeromagnetics, gold, LANDSAT, maghemite, normalised ratio, palaeochannel, radiometrics, REG-MAG, regolith, SPOT, weathering, Yilgarn

Advances in MT and CSAMT for Deep and Shallow Ground Conductivity Imaging

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Abstract

Geophysical technology has seen rapid advances within the past several years in a wide range of disciplines. Only recently has it been possible to provide images of subsurface lithologic structure and fluid distribution at a scale that is useful for resource development and site management. This has had far reaching economic and environmental implications.

Significant advances have come in electrical methods like magnetotellurics. These techniques provide subsurface electrical conductivity images useful in mineral resource exploration, groundwater investigations, contaminant waste studies, and a variety of other engineering applications. The high sensitivity makes it possible to differentiate between fresh and salt water aquifers, to locate acidic leachate zones in landfills as well as to distinguish ore bearing zones in mineral exploration, which has been a long standing application of the technique.

In particular there are several reasons to consider using natural source or distant source methods. Modelling for complex two- and three-dimensional environments is much simpler for the distant source methods than for controlled source methods. Also since the natural field signal levels increase as the frequency lowers, greater source energy is available for probing deeper structures. Note that the more realistic inhomogenous earth requires continuous surface coverage to avoid spatial under-sampling.

Mineral exploration surveys have been performed all over the world demonstrating the resolution of the MT method. In addition to delineating the shallow features related to the conductivity targets, features of large deep regional structures are also sometimes indicated.

As additional groundwater resources are sought, the practice of selecting drill sites based upon prior experience is producing too many low quality, low productivity water wells. Siting wells based on surface magnetotelluric measurements and conductivity cross-sections has greatly improved the success rate of drilling and has provided a more objective means of selecting drill sites.

Keywords: magnetotelluric, controlled-source, conductivity imaging, groundwater

Processing Magnetotelluric Data with Modern Statistical and Numerical Techniques

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University of Queensland

Abstract

Magnetotelluric (MT) impedances are estimated from electric and magnetic field data using a Kalman filtering method. Unlike most of the methods currently used in processing magnetotelluric data, this technique is a time domain method which uses a linear, discrete-time filter to recursively obtain estimates of ground response. A three step procedure is proposed, which allows the incorporation of remote reference data.

The Kalman filtering technique is applied to the "active interval" subset of the standard EMSLAB magnetotelluric dataset, and the results are found to be comparable with those from other commonly used analysis methods for magnetotelluric data.

Keywords: Magnetotelluric, Kalman filtering, remote reference

Large-scale Electrical Conductivity Structure of Australia from Magnetometer Arrays

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Abstract

A wide range of sets of electromagnetic observational data (geomagnetic depth sounding and magnetotelluric sounding) now exist for the Australian continent. These data show regions of the continent where the conductivity structure is approximately one-dimensional on a gross scale, relative to zones, called "conductivity anomalies", where induced electric current flows preferentially.

Progress is being made in the development of a numerical method which inverts such observational data automatically, to give an image of the conductivity distribution of the whole continent, set in its surrounding seas. Thin-sheet algorithms, as developed by Weaver and Weidelt and colleagues, are employed, and conductance values are found for grid units in a sheet representation

of the continent which extends from surface down to depth 10 km. The grid units are typically 100 km in horizontal dimension. The model is solved by numerical inverse methods.

The advantages and limitation of this approach are discussed in the light of experience so far, using observed data in the form of Parkinson or Induction arrows, at a single period.

Keywords: Australia, electrical conductivity, geomagnetism, magnetometer arrays, thin-sheet modelling, geophysical inversion.

The Use of Sensible Velocities for Migration

Steven Carroll and Greg Beresford

Abstract

Conventional seismic processing is unable to properly image complex geological structures such as those found on the North West Shelf of Australia. Lateral variations resulting from faulting hinder complete imaging of the underlying structures. Prestack depth migration is the correct way to image such structures but requires very accurate velocity field information in order to do so. Prestack time migration and post-stack migration are quicker methods but they make assumptions that are quite often invalid. Rules are needed to identify the cases when simpler methods will work, and to decide the velocity models needed for each type of migration.

A synthetic seismic dataset was developed, based on the Oliver line from the North West Shelf of Australia, containing lateral velocity contrasts of 60%. Both time and depth algorithms were used to assess the amount of smoothing the velocity model was able to tolerate while still remaining suitable for interpretation. Migrating with a smoothed velocity can cause two undesired effects. Events can be mis-positioned vertically, and their amplitudes can be degraded. For different amounts of smoothing these two effects can be measured as a function of lateral position to evaluate the performance of the migration on the Oliver model.

Depth errors of 70 m and a 60% reduction in amplitude for a reflector at 2800 m resulted when the velocity was smoothed laterally over 200 m in prestack depth migration. The same smoothing resulted in a 40 ms time error with 50% amplitude reduction for prestack time migration. Rotating the smoothing to the vertical direction produced a 45 m depth error and an amplitude reduction of 40% for prestack depth migration. Prestack time migration produced results similar to those in the vertical direction.

Model-based velocity analysis

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Abstract

Semblance displays are commonly used to indicate the velocities required to flatten reflection hyperbolae during a velocity analysis of seismic data. "Model-based velocity analysis" is a scheme for interpreting semblance analyses that uses an elastic synthetic seismogram computed from a detailed depth model. The depth model is constructed from logs taken from an adjacent well. The semblance analysis of the synthetic and the P-wave RMS velocity function derived from the depth model are then used to guide the velocity analysis of nearby field records. Semblance analyses of additional synthetics, such as those computed without multiples, enable noise events to be more readily identified. Strong noise events remain identifiable on field data semblance analyses computed away from the well. A model-based approach thereby allows more effective extrapolation of the well-log information.

A model-based velocity analysis revealed that interbed multiples had been mistaken for primaries in conventional velocity analyses from the Gippsland Basin. The high amplitudes and lack of differential moveout of the interbed multiples relative to the primaries resulted in picks that were 5 to 10% lower than the stacking velocities of the primaries. Re-stacking using the model-based velocities provided far greater continuity across a 4 km seismic line from the Gippsland Basin that had been processed through to stack in the t-p domain.

Applying the model-based approach in the t-p domain allowed even further extrapolation away from the well. This was due to a dramatic improvement in the resolution of peaks when the semblance was computed in the t-p domain. The improvement resulted from the use of wide-angle reflections and the theoretical advantages of the elliptical moveout correction. Semblance analyses of field records showed a 2 resolution improvement in the target zone after the application of a point source t-p transform. A 5 resolution improvement was achieved at the shallow Miocene carbonates where the reflection ellipses were flatter and contained a supercritical segment that was muted in the t-x domain.

Keywords: velocity analysis, seismic processing, t-p domain, Gippsland Basin

DMO in the Radon Domain

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Abstract

A new dip-moveout (DMO) processing technique is proposed. The method is based on an integral DMO method in the Radon domain called Radon DMO, which is especially applicable to irregularly sampled 3-D datasets. Radon DMO offers several advantages for processing surveys with irregularly sampled design or acquisition characteristics, common problems for land and Ocean Bottom Cable 3-D surveys in particular. First, the Radon DMO operator is nonaliased and dealiasing. Missing traces do not cause spatial aliasing, precursor noise, or unbearable distortions of phase and amplitude. Second, Radon DMO does not require that input traces belong to one offset bin. Input traces can be organised from multiple offset bins in the same azimuth grouping to perform Radon DMO. Third, the DMO-corrected output can be either stacked or unstacked, which enables the full range of post-DMO processing including post-DMO velocity analysis.

The Radon DMO operator directly maps data from the NMO-corrected time domain to the DMO wavefield in the Radon domain. The impulse responses of Radon DMO are hyperbolas. The method is built upon a process that transforms a single, NMO-corrected trace into multiple traces spread along hyperbolas in the Radon domain. Most integral methods include the application of a 45° phase shift, as well as offset, time, and frequency-dependent gain factors when spreading the traces along ellipses. Such compensations are generally unnecessary with Radon DMO, which greatly simplifies program development and reduces the number of critical elements to control. By eliminating costs associated with gain factor application, the added costs for inverse Radon transform are alleviated. Total costs compare well with conventional integral DMO methods.

Keywords: DMO, 3-D, artefacts, irregular sampling, survey design, Radon, aliasing

Integrated Lithostructural Mapping of the Rössing Area, Namibia Using High Resolution Aeromagnetic, Radiometric and Landsat Data

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Abstract

This paper presents results of an integrated appraisal of recent high-resolution aeromagnetic, radiometric and remote sensing data over the Rössing mine area and lower Khan Gorge region of Namibia. The airborne geophysical data were acquired in 1995 by World Geoscience Botswana (Pty) Ltd., on behalf of the Geological Survey of Namibia as part of a European Commission funded project. Image processing and interpretation of the high resolution (250m line spacing, 80m flying height) data provide a fresh overview of the complex structure within the Damara orogenic belt, irrespective of regolith cover.

Structure around the Rössing mine was interpreted from stereoscopic aerial photographs and the regional structural setting was interpreted from high-pass filtered aeromagnetic data. Spectral Landsat TM data, total field magnetic intensity data and imaged airborne gamma-ray spectrometer data enabled the delineation of lithology. Resulting interpretation maps clearly show an hierarchy of polyphase folding, which had been described by earlier field mapping, and a hitherto-unrecognised system of late (post-F3) north-northeast oriented sinistral strike-slip faulting and associated northeast-oriented, southeast-vergent thrusting. Rotation of F3 fold axes from northeast to north-northeast orientations is common, and the overturning of F3 fold axes to the south of the Rössing mine may also be due to post-F3 transport.

Early Palaeozoic alaskitic intrusions of the type which host the world-class Rössing uranium deposit appear to be largely related to late sinistral transtensional ladder veins associated with the north-northeast trending post-F3 sinistral strike slip faults. The actual Rössing alaskite dyke swarm appears to be located within an east-northeast trending jog along a regional north-northeast trending structure, which separates two regions of completely different structural styles.

New Algorithms for Visually Enhancing Airborne Geophysical Data

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Abstract

The quadrature of a total magnetic intensity field (TMI) exhibits detail not evident in the TMI, the instantaneous phase of the TMI which maps continuity and which appears to have superior resolution to vertical gradient operators, the instantaneous frequency operator which maps character changes in the TMI. Fractional vertical derivatives have enhancement properties intermediate between the classical first and second vertical derivatives. Stabilised downward continuation allows continuation below shallow magnetic layers to enhance the magnetic effects of deep layers. Coherence filtering maps fault zones and anomaly axes. The magnetic mineral accumulations in the regolith may be mapped using appropriate non-linear filtering techniques.

Construction Of The Refraction Time Section By Convolution.

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Abstract

The great majority of seismic refraction data are processed with the first and occasionally later arrival times derived either by hand picking or by computer based algorithms. These traveltimes are used in a wide variety of processing and inversion methods which seek to determine the subsurface seismic velocity distribution. It is unusual to employ the complete seismic trace with most of the commonly used approaches.

We propose the convolution of two seismic traces, representing a forward and a reverse travel path, in order to derive a third seismic trace representing the time-depth function of the generalised reciprocal method (GRM). Two further steps of subtracting a reciprocal time, which can be treated as a static or base level shift, and of halving the time scale, which can be treated as a simple scaling operation, are required.

The major benefit of the convolution process is that it permits the amplitude information in the seismic trace to be employed in a convenient manner. The amplitude of each arrival is a function of the inverse square with distance spreading within the refractor, as well as the inelastic attenuation within the overlying layers. To a first approximation, convolution compensates for the inverse square with distance spreading, so that the resultant convolved amplitude reflects the various lithological variations above the refractor. Another feature of the convolution section is that it accommodates the second arrivals associated with high relief structures, thereby permitting greater resolution of those structures using the migration or imaging methods of reflection seismology.

However, a more important feature of the convolution section is that it addresses the problem of the very large variations in signal-to-noise ratios observed with each seismic field record. This problem is not usually considered in most inversion methods which employ forward and reverse traveltime data. The convolution process adds signal-to-noise ratios, thereby producing a resultant which more realistically reflects the quality and accuracy of the data and the processed data.

The major problems associated with the convolution section are related to noise prior to the first arrivals. The paper will discuss some of the noise reduction methods including predictive deconvolution, as applied sets of field data.

Rapid Automatic Determination of Shallow Velocity-depth Structure Using First Breaks and the Generalised Reciprocal Method

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Abstract

The generalised reciprocal method (GRM) is a convenient and substantial enhancement to the capability of the refraction method in dealing with irregular refractor interfaces with lateral changes in refractor velocity. Processing approaches have been developed which implement a fast automatic GRM-based approach and are capable of handling multifold refraction data such as that from long seismic reflection survey lines. A method is proposed for determining the resolution achievable with the velocity analysis technique as a function of the detector separation. This provides a means of optimising the resolution with spatially under-sampled data for most shallow exploration applications.

There are three major stages in this approach: the recognition through stacking coherency of individual layers within the multifold data, and the production of a single composite travel-time graph; the determination of the seismic velocities within each refractor using an automatic curve recognition technique, using the velocity analysis function to obtain the optimum geophone migration separation and to locate the lateral velocity variations within a refractor; and depth inversion in which a modified depth conversion factor is proposed to control the trade off between the vertical resolution of velocity layers and changes in layer thickness. This factor reduces spurious details in inverted depths layers and is stable when a layer appears or disappears in the section.

The approach has been tested successfully on both synthetic data and real data from the Kalgoorlie deep seismic reflection traverse. Results show that application of the techniques achieves better resolution than conventional manual interpretation, and provides a fast and direct inversion that appears to discount spurious detail.

Keywords: refraction, automatic GRM, resolution analysis, velocity-depth structure

Joint Application Of Seismic And Electromagnetic Methods To Coal Characterisation At West Cliff Colliery, New South Wales

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Abstract

Both seismic and EM measurements are used to provide information about the geometry of coal seams in advance of longwall mining. However, each method has limitations and the results may be capable of several different interpretations. An approach which is now common in such cases is the joint application of two or more independent types of measurements to help resolve ambiguity. This paper describes the application of long-offset transient electromagnetic (LOTEM) sounding in Australian coal mining at the West Cliff Colliery, New South Wales. A feasibility study was carried out before the field survey in order to obtain the optimum measurement parameters. The interpretaion of LOTEM data is based on both 1D and 2.4D automatic inversion techniques. Using prior information from seismic surveys and well logs, it was possible to map the electrical properties in coal seams. Since the electric properties are closely related to stress as well as water saturation in coal seams within the sedimentary pile, quantitative relationships between the changes in stress or water saturation and electrical properties can therefore be established. The results indicated that the progress of drainage and of stress advance in association with mining can be monitored by measuring the changes of resistivity in coal seams from the surface using the LOTEM method.

Seismic Processing in Areas of Complex Near-Surface Velocity Fields: A Case Study

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Abstract

The ability of a number of processing techniques to accommodate a complex near-surface velocity field

resulting from a highly irregular water bottom has been evaluated on seismic data from the Timor Sea. Conventional processing is not appropriate where such large lateral velocity variations exist. One approach is to effectively remove the influence of the irregular water bottom by replacing the water layer with higher velocity material and recomputing seismic travel times. Conventional processing can then proceed more successfully. The water replacement statics technique is a simple but efficient method for computing corrective time shifts. A more accurate algorithm to compensate for propagation effects of the near-surface velocity field is utilised in the wave-equation layer replacement technique. Both water-layer replacement techniques produce sections with increased horizon continuity and less structural distortion when compared to those generated using only conventional processing techniques. Although results from the two methods are similar in the present case, the wave-equation method is generally preferred because of its more realistic computation of travel-time corrections.

As an alternative to the water-layer replacement methods, prestack depth migration (PSDM) can be used to image seismic data in areas characterised by irregular water-bottom topography. However, PSDM is sensitive to the interval velocity model used for the migration. To achieve results which justify the computational expense of PSDM, considerable effort must be spent deriving an interval velocity model. In this study, an iterative migration/linear inversion scheme is used to construct an accurate model. PSDM based on this model produces a seismic section superior to those generated from the replacement techniques. Incorporation of high-resolution reflection topography into the model-building process is suggested as a means of further improving PSDM results in areas of complex near-surface velocity fields.

Keywords: irregular water-bottom topography, near-surface lateral velocity variations, replacement statics, wave-equation layer replacement, prestack depth migration.

Computation of principal directions of azimuthal anisotropy from P-wave seismic data

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Abstract

Principal directions for an azimuthally anisotropic medium are the directions along which the quasi P and quasi S waves propagate as pure P and S modes. For azimuthal anisotropy, induced by a single set of oriented vertical fractures, two of these principal directions are the directions parallel to and perpendicular to the fractures.

To investigate if conventional P-wave data could be used in fracture detection, we computed synthetic data for an isotropic Taylor shale over a fractured Austin chalk model. We found that the modelled P-wave reflection amplitude variation with offset has different slopes along different directions. We also found that the reflection amplitude at fixed offsets is periodic in 2, where is the orientation angle of the shooting direction with respect to one of the principal directions. For fracture induced anisotropy, this principal direction corresponds to the direction parallel to or perpendicular to the fractures. We use this periodic azimuthal dependence to obtain fracture orientation and a qualitative measure of the fracture density from the azimuthal P-wave data.

We applied our technique to real P-wave data, collected over a wide source-to-receiver azimuth. Computations using our method gave an orientation of the principal direction consistent with the general fracture orientation in the area as inferred from other geological and geophysical evidence.

Keywords: azimuthal anisotropy, fractures, AVO

Processing through to stack in the t-p domain

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Abstract

Improved seismic sections can be obtained by processing through to stack in the t-p domain. This approach provides significant improvements over routine processing, using hyperbolic velocity filtering (HVF) to suppress the t-p transform artefacts. HVF is a form of time and offset variant filtering that only allows each point in the t-x domain to contribute to a small number of p traces during a t-p transform. HVF can be incorporated into a point source t-p transform, extending previous implementations that applied HVF during the slant stack. This assists gap deconvolution by providing plane-wave amplitudes in a t-p gather where reverberations are exactly periodic along p traces and where S-wave reflections and long-period multiples are suppressed. The t-p domain also offers improved velocity analysis through the use of wide-angle reflections and because primary reflection ellipses never cross each other. The t-p transform of a CMP gather can then be stacked with further advantages resulting from the elliptical moveout correction, which minimises wavelet stretch and approximates the exact reflection traveltime better than NMO. Examples from the Carnarvon and Gippsland Basins confirmed that the cumulative theoretical advantages of t-p domain processing are achieved in practice.

Keywords: t-p domain, seismic processing, hyperbolic velocity filtering, Carnarvon Basin

Magnetic and Gravity Modelling of the Renison Tin Mine, Tasmania

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Abstract

Tin mineralisation occurs at Renison Bell, near Zeehan in Tasmania, as a group of cassiterite-bearing massive pyrrhotite bodies in Cambrian sedimentary rocks.

Mineralising fluids from the underlying Pine Hill Granite have replaced carbonate rocks with massive sulphides and cassiterite. The discrete blocks of massive pyrrhotite have high density and high magnetic susceptibility contrasts with the comparatively barren country rock. They are strongly remanently magnetised and are excellent geophysical targets.

A detailed geophysical model of the mine was created from a database comprising 1:2500 scale geological mapping and geological logs of approximately 4000 drill-cores. The model comprises 93 parallel cross-sections, each 1.5 km long, spaced 20 m apart. Each cross-section is comprised of up to 150 polygons which represent all known individual rock types and ore bodies. The magnetic response of the model was computed and the residual between the model and the observed response, measured by a low-level helicopter magnetic survey, revealed several anomalies unaccounted for by the model. Drill testing of these anomalies led to the discovery of several hitherto unknown massive sulphide occurrences.

Surface gravity data of the mine and surrounding district were enhanced by applying digital terrain corrections. The corrected Bouguer anomaly revealed a hitherto unknown positive anomaly associated with the ore zones of the Renison mine. The gravity anomaly of the model was also computed. Unfortunately, the limited resolution of the observed data prevented the delineation of ore targets.

The terrain-corrected Bouguer gravity data were also used to model the shape of the underlying non-magnetic Pine Hill Granite. A computer inversion method was implemented to build a 3-D block model of the granite. Results agreed with previous conventional 3-D modelling techniques but yielded improved resolution of the granite form.

The project involved development of new computer software to build and edit the large and complex 3-D geophysical model of the mine, and to compute the model's magnetic and gravity responses. Software was also developed to build and compute the gravity response of a 3-D block model of the underlying granite.

Keywords: block modelling, cassiterite, computer modelling, gravity, inversion, magnetics, Pine Hill Granite, pyrrhotite, Renison Mine, Tasmania, terrain

Semi-Automated Interpretation System for Potential Field Data Based on Profile Data

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Abstract

Data from high resolution airborne magnetic surveys continue to accumulate in Australia and elsewhere, providing an enormous amount of geophysical data to assist mineral and petroleum exploration. Unfortunately, only the interpolated gridded data is generally used to extract geological information, mostly confined to a spatial style interpretation. MIM Exploration has attempted to redress this by re-designing a semi-automated profile based system giving additional quantitative information highlighting geological features which are not normally extracted from qualitative image based interpretations.

The original AUTOMAG (Z. Shi & D. Boyd, 1993), is an automatic Naudy based parameter estimation program using magnetic profile data. Two model types, dyke and edge, are assumed; the parameters computed are depth, width (for dyke only), dip and susceptibility. The original algorithm was unable to compensate for body strike, assuming all bodies were perpendicular to the flight line direction. This assumption causes over-estimation of the sensor to source distance (d) for a body striking obliquely to the flight line. For example a dyke at 45° to the flight line will have d over-estimated by 42%. Other parameters are also affected.

A new package has been developed with Automatic Trend Search (ATS) using profile data which now defines the strike for edges and dykes, allowing compensation of all parameters. The new AUTOMAG algorithm applies the strike in its interpretation and portrays the results as depth maps, including strike and dip information, and magnetic susceptibility.

The value of this approach is demonstrated using data from the Mabel Creek area in South Australia. The area was targeted to determine whether basement was too deep for economic exploration. Source to profile strike is 50° and data were processed with and without strike correction and the results compared with drilling. Without strike correction the depth to source (minus flying height) was 285m; with correction and the new AUTOMAG algorithm, the depth to source was estimated to be 199m. A nearby (not coincident) drill hole encountered magnetic basement at 178m, clearly demonstrating the value of ATS.

Another area where AUTOMAG and ATS have demonstrated success is north of Cloncurry in North West Queensland. High frequency shallow-sourced anomalies are quite continuous but dip and strike data demonstrate that these units have variable dips over their strike length. The map presentation of interpreted parameters is used to determine structural information.

The new software is enabling explorationists to better interpret the detailed airborne magnetic data currently available. Meaningful quantitative data are being extracted from profile data and used to assist in focusing exploration.

The 3D Analytic Signal: A creative solution or a waste of time?

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Abstract

The fundamental aims in magnetic interpretation are source identification and location, i.e. an approximation to the geometry of the source needs to be made, with its geological nature being the ultimate goal, followed by "mapping" the boundary of the upper surface and determination of the depth to the source. Superposition of magnetic sources at various depths, interference from neighbouring sources, together with the effects of a possibly unknown direction of magnetisation, can often make magnetic interpretation difficult. Derivative analysis, reduction to the pole, and other filtering and image processing methods are commonly used to help achieve these aims.

Recent workers have suggested that the 3D Analytic Signal method has three significant applications: 1) in depth determination, 2) as an alternative to reduction to the pole, and 3) in mapping the boundary of the upper surface of a magnetic source. In this paper, each of these applications has been systematically investigated on theoretical and field data from high- and low-latitude regions, and with varied source geometry.

Initial results have shown that while depth determinations may be easily made for some sources from their analytic signal, the increasing use of interactive modelling algorithms makes this aspect of the application, as with other characteristic curve methods, a trifle academic.

The currently used definition of the 3D Analytic Signal is incomplete, and is not always independent of magnetisation direction for all source geometries. In theory, tabular sources may be successfully mapped from the analytic signal but the signal from 3D sources is dependent on depth extent and magnetisation direction and can be quite complex. In practice, even well-resolved magnetic sources cannot always be correctly demarcated on analytic signal maps.

Since the analytic signal is calculated from the derivatives of the total magnetic intensity, and the across-line horizontal derivative is poorly defined, its signal to noise ratio is much worse than that of the straight vertical gradient. Additionally, with real data, weakly magnetic sources in the vicinity of stronger sources are incorrectly transformed, suggesting a necessary revision of the current formulation.

The analytic signal can be effectively applied to improve interpretation of low-latitude data, in the analysis of sources suspected to have a strong but unknown remanent component, as well as in identifying sources of limited depth extent.

On the Use of the Geoid in Geophysics: A Case Study Over the North-West Shelf of Australia

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Abstract

The geoid is the fundamental surface that defines the figure of the Earth. It is approximated by mean sea-level and undulates due to spatial variations in the Earth's gravity field. The use of the geoid in regional geophysics is illustrated for the North-West Shelf of Australia by removing long-wavelength geoid features, due predominantly to deep-Earth mass anomalies, in order to reveal near-surface structure. After this process, the residual geoid anomalies correlate well with known geological structures. Therefore, the geoid can provide information, complementary to other geophysical data, of the Earth's internal structure.

Keywords: geoid, geodesy, tectonic elements, spectral analysis

Fast Combination Of Satellite And Marine Gravity Data

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Abstract

A new method has been developed to combine satellite measurements of the sea surface height with shipboard and terrestrial measurement of gravity. Existing methods are expected to be improved upon by greatly reducing computation time through the use of fast Fourier transforms, whilst yielding a similar degree of accuracy. The increased speed of computation would result in the ability to generate an accurate, high-resolution gravity field which will improve geophysical interpretations used for oil exploration.

The method is particularly suited to the combination of dense satellite data over large areas, such as provided by the European Remote Sensing altimeter, with closely spaced ship-track data, such as collected by an oil exploration or geophysical research vessel.

Keywords: gravity, altimetry, exploration, geophysics

Gravity Gradient Tensor Invariants for Exploration

Mark Dransfield

Abstract

Significant problems in the use of the gravity gradient, Γ, for mapping variations in the earth's gravity are the complexity of its responses to even simple bodies; the difficulty of displaying a tensor field in a form suitable for ready interpretation and the dependence of the components' responses on the system of coordinates. These problems are eliminated or reduced by the use of the invariants of the tensor. This approach is closely connected with a geometrical view of the gravity field which provides considerable physical insight for interpretation.

In the neighbourhood of a measurement point, P. the gravitational potential can be described as either a family of quadric surfaces in R^3 parametrised by the potential difference or as a single quadric surface in R^4 with Γ as the common quadric form. In the latter case, the eigenvalues of Γ can be identified as the principal curvatures of that surface and the eigenvalues form a coordinate system E.

Alternatively, we may consider the behaviour of Γ on the equipotential surface containing P. In this case, it is natural to use the coordinates, L, whose axes are aligned with the local vertical and the local principal directions of the equipotential surface. In L, the components of Γ associated with the principal directions are the principal curvatures of the surface scaled by the magnitude of the gravitational acceleration at P.

A linear feature in the density structure of the earth will force an alignment of the earth's gravity field, and therefore of the principal directions, to the direction of the lineament. The invariants of Γ therefore naturally separate the responses of linear features from those due to isolated bodies. This property is clearly of great value in the geological interpretation of gravity gradient

surveys. Additionally, the rotation between E and L forms two fields which act as edge detectors.

A simulated Γ survey over a complex three dimensional geological model of part of the Canning Basin demonstrates the power and value of these invariants in geological interpretation.

New Geophysical Data Sets For The Curnamona/Olary Area

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Abstract

A range of new geophysical data sets have been generated for the Curnamona Province on the South Australia/New South Wales border through the Broken Hill Exploration Initiative.

Designed to stimulate the search for new deposits to replace the dwindling resources of the Broken Hill mine, the BHEI is a joint Commonwealth/State program involving AGSO, NSW Department of Mineral Resources and Mines and Energy South Australia. The South Australian portion of the main BHEI study area covers the southern half of the Curnamona mapsheet and the northern half of the Olary mapsheet.

Consultations with industry during the planning stages of the BHEI identified high resolution airborne geophysical data and regional gravity data as top priorities along with 1:25,000 scale geological mapping programs over the main study area. To augment these mapping programs with 1:25,000 scale magnetic and radiometric images required complete coverage with airborne surveys of 100 metre line spacing.

In 1995, MESA and AGSO each flew surveys of approximately 55,000 line kms in the main study area with line spacings at 100 metres. These high resolution surveys marked a significant departure from the traditional role of government funded airborne surveys of providing regional coverage over broad areas of unknown potential.

Magnetic and radiometric data from the two surveys have been merged with data from adjoining company and government surveys to produce 1:100,000 scale images for each of the six 1:100,000 Mapsheets covered by the main study area. Images for each of the 1: 25,000 Mapsheet areas are in preparation.

AGSO proceeded to fly a further 80,000 line kilometres over the remainder of the BHEI study area (northern Curnamona, Frome and southern Callabonna mapsheets) at the more conventional line spacing for government surveys of 400 metres.

Prior to the BHEI, gravity coverage in the study area comprised only the standard BMR 7 km grid with isolated traverses. In 1995, 3,500 gravity stations were added to the southern portion of the study area on a 1km by 2km grid. A second gravity survey in 1996 added a further 4,500 stations to the northern half of the study area on a 1km by 1km grid.

Through the Broken Hill Exploration Initiative, the Curnamona Olary region now has the most detailed geophysical coverage of any area in South Australia.

Geophysical Modelling of Structure and Tectonostratigraphic History of the Longford Basin, Northern Tasmania.

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Abstract

A new gravity survey combined with ground-based magnetic surveys have enabled detailed modelling of basement structures in the Longford Basin of northern Tasmania. This basin began to form in the mid-Jurassic, but contains only Cainozoic sediments. The models suggest that the basin has been formed by a series of predominantly northwest-trending Jurassic normal faults which have produced a series of half-grabens in which blocks were downthrown to both east and west with dips of up to 10° W.

The basin blocks incorporate Palaeozoic to Mesozoic Parmeener Supergroup sedimentary rocks intruded by pre- to syn-fault Jurassic dolerites. These units overlie an older, geophysically distinct, Devonian fold-thrust terrain. Much of the tectonic activity from the Palaeozoic to the Cainozoic appears to have been controlled by the Tiers Fault system, a major gravity and magnetic lineament within the Tasmanian crust. In contrast to many other Tasmanian Mesozoic-Cainozoic basins, the Longford Basin is exclusively continental, with up to 800 m of Palaeocene to Quaternary fluvial sediments having been drilled in two wildcat oil wells. The basin also contains intercalated Late Eocene to Pliocene basaltic volcanic rocks. Magnetic data indicate three eruptive centres localised in reactivated Jurassic faults. Massive flows, now lateritised, have infilled an Early Eocene to Pliocene drainage system.

Keywords: Geophysical modelling; gravity surveys; magnetic surveys; tectonostratigraphy; Tasmania; basins; Mesozoic-Cainozoic.

Low Frequency Seismic and Transport Properties of Cracked and Fluid Saturated Crustal Rocks - A Laboratory Study

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Abstract

Seismic properties (shear modulus G and internal friction Q^{-1}) have been measured on a fine-grained granite (Delegate aplite, NSW) at seismic frequencies (1mHz - 1 Hz), through use of a locally developed forced-torsional oscillation apparatus with a newly implemented pore fluid system, under conditions of varying confining pressure P_c (50-200 MPa), pore pressure P_f (0 to 150 MPa) and temperature T (25-700°C). The purely hydraulic effects of fluid saturation were isolated by the use of argon as a chemically inert pore fluid. The permeability was measured in situ through the transient flow method, and the connected porosity (ϕ by pore-fluid volumometry.

The relationship between permeability k and the crack density ε, inferred from the shear modulus deficit, demonstrates the presence of a threshold density (cr of thermal microcracks beyond which the permeability increases markedly. This phenomenon is well described by a percolation model $k - (\varepsilon - \varepsilon_{cr})^{v}$, consistent with the notion that seismic properties depend on the total crack density, whereas the fluid transport properties are critically dependent upon the connectivity of the cracks. Our observations suggest that the k - ε relationship is essentially independent of pore pressure and confining pressure, and that the threshold crack density for markedly increasing permeability may depend only on the rock type. The variation of G for Delegate aplite is adequately described by an effective pressure law such that $G = G(P_{eff})$ with $P_{eff} = P_c - n.P_f$ and $n < 1$. The experiments also suggest that the value of 'n' may depend upon the inter-connectivity of the microcracks which determines the permeability of the rock. The measured seismic attenuation samples the transition between saturated isobaric and drained regimes, with an additional contribution attributed to thermally activated defect migration within the crystalline matrix.

Does the In Situ Stress Field Control the Orientation of Open Natural Fractures in Sub-Surface Reservoirs?

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Abstract

In order to evaluate naturally fractured reservoirs, it is critical to assess whether natural fracture sets believed to exist at depth (e.g., from surface mapping and/or seismic data) are likely to be open and productive or closed and non-productive. The semi-log relation between stress and the closure of natural fractures is combined with the effective normal stress acting on fractures to yield:

$$(d-k)/s - \ln \sigma_H' = \ln\{(n+1)/2n + [(n-1)/2n]\cos 2q\},$$

which relates fracture closure (d), the constants in the semi-log fracture closure/stress relation (k and s), and maximum effective horizontal stress (σ_H') magnitude with the effective horizontal stress ratio (n), and the angle between the normal to the fracture and the σ_H direction (q). This relation shows that:

(i) for a given fracture, the sensitivity of fracture closure to the anisotropy of the in situ stress field can be constrained by the effective horizontal stress ratio (n);

(ii) natural fracture closure is sensitive to fracture orientation with respect to the in situ stress field where n is high;

(iii) the sensitivity of natural fracture closure to its orientation with respect to the in situ stress field decreases markedly as n drops; and

(iv) the rate of change of closure with changing orientation is relatively low at very low and very high misalignment angles, and much greater at intermediate angles.

Basins of west Tasmania from shelf to abyssal plain: new geophysical data, new maps

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Abstract

The continental margin off west Tasmania is 500 km long and extends 200 km offshore, and covers an area slightly larger than the island of Tasmania. More than 50% has a sediment thickness greater than 2 km, and at least 6 km of Cretaceous-Tertiary section is present in places. The continental shelf is about 50 km wide and is underlain by four sub-basins (King Island, Sandy Cape, Strahan and Port Davey) of the Sorell Basin, which extends along the length of offshore west Tasmania, and is considered to be a southward prolongation of the gas-producing Otway Basin. This offshore area west of Tasmania has been under-explored, with only 3 wells drilled. The last (Cape Sorell-1), drilled in the Strahan Sub-basin, encountered free oil traces. Geochemical surveys of seabed sediments have indicated wet thermogenic hydrocarbons.

Recent geophysical surveys by AGSO were designed to map the geological architecture of the region and shed further light on the tectonic evolution of this part of the Australian margin. In 1994 AGSO completed an extensive swath-mapping survey aboard RV L'Atalante using a Simrad EM12D multibeam system. Seabed structure was mapped over most of the west Tasmanian margin beyond the shelf edge. Six-channel GI-gun seismic data were acquired at the same time, resulting in 5000 km of data along NW-oriented lines with 15 km mean spacing. Aeromagnetic surveying in late 1994 covered 50,000 km² of offshore west Tasmania. This was followed in March 1995 by a deep crustal seismic survey (16 s records) by RV Rig Seismic along the entire length of the west Tasmanian margin, mainly on the shelf, with multiple lines over the King Island and Strahan Sub-basins, and lines out to the southwest across the continent-ocean boundary (COB). These new data sets, together with results of earlier surveys, provide the basis for the first comprehensive study of the structural framework of this margin from shelf to COB.

The Sorell Basin, together with the Bassian basins (Otway, Bass, and Gippsland), developed in the latest Jurassic/earliest Cretaceous as part of the Southern Rift System that resulted from initial extension between the Australian and Antarctic cratons, which were part of eastern Gondwana at the time. Rifting was followed in the Aptian-Albian by low-energy sag-fill deposition (fluvial/lacustrine). Uplift and erosion in the Cenomanian coincided with Australia-Antarctica breakup to the west, and the onset of Tasman Basin rifting prior to breakup at ~80 Ma. In the eastern Otway/northern Sorell Basins, post Cenomanian deposition was shallow marine to fluvial. This phase of sedimentation was disrupted in the Maastrichtian-Early Paleocene by a major tectonic event that produced extensive faulting throughout the Sorell Basin. This event was associated with Australia-Antarctica breakup off west Tasmania, and was the last major structuring event in the Sorell Basin. Subsidence of the margin resulted in deposition of thick prograding Paleocene sequences in the north, and then similar thick Eocene sequences farther south as the spreading axis migrated southward (relative to Australia). Up to this time Late Cretaceous movement between Australia and Antarctica had been mainly slow

left-lateral strike-slip in a NW-NNW direction. At about chron 20-18 (mid-Late Eocene), the rate of Southern Ocean seafloor spreading increased dramatically and changed its direction to N-S. Continent-ocean transform movement continued along the western margin of the South Tasman Rise (Tasman Fracture Zone) through to the Miocene. Eocene wrench deformation affected mainly the southern Sorell Basin. The west Tasmanian margin sagged rapidly in post Eocene time and was starved of sediment, with terrigenous sediments giving way to temperate carbonates.

Structural Imaging Around Carbonate Platforms - A Case Study

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Abstract

Structural imaging of seismic data in the N W Shelf and Timor Sea is influenced by the presence of significant overburden lateral velocity variations associated with carbonate platforms. Exploration objectives may often be associated with the same faults around which the carbonate platforms have grown, resulting in considerable interest in the resolution of the associated seismic imaging problems.

The classic answer to imaging in the presence of such overburden velocity variations is to perform pre-stack depth migration to overcome non-hyperbolic move-out of reflectors. Since in the case of many carbonate platforms, the significant lateral velocity variations are largely contained within the first km depth, full pre-stack depth migration down to the target level may not be required. Rather an approach involving wave equation re-datuming may be proposed. Through wave equation re-datuming sources and receivers are downward continued to a datum below the significant lateral velocity variations hence removing the cause of non-hyperbolicity and enabling subsequent conventional common midpoint processing. This method may be of particular interest in the case of large data volumes such as 3D data-sets, where full pre-stack depth migration, with the associated requirement for an accurate velocity-depth model for all depths may be a more time consuming and costly approach.

In this paper, we compare methodologies and results obtained by pre-stack depth migration and wave equation re-datuming for a 2D seismic profile acquired over a large carbonate platform in the Timor Sea. Conventional time domain processing on this line is seen to exhibit unacceptable levels of image distortion beneath the flanks of the platform which the pre-stack depth migration scheme resolves. The pre-stack depth migration and wave equation re-datuming algorithms applied are both based on Kirchhoff schemes, in the latter case a constant velocity scheme recursively applied to accommodate the overburden velocity structure.

The accuracy of the derived overburden velocity model is the critical factor in successful results from either pre-stack depth migration or wave equation re-datuming. In the case of pre-stack depth migration, analysis of common image point gathers is a well established procedure which gives an unambiguous control on the validity of the derived velocity-depth model (not strictly true in the case of non-true dip direction 2D data). For the wave equation re-datuming approach common image point gathers are not available, hence a modified time domain approach for velocity model derivation and validation is followed and illustrated with results from the case study. To a large extent the results obtained by the different approaches in resolving the sub carbonate platform imaging problem are seen to hinge on the accuracy of the respective velocity models.

How To Quantify The Quality Of Seismic Data

L. Peardon and I. Scott

Abstract

In this paper we describe a method to quantify the quality of seismic data and show how it can be used throughout the seismic chain to improve the quality of the final product.

Although the concept of quality as applied to seismic data is ill-defined and often very subjective, most people would agree that important factors to be taken into account when describing seismic data quality are:

- temporal and spatial resolution
- event position accuracy
- signal to noise ratio
- the match to survey objectives

With an objective means of quantifying the quality of seismic data in terms of these factors we can obviously monitor data quality. However, just as importantly, we also have the tools to obtain the optimum quality from a particular data set.

The method we use to achieve this is called Quantified Quality Assurance (QQA). The QQA methodology involves the statistical and deterministic derivation of geophysical quality indicators. These indicators include:

- the detectability of the primary events above noise (SNR)
- the resolving factor of the embedded seismic wavelet
- absolute noise levels
- effective bandwidth
- borehole matching using coherency matching techniques

QQA can be used during the Survey Evaluation and Design (SED) to set up quality benchmarks against which to monitor the quality of subsequent recorded and processed data. Furthermore it can be used as a means to make real-time acquisition decisions and to aid the selection of optimum processing parameters. Finally, QQA maps can be used as an additional aid to the interpreter when deciding in very subtle features that may be the result of an acquisition or processing anomaly rather than true geology. The method has been used in both Marine acquisition and processing projects with good results.

Offshore Southeast Asia: Regional Comparative Assessment Utilising Modern Non-Exclusive Seismic Data

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(Geco-Prakla)

Abstract

Offshore exploration of Southeast Asia began in the late 1960's decade when offshore seismic surveys were conducted in Indonesia and Malaysia. Major offshore oil and gas discoveries were effected soon afterwards during the 1970's decade. As prospective offshore basins of Southeast Asia became mature for hydrocarbon exploration, new plays are increasingly dependent upon seismic technology.

A recent trend emerging in offshore areas of Southeast Asia concerns the undertaking of non-exclusive seismic surveys for the purpose of regional studies in relatively unexplored areas and for the development of new licensing rounds. Therefore, upstream companies evaluating offshore acreage benefit from newly acquired, state of the art, seismic datasets that are cost effective both for prospect mapping and for regional geological evaluations.

Geco-Prakla has recently acquired, processed and interpreted suites of non-exclusive seismic surveys carried out in selected areas of Southeast Asia and Australia. Seismic data were acquired across several areas of the Sunda Shelf such as in the Gulf of Tonkin in the South China Sea, in the Palawan Basin offshore Philippines, in the Indonesian Natuna Sea, offshore Myanmar and North Sumatra on the Andaman Sea and off Madura Isalnd in the East Java Sea Basin. Extensive seismic datasets were acquired and interpreted in the outer shelf of the Bonaparte and Arafura Basins, on each side of the Timor Gap, in the Indonesian Timor Sea and in the Australian Shelf.

In the planning stage of these surveys several appraisals of geological and economical risks are undertaken. Surveys across the Sunda Shelf target Tertiary reservoirs whereas surveys in Eastern Indonesia and in the Northern Shelf of Australia are geared towards mapping of pre-Tertiary prospects. Furthermore, several surveys such as Andaman Sea, Palawan, Timor Sea, and Arafura Seas embrace frontier areas of deep water exploration. Ultimately, what determines the survey feasibility, and the acquisition grid size, is the assessment of risk This paper discusses comparative economical aspects related to the seismic data acquisition, data processing, seismic interpretation and geological risk for the systematic undertaking of non-exclusive surveys offshore Southeast Asia.

Geophysics In Water Resource Investigations

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Abstract

Prior to the 1990's data for water resource investigations was gathered with intensive and costly field programs. Geophysics was used to give specific bore sites. Recently, water resource management has evolved, based on the integrated interpretation of geoscience data sets. Regional data (including geophysics) are studied to develop a hydrogeological model. Field programs are directed at validating this interpretation. Ground geophysics may be used in investigation, evaluation and monitoring of groundwater resources.

Water Resources Division's geoscience data are managed using HYDSYS, a commercial hydrological database program. GIS technology enables the overview, combination and detailed referencing of information within the 'corporate' database.

The Division produces hydrogeological maps to show the extent and quality of groundwater resources. Satellite imagery is used for mapping geological boundaries, geological structures, springs, etc. This reduces the amount of ground truthing required for reconnaissance mapping. AGSO and NTGS regional aeromagnetics is used to locate lithological boundaries and fractures. Other available datasets include topography, roads, land tenure, bore locations, ground based geophysics, etc. Bore information such as yield, lithology, and water chemistry, are all linked to the bore location map, and to geophysical soundings and logging.

Satellite imagery and airborne geophysical mappings are used to determine morphological features such as drainage and weathering. Current research worldwide is aimed at interpreting regolith with remotely-sensed data. Interpretation of other airborne geophysical methods, including electromagnetic mapping to trace water quality changes, are still evolving.

Remotely sensed data can differentiate hydrogeological environments, and the ground geophysical programme must cover all identified environments. As an example, on the Ord River Irrigation project, an airborne electromagnetic survey was flown after a preliminary geomorphic study using satellite imagery and air-photographs. The EM was effective in mapping water quality and solid-rock geology.

Groundwater resource assessment starts with a hydrogeological model, which is modified as more data become available. Geophysical mapping can provide data for validation or review of the model. Monitoring networks may be combined with repeat geophysical observations to measure the responses to water and land use. Groundwater usage may then be monitored and licensed to preserve and protect the resource.

McArthur Basin Architecture: A New Perspective from Geophysics and GIS

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Abstract

Interpretations of the gross geometry of the McArthur Basin from regional potential field data are presented as a 2.5-D component of a metallogenic geographic information system (GIS) developed for the region. Isometric views of structure contours and isochores enable easier visualisation of relationships between basin geometry, faults, prospective units and mineralisation. The McArthur Group, host to the major HYC Pb–Zn deposit, is seen to extend well beyond its eastern limit of

outcrop as defined by the Emu Fault. Units identified as prospective using lithological criteria encoded in the GIS contain all known stratiform base metal mineralisation. Such deposits are preferentially located on the periphery of the thickest accumulations of McArthur Group sedimentary rocks.

Volcanism in the upper and lower Tawallah Group is much more voluminous than its comparatively small stratigraphic thickness measured in outcrop would suggest. Over 15 km of basin fill (including volcanics) is implied in some areas, but this may vary rapidly, implying considerable pre-McArthur Group structural development. A number of lineaments visible in the isochore images converge at the position of HYC, indicating bounding fault and strike-slip fault activity at this location during a large portion of basin evolution. These structures do not necessarily correspond to major regional faults interpreted from surface mapping.

Application of Airborne Gamma-ray Spectrometry: Some Canadian Examples

R.J. Hetu

Abstract

Airborne Gamma-ray Spectrometry is an exploration technique which has become more and more acceptable world wide. But, because the technique is very much computer oriented, the recognition and development of the method relative to other airborne systems was slow. It was colour presentation of the data that provided the opportunity for better appreciation of the merits of gamma-ray spectrometry. The rapid advances in computer technology over the past decade, too a certain degree, has paralleled the changing emphasis this technique has had on its application to exploration, geological mapping and environmental studies.

As a brief historic review, the Geological Survey of Canada began its airborne gamma-ray spectrometer program in 1969 with purchase of a Shorts Skyvan Series SC7 aircraft. The GSC operated the skyvan for the purpose of conducting low-level experimental airborne geophysical surveys until 1996 when the Skyvan was turned over to Crown Assets for disposal as a result of the termination of funding for the skyvan airborne program. However, the GSC is still active in this area with a large data base and access to a strong contract industry for new data. With increased demand for Gamma-ray data, we expect to continue to play a supporting role to a wide variety of clientele.

The poster illustrates the impact Gamma-rays have had on the mining and mineral industry, as well as in other jurisdictions. For example, the Mazenod venture uses the results of a multi-parameter airborne geophysical survey flown by the GSC in the southern Great Bear magmatic zone to promote a potential target similar to the type related to the giant Olympic Dam deposit in South Australia. Other recent examples include the Swayze survey covering a meta-sedimentary belt just north of Sudbury, Ontario. The use of Gamma-ray data for environmental reasons are exhibited by our Chalk River survey which was used to provide a background radiation baseline for an area prior to the potential long term storage of low-level waste material in a waste management facility.

Spectral Gamma-Gamma Logging In Ore Delineation and Grade Estimation

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Abstract

The spectral gamma-gamma (SGG) logging method is currently being investigated by the Geological Survey of Canada (GSC) as a possible technique for downhole assaying and discriminating between economic and non-economic sulphides minerals. The SGG method is based on the different interactions of gamma-rays with matter. The back-scattered gamma-ray energy spectrum from a radioactive source contains information about the density and heavy element content that is closely related to the effective atomic number of the rock formation. The shape and amplitude of the back-scattered spectrum varies with changes in the type and content of heavy element constituents. A ratio of the high-energy to low-energy gamma-ray intensities (the SGG ratio) in selected energy windows of the back-scattered gamma-ray spectrum is currently used to determine the ore distribution and estimate base metal concentration along the borehole.

The GSC has made SGG measurements at several base metal sulphide deposits in Canada, three of which are presented in this poster. Borehole SGG data acquired at a sandstone-hosted lead deposit correlated so well with lead assays that log-based predictions of lead content were possible. In the other two examples (Cu-Pb-Zn polymetallic sulphide deposits), good correlation between the total base metal content and the SGG ratio showed that the SGG technique was equally effective in estimating total base metal content. At one of these deposits, where there was known zonation in the distribution of pyrite and Pb-Zn sulphides, the SGG data showed a clear distinction between the non-economic pyrite and economic Pb-Zn sulphides, because of the relatively high percentage of galena (which has a high effective atomic number), in the latter.

This poster demonstrates the usefulness of the SGG technique in accurately defining ore boundaries and providing in-situ base metal assays. In addition, it shows potential as a technique for discriminating between economic and non-economic sulphides.

Automatic depth estimation in regional magnetic surveys: a case study from North West Victoria

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Abstract

Depth to basement is a critical parameter for mineral and petroleum explorers and for all those interested in the interplay between a basin and its basement. The poster describes the approach taken by the Geological Survey of

Victoria and M.I.M. to the West Initiative Area within the Victorian Initiative for Minerals and Petroleum. In the region, the Palaeozoic basement has potential for gold and base metals. The overlying Murray Basin contains mineral sands and coal deposits. Petroleum may be present in pre-Tertiary infrabasins below the Murray Basin.

Depths to basement were calculated on data from airborne magnetic surveys covering about three 1:250 000 map sheet areas. A work station using AUTOMAG (Shi & Boyd, 1993) processed the 120 000 line km of data. AUTOMAG computes depths to basement following the Naudy approach, using either the TMI or the first vertical derivative for dykes, and for edges using the first horizontal derivative. The output includes estimations of depth to basement, susceptibility, and dip and a measure of how well the model fits the profile.

The output was screened to cut out poor model fits, extremely low susceptibilities and depths calculated above the ground. The remaining depths were then coloured according to depth and displayed and printed with a grey-scale first vertical derivative image as background. ERMapper was used to construct the plot files. Visualisation relied on the ability of the eye to sort colours. Depths were not gridded. This means that multilayered depth solutions can be visualised and effectively interpreted, provided the trends do not completely overlap. Checking depths against drill holes gave acceptable correlations. Repeating the process would take about 1 month.

This approach gives depths to basement and highlights late basement fault movements. It distinguishes areas of thick basin sediments and features, like palaeochannels, that may be significant in the basin.

Keywords: magnetic interpretation, depth to basement, Murray Basin

Integrated geological and geophysical inversion

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Abstract

A technique is presented for the multiply-constrained inversion of geological and potential field data. This technique speeds up the process of testing simplified kinematic structural models for specific structural and potential field data collected by field geologists and geophysicists. The scheme uses pre-existing software (Noddy) to calculate potential solutions, and as the inverse modelling scheme requires flexibility and speed over a potentially large parameter space, a genetic programming approach to the global optimization problem is used.

The Noddy integrated forward modelling package calculates geometries and potential field anomalies resulting from specified kinematic events. These models are then compared to the target data using correlation of potential field anomaly images to assign the fitness to the model, with the genetic algorithm breeding successive generations of models. Initial testing of the inversion scheme yielded successful models for a spherical plug, and a linear dyke. This technique can be applied to multiple-event histories, and in the future will be extended to correlation of geophysical and geological data using a topological approach.

While this approach requires the structural geologist to interpret the structural history of the area, it is a potentially valuable tool for constraining 3D models to fit both geology and geophysical data sets.

An Atlas of the Potential-Field Response of Geological Structures

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Abstract

The interpretation of gravity and magnetic data sets in terms of three-dimensional geology requires training in the principles of both structural geology and potential-field geophysics, however these fields are still commonly taught as distinct topics. As part of a project to develop an integrated geological and geophysical forward modelling scheme (known as Noddy), we have assembled an atlas demonstrating the relationship between simple geological structures and their potential-field response.

These models encompass the traditional demonstrations of the effects of varying depth, latitude and dip on the response of simple geological bodies, but also demonstrate how to interpret more complex geological scenarios such as refolded folds and faults, growth faults, alteration haloes and folded remanence vectors. In this poster we present a subset of the full atlas including basic geological and geophysical principals, single structures, representative structural settings, remanence effects, and a case study. These models can provide a useful framework in training of an integrated approach to the structural interpretation of potential-field data, and can provide the basis for further modelling of specific geological terrains.

Preliminary Structural Interpretation of Aeromagnetic Data, Maun, Botswana

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Abstract

The first phase of the Maun Groundwater Exploration and Resource Assessment Project was a detailed high resolution fixed-wing aeromagnetic and radiometric survey whose aim was to locate features related to groundwater occurrence and movement as well as map regions of basalt below which it is expected may be Ntane sandstone, a good source of fresh ground-water elsewhere in Botswana. In total, 69,596 line kilometres of

data was acquired along traverses spaced at 250m intervals, 80m above ground level mean terrain clearance. Sampling was done at 10 samples per second or 8m. The data were gridded at 70m cell size and various processes such as reduction to the pole, derivative calculation and lies in northern Botswana on the southeastern fringe of the Okavango Delta, with Maun almost in the centre.

The solid geology of the project area is obscured by Kalahari Group sediments which may locally exceed 100m. Basement consists of low-grade Proterozoic meta-volcanic Kgwebe Formation and meta-sedimentary Ghanzi Group, unconformably overlain by sedimentary and volcanic rocks of the Karoo Supergroup. There are two known major faults - the NE-SW striking Thamalakane and Kunyere faults. Both are downthrown 100 to 300 metres northwest.

The southern part of the aeromagnetic map is dominated by WNW-ESE trending linear positive anomalies representing dolerite dikes, part or continuation of the Dike Swarm that is visible all the way from eastern Botswana. Geologically mapped faults such as the Kunyere and Thamalakane can be seen to intercept and at places to terminate the dikes. The northwestern side of the Kunyere fault has been down-thrown. The northwestern side of the Thamalakane fault is also down-thrown relative to the southeastern side. Two previously unknown faults (A and B,) are interpreted to the east of and parallel to the Thamalakane fault. Transverse to the Kunyere and Thamalakane fault system are fault controlled stream valleys (Shashe and Nxotega). These are potentially good hydrogeological areas as the faults are open.

Texturally, the southeastern quarter of the map shows a smooth texture comprising mostly long wavelength anomalies, suggesting deeper sources. The northeastern part of the project area shows a more mottled pattern (typical of basalt layered areas) with occurrences of high amplitude anomalies (some of which are probably dikes).

Inversion of controlled-source EM data in apparent resistivity over layered earth

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Abstract

Recently, Roy and Das (1996) proposed, based on regularized unconstrained optimization method, a nonlinear inversion scheme for direct current resistivity sounding data. In this inversion a posteriori regularization parameter from a 'discrepancy principle' of Engl (1987) is used. The regularization parameter is itself improved when the residual error functional, determined by Polak-Ribiere conjugate gradient method, is minimized. Such a regularization results in a fast convergence to the desired model even when a guess model is a homogeneous half-space generated by layers of equal resistivity. Besides, this inversion scheme is efficient even when the data are corrupted by noise. This nonlinear inversion scheme is applied to synthetic field measurements of mutual coupling ratios (MCR) by slingram configurations (horizontal coplanar, vertical coplanar, vertical coaxial systems). Unfortunately, MCR curves over different layered earth models are almost identical in shape. Also, as the MCR curves do not reflect the resistivity distribution of the subsurface, an initial model to start the inversion is difficult to obtain. For the inversion of an MCR curve our starting model is, like the direct current cases, a half space consisting of layers of equal resistivity. However the inverted models from MCR curves are unacceptable. In a recent publication, Das (1996) has shown that a unique apparent resistivity curve over a layered earth can be obtained from different combinations of electromagnetic fields measured by five different transmitter-receiver configurations. An apparent resistivity curve reflects the subsurface resistivity distributions and leads to a starting model for inversion. We have converted the previously used synthetic MCR field measurements into apparent resistivity data and then input the results into the inversion scheme. The inverted models from controlled-source electromagnetic apparent resistivities are quite close to the actual models. We have applied our inversion scheme on data which contains 3 percent and 5 percent random Gaussian noise. It is found that the inversion is stable yielding the desired models from the noisy data.

Ground infrared thermometry (GIRT) in the determination of subsurface coal fire

Indrajit G Roy, Gyanesh Sharma and Kalyan Chakvabarty

Abstract

Ground infrared thermometric (GIRT) measurements were carried out in delineating subsurface coal fire over a prominent coking coal deposit of Jharia, Bihar, India. GIRT data provide significant information viz. shape, depth, spatial extension and age of the fire body, thereby help in prognosticating a new zone to get affected by the existing fire body. Coal catches fire either due to endogenic (spontaneous combustion process of coal) or exogenic (human activities) causes; however, the endogenic cause is more likely over the other one. Heat flows out from the fire body to the surroundings, mostly due to conductive phenomenon. Thermal conductivity of the strata surrounding the coal bed is usually more than that of the coal bed, causing it to lose heat less rapidly than the surrounding strata under the condition of either limited or no circulation of air. This however, allows coal surface to accumulate heat which often triggers an otherwise unaffected coal bed to catch fire in presence of sufficient oxygen when its surface temperature due to accumulation of heat crosses the critical ignition temperature. In the present paper, we have demonstrated the feasibility of GIRT measurements in delineating buried fire body. The temperature data are processed and contoured. The processed data depict temperature anomalies over the buried fire body. We have inverted temperature anomaly data to find the parameters viz the shape, depth, aerial extent and age of the fire body. Inverted results are in good agreement with the available mining data. The above parameters are used for necessary prognosis regarding the movement of the fire front and to identify new area susceptible to catch fire in near future.

Optimum XY Determination for Refraction Analysis with the Generalized Reciprocal Method Using Image Processing

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Abstract

A crucial step in the fully optimised application of the generalised reciprocal method (GRM) for analysis of seismic refraction data is the determination of the optimum XY value. Although the methodology for this determination has been described extensively in the literature, it still remains an aspect wherein the results are as much a consequence of the styles and parameters of presentation as the practitioner's competence with the technique.

To date, the most successful method for this determination has been to use the velocity analysis function computed for a range of XY values using traveltime data with adequate spatial sampling. The computations are presented in a stacked profile style, in order to improve clarity by minimising over-plotting of values with different XY values. Also, the vertical axis which has the units of time, requires adequate scaling in order to facilitate recognition of the subtle variations in the velocity analysis function associated with the different XY values. Commonly, these variations are less than a few percent of the computed values and they may be difficult to recognise with inappropriate scales of presentation. The process for the determination of the optimum XY value, is essentially an exercise in pattern recognition, wherein the trends or the spatial variations in the XY dimension, rather than the precise numerical values are examined.

This process can also be achieved with imaging processing techniques. The traveltime data are processed with the generalised velocity analysis algorithm in the usual manner, but without the introduction of base level shifts which are achieved with reciprocal time variations in order to produce the stacked profile presentation. The computations are gridded in the domain for which axes are distance along the seismic profile and the XY spacing. These gridded data sets are then presented with an image processing software package. The major advantages of this approach are that the critical parameters of separation and scale in the stacked profile presentation are automatically accommodated in the image, especially with histogram equalisation. For this study, the gridding was achieved by Encom Technology's ModelVision, while the imaging was done with ER Mapper.

Model studies and field data demonstrate the efficacy of the approach.

DIGHEM Applied to Salinity Studies

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Abstract

Recent studies employing airborne electromagnetic techniques to delineate conductivity variations in the near-surface have focussed on time-domain electromagnetic systems. This approach is certainly not the only airborne technique for very near surface investigations such as those necessary for Land Management programs and may not be the most suitable for such purposes. Airborne electromagnetic surveys utilising helicopter-borne, frequency domain systems have considerable advantages over present fixed-wing, time-domain systems in surficial conductivity investigations, particularly in salinity assessment and monitoring programs.

The DIGHEMV helicopter-borne airborne 5 frequency electromagnetic system has numerous characteristics which make it extremely proficient in studying near surface conductivity variations:

- The system is able to provide high resolution (paddock scale) data due to its small system geometry.
- The frequency-domain system relates directly to ground-based electromagnetic techniques used for land management studies.
- High frequencies yield high vertical near-surface resolution.
- The system has the ability to provide sub-surface cross-sections.
- Real-time, differential GPS gives the system under 5 m positional accuracy of data.
- The helicopter mounting provides the ability to maintain a consistent terrain clearance even in rugged conditions.
- Terrain clearance for the system is only 30 m, hence a small transmitter footprint and higher resolution data.
- There is no system asymmetry and hence no herring-bone patterns over flat-lying conductors on map products.
- The system always flies with a Caesium vapour magnetometer and can also carry a spectrometer. Radiometric data can be invaluable for soil mapping techniques and can be integrated into GIS databases.

A case study utilising the DIGHEMV five frequency system for the Kyeamba Valley Landcare Group near Wagga Wagga, NSW illustrates shallow depth electromagnetic responses from saline and waterlogged areas. Ground EM31 data overlain on the airborne data show remarkable correlation with the airborne data, particularly the 56 000 Hz resistivity maps. Lower frequency coplanar coil resistivity maps elucidate high conductivity zones at depth and indicate possible source areas of saline materials. Most importantly the airborne data clearly define areas of very high conductivity which may be omens of future salinity outbreaks. With the data from the survey, the local Landcare group was able to optimise their rehabilitation program.

The Application of Radiometric Data to Soil Mapping

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Abstract

Understanding the distribution of soils is important for agricultural planning and land use management. Previous soil mapping methods revolved around costly and time consuming ground mapping. The existing soil maps in the State are discontinuous and at different scales. Using radiometric surveys to map soil types has the potential to provide more accurate, high quality maps at faster rates than conventional methods.

A pilot study on the Nagambie 1:100 000 map sheet used detailed radiometric and Digital Terrain Model (DTM) data to develop a methodology for soil mapping.

As part of a National Geoscience Mapping Accord (NGMA) AGSO flew a geophysical airborne survey over the Bendigo 1:250 000 mapsheet in 1994 at 200 and 400 metre line spacing and 80 metre mean terrain clearance. The process involved image classification and analysis using total count, potassium, thorium, uranium and DTM channels. Ratioing and statistical analysis enabled the classification of soil and geomorphological units.

The geophysical data was used in conjunction with standard soil mapping techniques such as soil pits, pH, electrical conductivity, texture, colour and structure. This ground truthing enhanced the interpretation of radiometric images and improved the understanding of radiometric responses to different soil types.

In two months, the study produced a Soil Association map of far superior quality than would have been possible using conventional mapping methods. Hence exploration quality airborne geophysics can be used as an effective aid to soil mapping.

Magnetotelluric Analysis: Best 2-D Strike Direction and Principal Impedances

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Abstract

Electric and magnetic signals occurring naturally at the surface of Earth are recorded and combined to give values of the magnetotelluric impedance tensor. Such tensor values are functions of the electrical conductivity structure of Earth, as they result from electromagnetic induction taking place at Earth's surface. Special marine equipment is used to determine magnetotelluric tensors at seafloor sites.

In analysing the tensors it becomes of immediate importance to know whether they show characteristics of 1-, 2- or 3-D electrical conductivity structure. For the general case of 3-D, it is important to know how far the data depart from 2-D, and what the parameters of the "closest" 2-D case are, in terms of geologic strike, and principal impedances.

A general method for the analysis of such magnetotelluric data will be presented, based on simple geological models and involving operations of a rotation (which enters as a "twist"), and a pure shear (which enters as a "stretch"). The options and trade-offs in approximating 3-D data as 2-D are made clear in the analysis. Visualising the analysis is greatly aided by the use of Mohr circles to depict the tensor data and the rotation and pure shear operations, as will be demonstrated with field examples, both from Australia and overseas.

Terrain Corrections Are Critical for Airborne Gravity Gradiometer Data

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Abstract

Several developments aim to produce airborne gravity gradiometers with sufficient sensitivity to detect mineral deposits of several millions of tonnes at shallow depths. In a conventional ground gravity survey, a Bouguer slab correction is always necessary, with the terrain component of the full Bouguer correction often not needed unless the topography is severe. For airborne gravity gradiometers, however, the slab correction is exactly zero but the terrain corrections prove to be critical even with subdued or moderate topography.

This paper reports on research into airborne gravity gradiometer corrections, especially aspects that assessed the importance of regolith and its constraints of surface and bedrock topography, together with predicted target anomalies. Using an example of topography typical of the Western Australian shield, calculations show that densities of both regolith and bedrock need to be determined to better than 0.1 for adequate correction to be made to raw gravity gradiometer data. Topography also needs to be defined to about (3 m on 10 m pixels for adequate gravity corrections.

Keywords: terrain corrections, gravity gradients, airborne gravity and Bouguer correction

RINVERT for Windows Software for the Interpretation of Resistivity Soundings

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Abstract

The usual interpretation model for resistivity soundings is a one-dimensional earth which consists of multiple horizontal layers, each isotropic and homogeneous. The standard interpretation method is least-squares inversion. This paper introduces a software package called RINVERT for Windows which has been developed in Australia for the routine interpretation of resistivity soundings in a Windows(tm) environment. It has been designed to handle the Schlumberger, Wenner and Bipole-Bipole electrode arrays. For feasibility studies, training, or testing the closeness of an initial model, RINVERT for Windows provides a forward modelling facility as an adjunct to its least-squares inverse modelling procedure. An important feature of RINVERT for Windows is the incorporation of a monte carlo equivalence analysis which allows an automatic assessment of the extent of equivalence in each layer. Most of the effort required in preparing the resistivity survey report has been obviated by an automatic report generator, which generates and captions high quality figures and tables ready for incorporation in a report. An extensive Help facility, which is useful for novices, includes a hypertext glossary and an explanation of resistivity method fundamentals. The software is supported by a 110-page Users Guide with a step-by-step tutorial.

Keywords: resistivity, inversion, modelling, equivalence

Palaeomagnetism, Magnetic Petrophysics and Magnetic Signature of the Porgera Intrusive Complex, PNG

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Abstract

Investigation of magnetic properties and magnetic modelling of the Porgera Intrusive Complex, Papua New Guinea, has established representative magnetic properties and the palaeomagnetic signature of the major rock types of the Complex. Relatively unaltered intrusive rocks of the Porgera Intrusive Complex are moderately to strongly magnetic, whereas strongly altered intrusives, mineralised zones and country rocks are very weakly magnetic. For most intrusions, Koenigsberger ratios are substantially less than unity, indicating that induced magnetisation is predominantly responsible for anomalies associated with most of the Complex. Hornblende diorite and hornblende diorite porphyry tend to be the most magnetic rock types in the Complex. However, all fresh intrusive rocks sampled, from very mafic to intermediate compositions, have fairly high magnetic susceptibilities. Primary thermoremanent magnetisations are retained by most of the intrusive rocks, unless they are highly altered. Both normal and reverse polarity remanences are preserved in the Complex. Primary magnetisation is carried by multidomain (titano) magnetite. In addition, the remanence carried by the intrusives is weakly to heavily overprinted. Primary remanence directions have been rotated and are steeper than the Miocene reference field directions of corresponding polarity, thus demonstrating tilting of intrusions in the Complex since emplacement. The sense of tilting is reasonably consistent, although the amount varies up to 50° or 60°. Prior to tilting, there appears to have been variable rotations about the vertical, mainly in a clockwise sense.

Magnetic modelling incorporating measured magnetic properties and known geometry of the shallow intrusions has led to interpretation of a deeper mass of the Complex. Modelled tilts of the shallow bodies agree with the sense of tilting from palaeomagnetic data, but are less extreme. This suggests that rotations at two different scales are being detected. The tectonic rotations are evidently in response to thin-skinned tectonic processes which have accompanied the rapid uplift of the Complex. Palaeomagnetism is a powerful tool for detecting such rotations and could be particularly useful for elucidating the structural history of young deposits in tectonically active areas. The present study has detected hitherto unsuspected structural complications, which may have implications for locating further mineralised zones.

Keywords: Porgera, PNG, palaeomagnetism, overprints, magnetic properties, magnetic modelling

Seismic Method Application For Gas Field Development, A Case Study In Pantai Pakan Timor Area, Northern Sumatera Basin

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Abstract

Two main producing reservoirs in Northern Sumatera Basin including Pantai Pakam Timor gas producer field are Belumai Formation (deep zone) and Keutapang Formation (shallow zone). This paper discussed the effort to take as many as advantages of the available seismic methods application for gas exploration, especially of the shallow zone. The study is conducted using "true amplitude" reprocessed seismic sections and PPT-1, PPT-2 and PPT-5A wells data.

The amplitude distribution map indicates narrow and strong seismic amplitude around PPT-1 well, while the even larger and stronger amplitude occurs on the south-western of PPT-2 and PPT-5A. Amplitude strength corresponds to net pay thickness, as at PPT-1 with 19.5m net pay seismic section shows strong amplitude, while at PPT-2 and PPT-5 with 4.5m net pay, the amplitude is weaker.

Turning effect analysis is considered necessary for the area's shallow zone since the seismic data show 40 msec dominant period, while the objective reservoirs is thinner. Therefore, interference of two reflection events from top and bottom of thin bed is likely obliterate the actual seismic signature and consequently lead to false time picking.

Considering this analysis, the untested highest amplitude area in the southwest which corresponds to the structural culmination in the southern part, might indicate thicker pay than PPT-1.

Reflection strengths, apparent polarity and instantaneous phase are treated for illustrating more detail geology, and reservoir characterisation. They provide configuration of fault systems, depositional patterns, and gas distribution in the objective.

AVO analyses that show the amplitude increase with offset, confirm the present of gas reservoir and seismic inversion that show low impedance layer at strong amplitude.

Modern Marine 3D Seismic Acquisition - Technical Considerations

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Abstract

The options available for a geophysicist planning a marine 3D seismic survey have changed dramatically in the last decade. Ten years ago twin streamer acquisition had just been introduced and twin source/twin streamer geometry was at the leading edge of technology. Today, with multi-streamer, multi-vessel towed streamer geometries, ocean bottom cable systems and most recently vertical cables, marine 3D survey planning had become increasingly complex and the geophysicist must consider an ever wider range of both acquisition and processing parameters in order to determine the optimum technical and economic solution for each survey objective.

The interplay between wide swath towed streamer configurations - where as many as 10 streamers are now available behind a single vessel - and the imaging methods to be used in the processing of the data are of prime importance as are the continuous minimum near trace offset and shot line spacing in OBS surveys and the vertical hydrophone separation/buoy distribution in vertical cable surveys.

In this paper a review of the available technology options will be presented, the key technical issues will be examined and survey planning examples shown which illustrate typical problems and how they may be overcome.

A new regional exploration method for detecting hydrocarbon alteration plumes: the ALTREX method

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Abstract

Recent work has shown that in some cases hydrocarbon reservoirs are overlain by an associated hydrocarbon alteration plume. If it were possible to detect these alteration plumes with an airborne geophysical method, then the airborne method could be used on reconnaissance surveys to identify prospective areas. These leads could be surveyed later in more detail with seismic (2D or 3D) or other methods to develop the prospect.

Reynolds et al (1991) have concluded that under some conditions, alteration plumes have an anomalous magnetic susceptibility. Susceptibility is commonly mapped with airborne magnetic methods.

The electrical conductivity can also show an anomaly over alteration plumes, with the anomalies being strongest when the near surface rocks are porous and iron rich. (Sternberg, 1991). Sternberg measured the conductivity using the IP method, which is a relatively slow and expensive method of collecting data and requires electrical contact with the ground. However, conductivity can also be measured with an airborne electromagnetic system.

Work by Saunders et al (1994) shows that the radiometric response of the near surface material can be sensitive to hydrocarbon alteration. Radiometric sensors can also be mounted on an airborne platform.

The ALTREX™ method is a combination of the three airborne methods: magnetics, electromagnetics and radiometrics. The multi-method approach increases the possibility of seeing an anomalous signature from one of the mapped quantities. ALTREX has been tested in a number of on-shore exploration fields. It is only in some of the fields that there is a near surface magnetic anomaly associated with the alteration. However, in most cases, the magnetic maps do show responses which can be attributed to structural features. The conductivity of the top 300 metres is much better at mapping the alteration plume and the anomalous zones measured correspond very well to the producing field (which is buried much deeper). On the surveys flown recently, the radiometric data was not collected, but Saunders et al (1994) show a good correlation of anomalies and producing fields.

In summary, ALTREX provides a unique reconnaissance tool for regional scale alteration of on-shore basins, and as such, an indirect tool for hydrocarbon exploration.

Keywords: regional exploration, hydrocarbons, alteration, electromagnetic data, magnetic data, radiometric data, ALTREX™.

High Resolution Aeromagnetic and Gravity Surveys used to Highlight Basin Geometry and Structure.

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Abstract

New aeromagnetic and gravity surveys acquired as part of the Discovery 2000 initiative by the NSW Department of Mineral Resources are reviewed in the context of their importance to future exploration for petroleum in the Darling and Surat Basins. Each of the new aeromagnetic surveys was flown with a 400 metre line spacing and 80 metre terrain clearance. Gravity surveys have been undertaken at a 4 km station spacing. Both surveys used differential GPS for location and levelling which provided very accurate results. Comparison with the earlier State aeromagnetic compilation reveals that many new geological features may be interpreted from the new data particularly within the sedimentary pile. Interpretation of these new data combined with recently acquired seismic data and reinterpretation of existing seismic data has indicated new structures within the basins and that the basin shapes themselves have been redefined. Tectonic features that can be identified on the NSW data include normal and thrust faulting and large horst and rifted blocks. These tectonic features could provide suitable structures for the entrapment of petroleum. The fact that variety of both large and small scale structural features can be mapped over large regional areas provides hope that for the first time the basin geometry and history may be understood. These data will be used to site the location of future seismic reflection surveys. The level of geological detailed data which can be interpreted from these new high resolution surveys compared to the surveys carried out approximately 10 years ago indicates their great value to exploration projects whether they are mineral, coal or petroleum.

Application of Magnetic Methods to Deep Basin Structures

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Abstract

Although magnetic methods have long been used in basin studies the data are often under-utilised since the formations of a relatively undeformed basin approximate sub-horizontal tabular sources except at basin edges. Horizontal sources are known to generate negligible anomalies. Very small angular deviations from tabularity, or horizontality, however, will generate very large responses at basin scale. This response is largely independent of source contrast, thickness, dip, or the orientation of either the source or the field, but is very sensitive to small changes in dip differentials between upper and lower surfaces of the source.

Classical rift sequence forms may account for many of the anomalies observed in basins and no presumption of basement sources is uniformly justified. Anomalies must be treated with basin perspective and scale and not as isolated elements.

Keywords: basins, magnetics, structures, rifts

A Regional Gravity and Magnetic Study of the Malay Basin

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2. *Petronas*

Abstract

A regional study of the Malay Basin was undertaken to investigate deep structure and evaluate possible deep gas plays. As part of this project 14 lines of 12 second seismic data were shot. Marine gravity and magnetic data was also acquired on these lines.

The residual Bouguer gravity map shows that the basin has a complex structure at depth with several discrete depocentres separated by basement highs. Modelling of the gravity profiles reveals considerable crustal thinning along a northwest-southeast oriented axis. Crustal thinning is asymmetric with an abrupt change in thickness on the western side and a more gentle change on the eastern side. Density variation within the basin is controlled primarily by depth of burial with little stratigraphic influence. This is possibly related to zones of overpressure which have not experienced normal compaction histories. There is no distinct gravity expression for the high amplitude and anticlines in the southeast of the basin which suggests that these structures may have had some diapiric component of growth. Other structural highs have weak negative gravity expressions and have been modelled as inversions over underlying basement depressions.

Magnetic interpretation used 1988 regional aeromagnetic data. Most of the magnetic field variation is due to susceptibility contract between basin sediments and surrounding basement. A more comprehensive mapping of basement faults was possible from the aeromagnetic data than from the gravity data because of higher density of the aeromagnetic coverage. Extensive faulting is recognised with a particularly prominent set of north-easterly trending dislocations. Linear anomalies across the Penyu Trough and southern Malay Basin are due to horst-graben basement topography. Magnetic modelling along the seismic profiles reveals that magnetic basement is generally at a greater depth than acoustic basement. This discrepancy may indicate the presence of pre-Tertiary section. Over the Tenggol Arch seismic and magnetic basements are coincident. This suggests that pre-Tertiary sediments were never deposited there or have subsequently been stripped off.

The Application Of Geophysics In Iron Ore Mining In The Hamersley Basin, Western Australia

Amanda Butt and M. F. Flis

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Abstract

Hamersley Iron Pty. Limited operates five iron ore mines and has a number of advanced evaluation projects in the Hamersley Basin, Western Australia. These deposits range in style from bedded iron in banded iron formation host, to detrital iron accumulations. Numerous problems are encountered during mining in these varied geological environments. These include pools of high manganese concentration, self igniting black shales, definition of detrital iron accumulations, fault exploiting dolerite dykes, and lithology determination amongst others.

Each of these problems requires an unique solution. For example, natural gamma ray logging is used to determine stratigraphic level of intersected lithologies. Together with other parameters, this method is now being extended to identify actual lithologies using artificial intelligence technology. Ground penetrating radar and radio imaging methods are employed to outline ore geometries and assist in assessing ore quality. More classic methods, such as high resolution ground magnetometry and resistivity are used to define dykes, map structures and support ore block modelling. Thus, geophysics is now playing an integral role in mine site planning. As a result, production costs should decline, and product quality should improve through better definition of ore/waste geometry.

Keywords: Tom Price, Marandoo, iron ore, bedded haematite, detrital iron deposits, ground magnetic, gravity, EM31, magnetic induced polarisation, radio imaging, ground penetrating radar

Application of Electrical Techniques for Iron Ore Exploration

P. J. Hawke, M. F. Flis

Abstract

Geophysics has been used in iron ore exploration in the Hamersley Basin for more than twenty years. The use of the magnetic technique for structural and lithological mapping has been well documented. While direct detection of hematite mineralisation through this method has been reported, this is not believed to be a reliable means of targeting iron ore. The application of other techniques, including the radiometric, gravity and electrical methods is not well covered in literature.

Geophysical methods have been applied to aid mapping of the Giles Mini martite hematite deposit. Regional lithomagnetic units and late stage faults are identified in magnetic data. However, layer parallel faulting can not be identified by this technique. Ground electrical methods, on the other hand, have proved to be a useful tool in tracking not only outcropping lithologies to depth, but also detecting and mapping the fault system truncating the orebody to the north.

Keywords: Hamersley Basin, iron ore, hematite, Giles Mini, magnetics, airborne EM, TEM, induced polarisation, downhole logging

Some Geophysical Applications for Data Classification

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Abstract

Unsupervised data classification is a technique which can be applied to geophysical data as a means to simplify the interpretation process by dimensional reduction of multivariate data. This technique has found applications in both land use and exploration contexts. Multivariate classification has traditionally been applied to satellite images and more recently to radiometric data.

This paper examines several novel applications for data analysis by classification, specifically the classification of magnetic, radiometric and gravity data. Joint classification of different data sets such as radiometrics with TM is also considered. It has been found that semi-automatic interpretation of wireline logs is possible using classification algorithms. Some pitfalls of unsupervised classification algorithms are also discussed.

Data can only be classified jointly where the observed anomaly on both data sets is caused by the same geological phenomenon. This situation can arise in the classification of soil types using radiometric and satellite images and in the search for diamondiferous kimberlites using radiometric and magnetic techniques. Field examples for both these circumstances are provided.

Joint classification of gravity and magnetic data is also possible, an example using a regional aeromagnetic and gravity survey is provided.

Wireline logs can also be classified jointly to provide a semi-automatic first pass interpretation. Field examples from Sunrise Dam are presented.

Interpretation and modelling, based on petrophysical measurements, of the Wirrda Well potential field anomaly, South Australia.

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Abstract

The Wirrda Well Prospect is located approximately 20 km SSE of Roxby Downs and 500 km NNW of Adelaide, South Australia. The Wirrda Well deposit consists of a massive granite breccia. Within the breccia, haematite and magnetite are pervasive and copper, uranium and gold are associated. Evidence suggests this distinctive deposit may be an analogue of the Olympic Dam orebody.

A variety of petrophysical measurements have been made on drill core samples from the Wirrda Well deposit, including density, gamma activity, compressional velocity and thermal and electrical conductivity. Detailed magnetic studies were also undertaken, comprising magnetic susceptibility, natural remanent magnetisation, partial demagnetisation, anisotropy and saturation magnetisation measurements.

Results of these studies enabled comparisons to be made between the physical properties of the host rocks, the cover sequences and the surrounding country rocks. Generally the host rocks are of greater density, have a higher magnetic susceptibility and gross gamma ray activity, and are better conductors of thermal and electrical energy than nearby unmineralised rocks. The main carrier of magnetism was found to be multi - domain, coarse - grained magnetite and remanence was a significant component of the total magnetisation.

The Wirrda Well potential field anomaly consists of near coincident magnetic and gravity highs. Modelling of the ground magnetic data, constrained by geological logs and petrophysical measurements, could not account for the observed anomaly, suggesting the main causative body of this anomaly has not yet been intersected by drilling.

From modelling of the gravity anomaly, it was demonstrated that only half of the magnitude of the anomaly can be resolved, utilising bodies constrained by drillhole data. It has been concluded that the remainder of the anomaly may be explained by the presence of a central vertical pipe with three apophyses radiating to the NW, SE and SW, that are largely untested by drilling.

Key words: Andamooka SH53-12, Cu - U - Au, gravity, magnetics, petrophysics, Stuart Shelf, Wirrda Well

Coal Field Structure and Intrusion Mapping by Helicopter Magnetics

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Abstract

With the increasing employment of long-wall mining equipment nowadays, an unexpected encounter with a small throw fault, or worse still, a sill of volcanic rock within an exploited coal seam will disrupt mine operations possibly resulting in the loss of millions of dollars. In addition the heat from intrusions can cause cindering of the coal for many tens of metres either side which means lost coal production over extensive areas. Generally evidence of these types of disruptions cannot be obtained by surface geological mapping alone.

The recent advent of high sensitivity, fast sampling magnetometers, coupled firstly with the greatly improved accuracy of navigation and positioning provided by real-time differential GPS and secondly, striking displays of magnetic data using colour imagery, has dramatically increased our ability to reveal and delineate subtle structure and the presence of small igneous intrusions at depth in coal seams. Airborne surveys are the most effective way to conduct such surveys and helicopters have the advantages over fixed-wing aircraft of slower speeds to provide the closer data sample intervals needed to detect smaller features and are more manoeuvrable when, as is often the case, the survey area is interspersed with cultural features that have to be avoided.

Several surveys have been conducted recently in the Sydney Basin making use of these beneficial characteristics of helicopter-borne acquisition systems. Plugs, sills and dykes have been delineated, in some cases beneath lakes. More subtle features have been revealed as well, including a linear anomaly of only 0.2nT amplitude which was shown by drilling to be a fracture. At the Elouera Colliery west of Wollongong, a helicopter-borne magnetometer survey over an area where extensions to longwall mining were planned, identified numerous dykes, pipes and structural features.

High Resolution Seismic Survey For Shallow Coal Exploration Using A High Frequency Electromagnetic Vibrator And High Sensitivity Geophones

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Abstract

A high frequency and wide bandwidth seismic source is required for high resolution surveying in shallow coal exploration environments. A more environmentally acceptable source than explosives is also desired. In order to obtain the high frequencies required, an electromagnetic vibrator and new geophone have been developed. Field testing was carried out in the Taroborah area in central Queensland beginning in 1992 to compare the energy output of an experimental vibrator with that of an explosive source and to calculate the vibrator force required to obtain useable reflection signal. A larger vibrator was developed from these results and used to obtain production data.

High frequency reflections of 120-140 Hz from coal seams at 300-400 metres in depth and 180 Hz from 100 metres depth have been acquired to recognise closely spaced multiple coal seams and small faults with throws of a few metres.

keywords: high frequency electromagnetic vibrator, high resolution, shallow coal, high sensitivity geophone, vibration force, Q value, small faults.

Shear-wave splitting analysis of multi-offset coal VSPs in the Bowen Basin

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Abstract

A shear-wave splitting analysis has been carried out on multioffset, shallow VSP data from the Gordonstone coal prospect in the Bowen Basin, Australia. In comparison to previous petroleum-scale investigations, the analysis is complicated by the short time window available for shear wave analysis, and interference from preceding P-wave energy.

A simple pre-processing scheme incorporates highcut filtering, as well as a two-stage coordinate orientation procedure, designed to enhance the shear wavefield for the subsequent splitting analysis. Several single-source algorithms for shear-wave splitting analysis are

considered, with the primary aim being determination of the polarisation azimuth of the fast split shear wave. The results from two of the boreholes, whose shots are at large offsets, show good consistency between the different algorithms, and from shot to shot. Results from the third borehole are considered less reliable, especially for those shots having smallest offsets.

The preferred fast shear-wave polarisation azimuth is 60° E. This compares well with a number of independent estimates of the direction of maximum horizontal compressive stress in the Bowen Basin. In general, the slow shear wavefield is poorly determined. However, hodogram analysis on some traces permits estimation of the time delay between fast and slow waves. These observations are consistent with a variation of approximately 2% between the fast and slow shear-wave velocities, indicating moderate development of azimuthal anisotropy.

Keywords: shear-wave splitting, fracture-induced anisotropy, Vertical Seismic Profile

Application of GPR in Open Pit Coal Mines for Mapping of Overburden, Seam Thickness and Guidance of Continuous Mining Machines

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Abstract

This paper presents the results of a 3 year research program conducted through the Australian Coal Association (ACA) and sponsored by the Australian coal industry to investigate the application of Ground Penetrating Radar (GPR) to several areas critical to open pit coal mining.

This project has produced results which clearly demonstrate the capability of GPR for rapidly mapping the overburden and coal strata, and for monitoring fluctuations in the coal/shale interface in real time to assist the Continuous Surface Miner (CSM) operator in machine guidance.

Improved high power low frequency (30 MHz and 60 MHz) antennae were constructed and used to image structures in the overburden up to a depth of approx 18m. The depth to the top of the coal seam was measured and geological structures such as faulting, washout channels, and variations in lithology types and seam thickness were mapped. Indurated zones in the overburden containing hard ironstone nodules, which break the teeth on large bucket wheel excavators, were mapped with GPR.

Variations in the extent to which shallow coal seams have been affected by oxidation were identified and thus groundradar has the potential for delineating the lox-line.

Pre and post blast surveys were conducted and showed that high resolution GPR can be used to image the extent of fracturing in the coal and thus blasting effectiveness can be measured in situ.

Old underground workings were detected to depth of 10 -15 m from the ground surface or the pit floor, and subsidence affected areas above deeper old workings were mapped.

For the guidance of mining machines, the field trials were conducted using 500 MHz and 900 MHz dipole antennae and 1 Ghz horn antennae. The initial trials were conducted with the equipment mounted in a 4WD vehicle, and the production trials conducted on a WIRTGEN 4200 Surface Miner, which is the largest mining machine of this type in the world. Special housings were used to mount and protect the antenna and GPR equipment in this extremely harsh environment, with corrosive water, mud, coal dust, high temperatures and excessive vibration levels. The field tests demonstrated that GPR can discriminate the coal/rock interface at the base of a seam, and can also image thin layers of rock parting within the coal. This information was reduced by signal processing to a simplified format and displayed in real time in a manner which could be readily interpreted by a CSM operator.

The results of this GPR project have implications for open pit mine planning, for maximising the effectiveness of coal stripping operations, and for blasting design.

2.5-D Acoustic Wave Modelling in the Frequency-wavenumber Domain

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Abstract

3-D acoustic wave propagation in a 2-D model is simulated in the frequency-wavenumber domain. The initial-boundary-value problem of the hyperbolic wave equation is converted to the boundary-value problem of an elliptic Helmholtz equation by a Fourier transform with respect to time. A spatial Fourier transform in the strike direction renders the problem of solving a 3-D generalised Helmholtz equation into the solution of multiple 2-D generalised Helmholtz equations. Each of these 2-D generalised Helmholtz equations is associated with a pair of frequency and wavenumber, and its discretisation via a finite-difference approximation leads to a sparse system of linear algebraic equations. The sparse matrix at the right-hand side is factored into the product of a lower triangular matrix and a upper triangular matrix. Then the solution of the linear system is obtained by forward and backward substitutions. This LU decomposition method has the advantage that the factorization of the sparse matrix at the left-hand side can be used for any number of right-hand sides (sources). At a given frequency, a set of wavenumbers are selected and their corresponding 2-D boundary-value problems are solved. The 3-D response for this frequency is then obtained by an inverse Fourier transformation of these solutions with respect to the wavenumber. Finally, time-domain synthetic seismograms are obtained by an inverse Fourier transformation with respect to frequency.

A 2.5-D absorbing boundary condition is derived from the paraxial approximation of the 3-D wave equation. It is more efficient than the 2-D boundary condition in suppressing the artificial reflections from the edges of the computational domain. It is simple to implement and computationally efficient. When a chosen wavenumber is equal to the wavenumber determined by the frequency and model velocity, a numerical singularity happens. This numerical singularity is avoided by allowing the

frequency to become complex. The Fourier transform with respect to the wavenumber can be accelerated by a non-uniform sampling in the wavenumber domain.

Poisson's ratio contrast and AVO responses: model study

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Abstract

A critical element in the use of amplitude versus offset (AVO) for gas detection or lithological discrimination is to define a parameter that represents anomalous behaviour. Shuey's approximation to the Zoeppritz equations for the compressional wave reflection coefficient has been widely used as a basis for defining AVO anomalies. Shuey's approximation states the AVO response as a linear equation. The intercept and gradient from this equation have frequently been used as key parameters to quantify AVO response. Generally, large gradients are normally assumed to be related to gas saturation. In order to better understand the gradient term, 25 model pairs of shale over gas sand, and shale over brine sand were used to analyse the gradient term as the sum of two functions. The first function is defined as the non-Poisson's ratio contrast term, and the second as the Poisson's ratio contrast term.

Three conclusions have been reached from this analyses:

1. The gradient may be significant even for a small Poisson's ratio contrast. This effect may be one of the reasons that AVO analysis is misleading in some geological settings.
2. Similar values of Poisson's ratio contrast may produce quite different gradients in different rocks.
3. In most cases the non-Poisson's ratio contrast term is constructive to the magnitude of gradient when the normal incidence reflectivity and Poisson's ratio contrast have opposite signs, while it is destructive to the magnitude of gradient when both have same signs.

Key words: AVO, Poisson's ratio, Poisson's ratio contrast, gradient, normal incidence reflectivity, Shuey's equation.

Fracture detection using P-wave AVO Measurements

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Abstract

Physical modelling of seismic wave propagation can provide insights into complex structural, stratigraphic and reservoir characterisation problems. The detection and delineation of fracture zones is very important in development drilling. Determination of fracture orientation within a reservoir may play an important role in EOR programs. The fundamental principle used in AVO studies is the extraction of shear wave information present in the reflection amplitude variation with source-receiver distance. The objective of this study is to determine if we can utilise the shear information in 3-D AVO surveys for fracture detection and delineation.

A 3-D physical modelling experiment was conducted over a simulated fracture system at the Allied Geophysical Laboratories at the University of Houston. The 'fracture system' consisted of three isotropic homogeneous layers with a transversely isotropic Phenolite disc embedded in the central portion of the middle layer. The three layers were: an upper layer of black resin, a middle layer of Stycast resin (containing the anisotropic disc) and a lower layer of casting resin. Two 3-D seismic surveys were acquired over the model; one with acquisition lines oriented parallel to, and a second survey with the acquisition lines perpendicular to the fracture detection. Multi-offset and multi-azimuth seismic experiments were also conducted over the simulated fracture system. After applying corrections for spherical divergence and source-receiver directivity the reflection amplitudes from the black/Stycast resin interface were analysed.

The results show that the 'fractured' disc is characterised by low AVO gradients in both surveys. In addition, the 3-D AVO gradient estimates from the survey perpendicular to the fracture orientations are 35-40% lower than the AVO gradient estimates from the survey with line orientation parallel to the fracture direction. Also, AVO effects along different line orientations suggest that at near offsets the amplitude behaviour is similar for all azimuths but at far offsets an anomalous amplitude is seen along an azimuth perpendicular to the fracture zone.

Keywords: Amplitude, AVO, Fracture, Azimuthal Analysis, 3-D seismic, Anisotropy.

The NSW Government's Discovery 2000 - Geophysical Surveys And Their Effect On Exploration

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Abstract

During the first three years of the NSW Government's six year 'Discovery 2000' Exploration Initiative budget, approximately $9 million was spent on the acquisition and processing of over 850,000 line kilometres of airborne magnetic and radiometric data, and 14,000 gravity stations. Both mineral and petroleum prospective areas were targeted, covering an area of over 200,000 square kilometres, equivalent to 26% of the State.

This paper will discuss the new high resolution geophysical datasets that have provided industry with a world-class product. Large parts of mineral provinces have been covered by low altitude airborne surveys at a close interline spacing. This data has been released in combination with a greatly improved gravity dataset. The resultant high resolution data will facilitate area selection and has encouraged new exploration in areas of 'relatively' thin cover.

In the Northern Parkes area, for example, the new airborne data represents a tenfold increase in resolution over the previously available data. Except for the AGSO 1960 reconnaissance aeromagnetic surrey (1.5 kilometre interline spacing), barely 10% of the area was covered with company surveys. The Department has completed a "first pass" interpretation using this new data. This involved analysis of colour images of the total magnetic intensity, grey-tone images of the 1st and 2nd vertical derivatives, together with the radiometrics, gravity, and incorporating known geology. To further encourage the explorer, the Department completed computer depth analyses, potential field computer modelling, geophysical logging and a physical property's data base.

CD-Rom's have been released for most of the survey areas. The CD package includes outcrop geology, bedrock interpretation, depth to basement, geochemical data, location of mineral occurrences, and geophysical images. The release of high resolution geophysics at affordable prices, combined with the accompanying 'value-added' products, have significantly increased the prospectivity of NSW.

A new Era: Collaborative Geological and Geophysical Mapping

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Abstract

A core function of the New South Wales Department of Mineral Resources is the ongoing geological mapping of the State of New South Wales. Until recently, airborne geophysical data were not used in field mapping. Now that Second Edition geological mapping has begun, and with assistance from the National Geoscience Mapping Accord, large areas of the State have been flown with high resolution airborne geophysical surveys. With the State Government now requiring more to be done with less, the integration of these airborne datasets with geology in a collaborative process is necessary to maximise efficiency of geological mapping. Integration is achieved by initially using standard data presentations in a pre-mapping interpretation, followed by a suite of data enhancements during the field mapping phase. On-going interpretation is further refined by the use of ground geophysics and potential field modelling to resolve specific problems. Post-mapping synthesis of the data in a GIS environment enables mismatch between datasets to be highlighted. The end result is more professionally produced, high quality geological maps.

New Applications of Borehole Geophysical Logging in Mining and Mineral Exploration

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Abstract

The AAC GSD has undertaken extensive research into borehole geophysical logging within the diamond and gold environments. Detailed interpretation of logs can yield quantitative results and extensively aid the creation of a 3-dimensional model of the orebody.

Three case studies are presented. These are the evaluation of an alluvial diamond deposit in southern Namibia, the Sadiola gold orebody in western Mali and a kimberlite pipe in central Botswana.

Evaluation holes in the Sendelings Drift alluvial diamond deposit were geophysically logged with a small suite of tools in order to assist mine planning. Neutron and induction logs calibrated using XRD data enabled the delineation of problematic zones of high clay and silt content. In addition, the cementation or hardness index was semi-quantitatively derived using a variety of other log responses.

Geophysical logging of 162 holes in the Sadiola gold deposit was carried out in order to create a density model of the orebody. In addition, the density logs were calibrated to semi-quantitatively map the various problematic clay types present in the highly altered surface zone. Various other logs were used to aid delineation of the oxidised zone, zones of high alteration and sulphide-rich zones

The kimberlite pipe in the third case study is very complicated, with multiple intrusions and a great deal of country rock assimilation. The evaluation project was very successful as with the use of detailed geophysical log interpretation, petrographic studies and chip logs a detailed 3-dimensional model of the pipe was created within a short space of time. Five subtly different kimberlite types were identified using the geophysical logs, as well as four country rock lithologies. The percentage ore dilution by country rock was also calculated using the geophysical responses. The information supplied by geophysical logging proved critical in terms of the understanding.

Taking downhole EM underground, at Hill 50 Decline, Mt Magnet, Western Australia.

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Abstract

Hill 50 Decline (part of the Hill 50 Gold Mine group of deposits) is located at Mt Magnet, 560 km NNE of Perth, in the Murchison Province of the Yilgarn Craton. The Hill 50 orebody is hosted by banded iron formation (BIF) "bars" of the Sirdar Formation, generally having a width

greater than 20 m. Gold mineralisation is localised along the NNE - NE striking faults, known as Boogardie Breaks, and sub - horizontal fractures. Sulphide replacement of the adjacent oxide - facies BIF has resulted in steeply plunging stratabound shoots ("pencils") of massive gold - bearing pyrite - pyrrhotite ore, with pyrrhotite being the dominant sulphide at depth and at the centre of the ore zones. Previously, pyrrhotite - rich BIFs have been shown to be characterised by significantly higher conductivities than their unmineralised counterparts.

Downhole electromagnetic (DHEM) surveying carried out in the Hill 50 underground was aimed at detecting these massive, pyrrhotite conductors. A 65 m x 80 m transmitter loop was laid out underground and drillholes were surveyed using the three component, Crone pulse EM system. Logistical problems experienced during data collection were largely related to firing times and data quality was greatly influenced by the numerous noise sources encountered in an operating underground mine (e.g. drill rigs, trucks etc.).

Modelling and interpretation of the resulting DHEM data has identified several conductors. With one exception, lying in the Outer BIF Bar 1, all the interpreted conductors are positioned within the Hill 50 BIF Bar. Mostly, the conductors are modelled as steeply dipping, while those modelled as shallowly dipping are considered to be related to mineralisation within the sub - horizontal fractures. Of the models tested so far, all have been shown to be directly related to massive sulphide mineralisation, the majority of which are associated with economic gold grades, demonstrating that the technique has been effective in delineating the pyrrhotite - rich BIF target underground.

Keywords: Archaean banded iron formation - hosted gold, Kirkalocka SH50-3, downhole EM, petrophysics

Development of the IP Tomography System and Field Testing in the Seta Area, Hokkaido, Japan

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Abstract

The geotomographical technique has been intensively developed since the mid 1980s. The Technical Development Division for Exploration at the Metal Mining Agency of Japan (MMAJ) has conducted research on the application of both DC resistivity and IP tomography technique for mineral exploration. The MMAJ developed a data acquisition system for IP tomography in 1994, which is based on the time domain IP method and the pole-dipole configuration, in order to acquire the primary and secondary potential data of good quality in reasonable time. This system is composed of a transmitter, receiver, controller, cables for measuring potential on the surface and in drillholes, cables for transmitting current in drillholes, relay boxes and cables to convey digital signals to select the injecting and measuring electrodes by operating a personal computer. Ten potential values of the data can be acquired simultaneously with only a negligible influence by the capacitive and EM coupling effect due to the built-in OP amplifier on the cables or relay boxes for potential. The MMAJ has also developed an inversion program which adopts Powell's hybrid nonlinear least-squares method using the finite element method (2.5 D). The chargeability in each block is calculated using Seigel's equation. The computation time for chargeability could be reduced by using a Jacobian calculation for modifying the parameters (resistivity) as the partial derivatives in Seigel's equation.

Using this system, MMAJ carried out an IP tomography field test in the Seta area, Hokkaido, Japan, in October 1994, in order to evaluate the efficiency and accuracy of the acquired data. Since 1989, the MMAJ has been conducting exploration for epithermal gold vein deposits in this area, which is characterised by mercury, kaolin, widespread silicification and hydrothermal breccias associated with a shallow hydrothermal system. Non-polarisable potential and current electrodes were set up with 20 m and 100 m separation, respectively, both on the surface (600 m line length) and in two drillholes (480 m and 300 m downhole length) in order to delineate the alteration zone using the primary data and the hydrothermal breccia zone, including abundant pyrite, using the secondary data. The data obtained by pole-dipole configuration were analysed by the joint inversion program of resistivity and chargeability. The reconstructed resistivity image indicates the silicified zone associated with high resistivity, the argillic zone with low resistivity, and the reconstructed high chargeability portion corresponds to the hydrothermal breccia zone. Such IP data can be very useful in the exploration for epithermal gold deposits by defining the boundaries of alteration and hydrothermal brecciation. However, it is necessary to conscientiously measure the chargeability of the core samples in the survey area for accurate interpretation of the reconstructed chargeability distribution.

Keywords: IP tomography, Seigel's

Synchronous Interval Analysis - A Possible Approach to the Seismic Mapping of Sequence Bound Lateral Lithology Changes

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Abstract

Sequence bound lateral lithology changes occur when aggradational stacking of depositional systems causes laterally distinct facies tracts to superimpose through geologic time. In the genetic framework of sequence stratigraphy, sequence boundaries encapsulate the depositional evolutionary paradigm of progradation, followed by aggradation and retrogradation. The genetic differences between these phases causes their distinct lithologic architectures.

The basal Jurassic of the Roma Shelf (Queensland) is a good reference section for developing approaches to map sequence bound lateral lithology changes from seismic data. Here the aggradational phase consists of stacked, laterally restricted meander belt sandstones surrounded by nonreservoir floodplain units. The overlying

retrogradational phase, typified by episodic flooding, consists of laterally extensive interbedded units which commonly offer the first coherent signal above the sequence base. This interval provides vertical sealing for hydrocarbon pay zones in the underlying sandstones.

An approach termed "Synchronous Interval Analysis" is proposed which exploits the lateral consistency of the retrogradational phase to map lateral lithology changes in the underlying aggradational phase. A statistical study of borehole intersections across the Roma Shelf indicates that, relative to the total thickness of the sequence, a close relationship exists between the thickness of sandstones at the sequence base and the thickness of isochronous intervals in the overlying retrogradational phase. This is caused by the differential compaction between the stacked sandstones and the adjacent mud dominated units. A mathematical analysis of this aspect indicates a compaction difference of approximately 40% for these lithologies when buried to just 200 m. Published work on a series of outcrops in the USA, at scales similar to seismic data, provides further support of this concept.

In contrast to seismic stratigraphy, Synchronous Interval Analysis is a fully objective interpretation approach. It capitalises on the tendency of coherent signal to image smooth planar surfaces such as those following geologic time lines. With the current armoury of workstation interpretation tools, the routine application of such an approach is now a distinct possibility. In particular, instantaneous phase displays assist in delineating subtle events while autotracking algorithms alleviate the compounding of event timing errors, a risk when traveltime intervals are mapped.

Structural interpretation of a sedimentary basin using high-resolution magnetic and gravity data

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Abstract

The Merlinleigh Sub-basin in the onshore Southern Carnarvon Basin is a frontier area for petroleum exploration, with limited seismic coverage and only two deep exploration wells. High-resolution aeromagnetic and semi-detailed helicopter-supported gravity surveys were conducted in 1995 to assist with the structural interpretation of the sub-basin. An evenly spaced grid of potential field data provided relatively cheap structural information, compared with the cost of acquiring seismic data, and an opportunity to test the relative effectiveness of gravity and magnetic data in a sedimentary basin. In the Merlinleigh Sub-basin, magnetic anomalies are dominated by near-surface and intra-basement sources. Gravity anomalies provide reliable definition of the structures at basement level and within the sedimentary sequence. Some of the gravity lineaments are consistent with fault trends mapped with seismic data, whereas others were undetected in the other datasets. North-westerly-oriented gravity lineaments represent transfer faults generated by the breakup of Gondwanaland in the Early Cretaceous.

Acquisition costs for the similar sized aeromagnetic and helicopter-supported gravity surveys were similarly priced. In contrast to gravity data, aeromagnetic data provided only a small contribution to the structural knowledge of the area. Gravity data collected on an evenly spaced grid are likely to provide more structural information than aeromagnetic data within this sedimentary basin.

Petroleum Exploration in Proterozoic Basins Using Potential Fields Data and Stratigraphic Coring

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Abstract

The Savory Sub-basin in the Officer Basin is a frontier area under-explored for minerals and unexplored for petroleum. The sub-basin consists of Neoproterozoic sedimentary sequences that overlie a complex mixture of Mesoproterozoic and older sedimentary, metamorphic and crystalline rocks. Neoproterozoic sedimentary basins such as the McArthur and Amadeus Basins have proven prospectivity for hydrocarbons, and the Geological Survey of Western Australia (GSWA) has initiated a study of the Savory Sub-basin to encourage petroleum exploration in this area.

The GSWA conducted a semi-detailed gravity survey (2x3 km grid) to assist with the structural interpretation of the Savory Sub-basin and with the positioning of a stratigraphic well. The accuracy of the reduced Bouguer gravity is ±0.6 micro ms^{-2}, which is a large improvement on measurements taken over the eleven kilometre grid previously recorded by the Bureau of Mineral Resources. In this area, gravity data can be more effective than aeromagnetic data to estimate sedimentary thicknesses, provided the formation densities are known so that plausible gravity models can be constructed.

Trainor 1 was drilled by the GSWA to test Neoproterozoic source rocks of the Savory Group, and was located where low density sediments were expected to occur. The well penetrated the prognosed Neoproterozoic sediments down to 83 m, however, higher density Middle Proterozoic or older sediments where intersected from 83 m to 709 m where the well was terminated. Without prior knowledge of the formation densities it is difficult to make appropriate estimates of sedimentary thickness from gravity data. Gravity data provides economical structural information during the initial phase of exploration in frontier basins. With well constrained density models reasonable estimates of sedimentary thicknesses can be made.

Keywords: Proterozoic sedimentary basin, Gravity, Magnetics, Density, Cores, Seismic, models.

Regional surveys in Victoria - experiences and lessons

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Abstract

The Victorian Government, through the Department of Natural Resources and Environment, is in the final year of a 3-year, $16.5 million program, the Victorian Initiative for Minerals and Petroleum (VIMP) to support the state's mineral and petroleum exploration industry. Projects being undertaken as part of the initiative include the acquisition of airborne magnetic and radiometric data, gravity and regional seismic data, stratigraphic drilling, geophysical interpretation and geological mapping. Major airborne surveys are being carried out in the north west of the state, the eastern highlands and the Otway Basin.

Since 1992, major changes have taken place in the legislation, quality of available data and government customer focus. This encouragement from government has resulted in a significant increase in exploration in Victoria. However, many areas still remain under explored. For the first time, the explorer now has access to high quality detailed regional data sets to help determine mineral exploration targets and include in a modern exploration program and to help determine mineral exploration targets.

The VIMP program has led to an increased level of sophistication in survey and product requirements. Major developments in data acquisition and processing have taken place in the airborne survey industry partly as a result of the VIMP surveys. Government and industry require contractors to carry out surveys to obtain high quality data, in a timely and cost effective manner. In addition, government requires regionally consistent data and marketable products with a long shelf life.

These differences between government and industry requirements are not always understood by industry and, in some cases, contractors. An assessment of the VIMP surveys is used to illustrate some of the issues involved.

Keywords: magnetics, radiometrics, gravity, digital terrain model, exploration, Victoria, Victorian Initiative for Minerals and Petroleum

Eastern Victoria: A New Exploration Frontier?

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Abstract

High quality airborne magnetic and radiometric data provide the cornerstone for the geological understanding of the relatively unexplored eastern highlands of Victoria. The Geological Survey of Victoria has obtained over 180 000 line kilometres of new airborne data in eastern Victoria. This data collection is a major component of the Victorian Initiative for Minerals and Petroleum (VIMP).

Eastern Victoria has an excellent geological section across the eastern Lachlan Fold Belt. The Late Ordovician Benambran event deformed Early Ordovician turbidites. Two cycles of rifting during the Silurian and Early Devonian resulted in transtensional rift-like grabens. Silicic volcanics and marine sediments filled these rifts. The Late Silurian Bindian Deformation resulted in major northwest and northeast fault trends which are apparent in the geophysical data. Granites with various magnetic and radiometric responses, have intruded the area, with several reaching the surface to produce calderas.

The area is rich in potential mineral targets. I-type magnetic granites have associated porphyry style copper-gold (including chalcocite blanket) mineralization. Silurian greisen dykes have associated tin-gold mineralization. The Silurian rifts host volcanic associated massive sulphide mineralization, including the Wilga copper-zinc deposit, and the Devonian rifts host epithermal gold mineralization. The Late Devonian carbonates of the area contain Irish style lead-zinc mineralization.

The new geophysical data allow improved mapping of the geological units of eastern Victoria, interpretation of the regional structural features, and identification of exploration targets. The regional geophysical datasets provide an excellent basis for mineral exploration in the under explored eastern Victoria.

Keywords: Victoria, geophysics, total magnetic intensity, radiometric, digital terrain model, geology, prospectivity, interpretation, mineral exploration.

New Data, new insights: an example from Western Victorian

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Abstract

The aeromagnetic surveys flown under the Victorian Initiative for Minerals and Petroleum and by others give a major regional dataset over western Victoria. This paper presents a new interpretation of the structural and tectonic history for the lower Palaeozoic rocks of the region derived from integrating the aeromagnetic, regional mapping and other datasets. It provides a new geological model for exploration beneath the thin Murray Basin cover.

Two distinct packages of rocks are present in the western Victorian basement; the eastern Stawell Zone and the western Glenelg Zone. The Stawell Zone contains turbidites and oceanic basalts typical of much of the Victorian Lachlan Fold Belt and which host major gold deposits. They are weakly magnetic with the basalts and pyrrhotitic slates providing most magnetic expression. Recent Ar-Ar dating gives a deformation age of about 435 Ma. Their western boundary is the northern extension of the Moyston Fault.

A new tectonic framework is proposed for the Glenelg Zone. Island arc volcanic rocks and metasediments of the

Zone have been variably metamorphosed and simply deformed in the 500 Ma Delamerian Orogeny. The rocks lie in a similar structural and tectonic position to those of the Mount Read Volcanics and have potential for VHMS deposits. Correlations can also be made with other Cambrian VHMS deposits and prospective regions in eastern Australia.

Along the South Australian border part of the Glenelg Zone, the Ozenkadnook Subzone, contains amphibolite grade rocks that have been complexly folded in a deformation that seems to be earlier than the Delamerian. These rocks are of uncertain affinity, but may be a northern correlative of the upper Proterozoic rocks seen in northwest Tasmania.

Keywords: magnetic interpretation, gravity interpretation, volcanic hosted massive sulfides, gold, tectonic framework.

The Structure And Evolution Of The Bass Basin As Delineated By Aeromagnetic Data

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Abstract

The Bass Basin, a failed Mesozoic rift, located offshore between Tasmania and Victoria, was formed by extension associated with the separation of the Australian and Antarctic continents. Integration of the first available complete aeromagnetic coverage of the area, newly available gravity data, existing seismic data, drill hole information and outcrop geology mapping, indicates that northeast-southwest tension ruptured and separated fragments of the upper crust to create a depocentre up to 60 kilometres wide. Fracturing along pre-existing basement lithological contacts and structures allowed transfer fault movements to accommodate this extension. Three main compartments developed in the basin, each of which underwent different degrees of extension. These compartments overlie accumulations of dense magnetic mafic material, evident on 14-second seismic reflection data, which were apparently produced by a mantle decompression process associated with crustal thinning. The largest of these mafic bodies displays the characteristics of a preserved, embryonic, oceanic spreading centre.

Structural style of the Warburton Basin and control in the Cooper and Eromanga Basins, South Australia

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Abstract

Deep-seated structures originating within the Warburton Basin have been intermittently reactivated during development of the unconformably overlying Cooper and Eromanga Basins.

Four major kinds of deep structures preceding deposition of the Cooper Basin have been described. 1) A strongly folded and faulted zone occurs on the eastern side of the Birdsville Track Ridge near Kalladeina 1. 2) Simple reverse faults are common and widespread. 3) Gentle folds occur in the Coongie area and become increasingly tight towards the eastern side of the Birdsville Track Ridge. 4) Simple ramp and imbricate thrust faults form the cores of structures along the Gidgealpa-Merrimelia-Innamincka (GMI) Ridge.

The interpretation of fault movement is consistent with matching of displaced seismic packages ensured by biostratigraphic evidence. Within the Warburton Basin, three major unconformities separate four major seismic packages (I-IV) according to their stratal terminations and reflection characteristics. It is difficult to trace seismic packages I-IV from the Kalladeina-Nulla area to other parts of the basin because of tectonic deformation and poor regional seismic data. However, the same Early Ordovician fossils in Kalladeina 1, Wantana 1 and Coongie 1 permit reliable correlation of high amplitude packages (seismic package II) in the vicinity of these wells. This correlation supports the interpretation of imbricate thrust slices in the vicinity of Wantana 1, which caused the Early Ordovician strata (top part of seismic package II) thrust over the younger low amplitude (seismic package III).

The Warburton Basin structural control in the overlying basins is mostly characterised by reactivation and propagation of the thrust faults along the GMI Ridge, and also further folding and faulting of the deformed zone along the Birdsville Track Ridge. The episodic, compressive reactivation influenced sedimentation and erosion of the Cooper and Eromanga Basins. Footwall structures are believed to be formed by reactivation and propagation of the thrust faults, and present potential targets for Permian hydrocarbons.

Keywords: Warburton Basin, Cooper/Eromanga Basins; structural style; thrust faults; folds; potential structural traps; seismic interpretation.

Geophysical Anomalies of the Central Belt in Peninsular Thailand

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Abstract

Regional gravity measurement, aeromagnetic and aero-radiometric data interpretations were carried out in southern part of peninsular Thailand, an area between latitudes 630N-800N and longitudes 9930 E-10045 E. The objective of this study is to delineate the boundary of the central granitic belt.

Minimum Bouguer anomaly was observed along the granitic outcrops of the central belts. The anomaly gradually increases toward Andaman Sea and the Gulf of Thailand on the west and the east respectively. Relatively high aero-radiometric anomalies confine very well with the outcrops of the granitic ranges whereas local

magnetic anomalies sparsely distribute along the ranges. Gravity modelling shows that the granite is underlain by a crustal rock of greater density. The granite is very thick along the ranges and gradually thin toward the west and the east. Magnetic modelling shows that the granite comprises the upper and the lower parts of different magnetic susceptibility where the upper one is the source of the magnetic anomalies.

Geological Interpretation of High-resolution Airborne Geophysical Data in the Broken Hill Region

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Abstract

The Broken Hill Exploration Initiative is a collaborative venture involving AGSO, MESA and the NSWDMR. It was initiated to support an exploration thrust into the Broken Hill region. The BHEI has provided new high resolution data sets that are being used to produce innovative products to assist explorationists.

New high resolution airborne geophysical data acquired in the Broken Hill Region are being used to assess the deformational history and define the regional structural regime. The interpretation of these data coupled with detailed structural mapping, may enable new structural and stratigraphic models to be postulated that will enhance and revitalise the exploration thrust within the Broken Hill Region. A combination of structural interpretation and zircon age dating has enabled AGSO staff to define a new deformational history for the region. The interpretation of geophysical data has provided new maps for the exploration industry and research workers. Deep seismic reflection data acquired by AGSO in mid 1996 is being processed at present and the initial brute stacks suggest that the data will complement the structural interpretation.

Work on the regolith components in the Broken Hill region has facilitated the production of two new broad scale regolith/landform maps. The regolith research has provided explorers with new data to assess the mineralisation potential in regions that host subcrop or blanket cover.

Government-sponsored Geophysics In Tasmania

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Abstract

Since the late 1970s the Tasmanian Geological Survey has been involved in a number of small geophysical projects which were either targeted at specific problems or intended to provide an incentive for exploration. By ensuring that all data acquired during such projects are fully integrated with existing regional datasets the utility of the projects has been extended to produce a progressive improvement in the geophysical interpretation of Tasmania. Associated interpretation has provided the MANTLE91 residual gravity model and the regional structure of the major Tasmanian granitoids.

In the East Coast Coal Project, gravity and magnetic data were used to optimise drilling for coal under as much as 600 metres of dolerite, and later to provide ground information for mine planning. Because of the lack of any sub-surface information, selecting drilling sites on dolerite-covered areas became difficult and gravity and magnetic methods were used successfully to define drill sites for reserve definition. The combined gravity and magnetic interpretation clearly showed the areas of thick dolerite cap and dolerite feeders where the coal measures may either be truncated or badly disrupted.

One of the incentives to mineral exploration was the Mt Read Volcanics Project, which included an evaluation of the geophysical signatures of all types of western Tasmanian metallic mineralisation and the applicability of geophysical techniques in the search for these deposits. Measurements over the major volcanogenic massive sulphide deposits show that the 'type' deposit from western Tasmania has a very subtle magnetic signature, is chargeable and a fair to good conductor. There will also be a gravity signature but the subtlety of this is such that even after terrain correction of the data this technique cannot be used for first-pass exploration.

A later project in northeast Tasmania involved the acquisition and interpretation of high resolution data to promote an under-explored gold province with the subsequent pegging of 95% of the area offered. On a regional scale the main Mathinna-Lyndhurst gold belt falls on a positive residual gravity anomaly and in part on a magnetic low. Closer examination commonly shows that mineralisation sites are located near crests of broad positive gravity anomalies interpreted as areas of maximum thickness of Mathinna Group rocks.

The Basement Elements Of Tasmania

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Abstract

A new compilation of magnetic data over onshore and offshore Tasmania plus existing geological mapping and gravity data have provided the basis for the production of a map illustrating the geometric distribution of the main basement units of the state. Significant aspects of the new interpretation map include: the delineation of the widespread sub-surface granite occurrences in Tasmania; identification of more extensive occurrences of Proterozoic rocks than previously known; mapping of the extent of the Dundas Trough and extensive north-western and southeastern continuations of the Beaconsfield ultramafic rocks; definition of the areal distribution of Mesozoic sedimentary basins; and the control of Proterozoic lineaments, in particular the Arthur Lineament, on the development of the Mesozoic basins.

Three-dimensional Kinematic Modelling of the Magnetic Field of the Southern Joseph Bonaparte Gulf

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Abstract

Kinematic modelling differs from traditional modelling techniques in that model geometries are obtained by subjecting an initial horizontal stratigraphy to specified structural deformations rather than being input as a pre-specified shape. The magnetic field over the southern Joseph Bonaparte Gulf of north-western Australia is ideally suited to a kinematic modelling approach because the magnetic response of the area is almost entirely due to an extensive sheet of Proterozoic Carson Volcanics, which apparently originally covered a large proportion of the area. That unit has subsequently been fractured and warped during Palaeozoic rifting. A three-dimensional kinematic model has been produced for the present geometry of the Carson Volcanics such that the computed magnetic field for the model closely duplicates the observed magnetic field. The object of the exercise was to test the kinematic modelling approach by using the Noddy modelling package under development by the Department of Earth Sciences, Monash University and to clarify the tectonic development and present structure of the Joseph Bonaparte Gulf region.

The modelling largely confirmed earlier interpretations of the data based on image analysis and modelling of profile data. Refinements indicated by the three-dimensional modelling were a magnetic feeder pipe to explain a large localised magnetic high and a salt accumulation with a diamagnetic susceptibility giving a negative magnetic susceptibility contrast relative to adjacent sedimentary rocks to explain a magnetic low previously interpreted as being due to a localised absence of the magnetic sheet. The interpretation of the salt body is consistent with drill and seismic data, thus demonstrating the effectiveness of kinematic modelling of magnetic fields.

Automatic interpretation of magnetic data using the Source Parameter Imaging method

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Abstract

This paper presents a novel method for automatically determining the parameters which describe the source of magnetic anomalies. The strength of the method is that the technique operates on gridded data and lends itself well to image processing of the results.

The approach we take is to estimate the depth to the source of each individual anomaly. This is done by using the concept of the analytic signal. It can be shown that an estimate of the *local wavenumber* of the analytic signal at each location is dependent on the depth to the source. In fact, the position where the wavenumber is a local maximum corresponds to an edge location, and the magnitude of the maximum can be used to determine the depth directly from the map. For this reason, we have called the wavenumber maps *local depth* images. If we assume no remnant magnetisation, then it is also possible to produce images of the *local dip* and the *local susceptibility (or susceptibility-contrast thickness)* of the source.

The new method, source parameter imaging (SPI), has been tested on synthetic data as well as on recent high resolution aeromagnetic survey datasets. The source estimates are good where the data satisfies our assumption of two dimensionality. SPI results are presented for several survey datasets including examples from a recent survey in the Surat Basin of New South Wales. The SPI images provide an excellent first pass assessment of depth to magnetic sources and allow complex features to be more rapidly interpreted.

Keywords: magnetics, automatic, interpretation, depth to basement, susceptibility, dip, image processing, Source Parameter Imaging, SPI

Automatic depth to basement analysis in modelled regions of complex structure

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Abstract

Current automatic depth to basement techniques aim to locate individual magnetic sources. This approach is appropriate for small areas with isolated anomalies but does not address the problem of calculating depth to basement, in a regional context, of multiply deformed terrains. The aim of this research was to test the Euler deconvolution depth to basement technique using complex geological models.

Four models were created using the structural and geophysical modelling program, Noddy. These models were used to provide complex magnetic data with which to test the Euler deconvolution method as formulated in the Intrepid geophysical processing package. It was found that the present form of output from the Euler technique was difficult to interpret for areas of complex geology, with up to 40,000 depth solutions being calculated.

By using synthetic magnetic data calculated by the Noddy program, and hence knowing the depth to the basement for each of the models, we determined that a linear relationship exists between the true depth and the apparent depth indicated by the peak in the frequency histogram of depth solutions.

An alternative method is being developed for displaying the information calculated by the Euler deconvolution tool. This method defines local depth estimates over a region and produces an apparent depth image, where the geometry of the basement can be seen clearly. The depth images are re-scaled according to the linear relationships derived from the initial tests on the synthetic data, and provide quite accurate estimations of depth to basement.

The Contribution Of Airborne Geophysics To Mineral Prospectivity In The Northern New England Fold Belt.

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Geological Survey of Queensland, Department of Mines and Energy.

Abstract

AIRDATA was a $3.5 million Queensland Government initiative designed to acquire high resolution airborne magnetic and radiometric data over 102 000 km^2 of central eastern Queensland. This dataset is integral to the first phase of the GEOMAP 2005 program designed to remap potentially mineralised parts of the state commencing with the Yarrol Province in the northern New England Fold Belt (nNEFB).

Historically the nNEFB has been an important producer of gold and to a lesser extent copper. Most mineral deposits occur in a variety of styles associated with Permo-Triassic magmatic activity. However the major producer has been the world class Mount Morgan gold-copper mine, hosted by Devonian volcanics, where exploration has recently recommenced near the mine site. Other prospects in the nNEFB include Mount Rawdon and Mount Mackenzie (both gold), and Develin Creek (base metals), the latter in rocks previously regarded as unprospective.

Intrusive rocks in the Yarrol Province have been remapped with the aid of results from AIRDATA. Interpretation of aerial magnetic data has facilitated the recognition of distinct intrusive phases within previously undifferentiated granitoid bodies ranging in composition from granite to gabbro. Examples include the Mount Gerard Complex, Glassford Complex and Kyle Mohr Granodiorite.

In sedimentary terrains, there is a marked increase in the radiometric response to all sedimentary rocks younger than mid-Carboniferous compared with sequences of Late Silurian to Early Carboniferous age, reflecting the tectonic evolution of the nNEFB. Interpretation of radiometric data allowed the identification of an unconformity between Early- and Late-Devonian rocks within the area previously assigned to the Mount Holly beds. This finding should significantly alter exploration models employed in this area in the future.

The AIRDATA dataset has been employed in the recognition of large scale structural features, many of which coincide with, and extend beyond lines of historic workings.

By linking geophysical data to other digital datasets eg. digital terrain models, Auslig topographic bases, and previous geology (from government and company mapping) the Geological Survey of Queensland has been able to focus field effort to delineate a new geological framework for improved knowledge of mineral potential in the nNEFB.

Geophysical Signatures Of South Australian Mineral Deposits

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Abstract

To take advantage of large quantities of new geophysical data and increased exploration interest due to the South Australian Exploration Initiative a compilation of the geophysical signatures of South Australian mineral deposits has been undertaken. This project has two stages which will be described in a two-volume publication. The first volume, scheduled for publication in 1996, summarises all publicly available data, and some proprietary data, on the geophysical signatures of the State's mineral deposits. Separate chapters describe deposits according to the dominant commodity. These include copper, iron, uranium, lead-zinc, and other commodities such as gold, nickel, talc and graphite. The total number of deposits discussed is forty-four.

The second volume, scheduled for publication in early 1997, is primarily concerned with newly acquired airborne geophysical data, from the South Australian Exploration Initiative and also Australian Geological Survey Organisation and commercial surveys. The majority of the data described will be aeromagnetic, but other data will be included as required and available. For each deposit, data from the surrounding few tens of kilometres will be presented and interpreted with emphasis on lithological and structural control of the deposit. Regional-scale interpretations will also be included, again emphasising controls on known mineralisation.

South Australian Exploration Initiative - Stardate 1997

Dave Cockshell

Abstract

Mineral and petroleum exploration in South Australia has entered a new era following the success of the South Australian Exploration Initiative (SAEI). The South Australian Government's $22.6 million investment in geoscientific information has provided the catalyst for a dramatic increase in exploration activity in the State and has initiated similar programs in other States.

Acquisition of aeromagnetic, gravity, seismic and radiometric data and merging with existing datasets has been a key component of this initiative. Improving industry's view of prospectivity has also been achieved through consolidation of geophysical, geological, cultural and environmental data, and providing resultant GIS datasets at nominal cost.

In the four years since the start of the SAEI, over 150 projects have been undertaken, comprising 59 for petroleum, 76 for minerals and 18 general projects. To date, the focus has been on new data acquisition, including airborne geophysics ($11 million), seismic ($2.2 million) and bedrock drilling ($2.1 million). The focus of future activities will move toward data collation,

consolidation and interpretation. In addition, attention will be narrowed to more specific targets and problem areas.

The success of the initiative to date is indicated by:

- gold discoveries at Challenger and Nuckulla Hill
- a 75% increase in area covered by mineral exploration licences or applications
- an increase in annual mineral exploration commitment from $10million to $30million
- 7 Petroleum Exploration Licences or applications in frontier basins
- doubling of petroleum exploration commitment from $45million
- undertaking of seismic surveys in sensitive areas such as Aboriginal Lands and National Parks

SAEI funding has not been directed toward technical innovation in terms of research and development. Instead, there has been a focus on providing industry with basic data and applying existing technologies to customise data to suit the explorer. Examples of such include:

- development of a radiometric test range
- trials of high resolution aeromagnetics and processing for petroleum exploration
- merging and upgrading of open file datasets of widely varying quality
- transcription of seismic and geophysical well log magnetic tapes onto high density media
- development of technique to statistically measure environmental impact and recovery

The full benefits of the SAEI will unfold over many years.

The Otway Continental Margin Transect: crustal architecture from wide-angle seismic profiling

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Abstract

Wide-angle seismic profiling along the Otway Continental Margin Transect defines the velocity structure from the continental crust onshore to the deep Southern Ocean across an area of extended and faulted basement to the Otway Basin in southeastern Australia. The basin is located in an intermediate tectonic setting between the southern Australia continental margin to the west where the Australian-Antarctic separation occurred close to the craton and an area to the east where the locus of separation failed to develop through the Bass Strait but was instead displaced to the south of Tasmania. This resulted in a triangular-shaped region of attenuated and thinned continental crust and lithosphere that forms basement to the Otway Basin sequences.

This continent-ocean transition was formed during a two-stage extension process in Late Jurassic to Cretaceous times. Onshore seismic reflection profiles have defined the half-graben geometry of first stage extension (rift) segments along the basin's northern margins with Palaeozoic rocks of the Delamerian and Lachlan orogens. The landward limits of the second stage extension were identified along the Tartwaup-Tyrendarra-Timboon Fault system.

A significant section of Otway Basin sequences (up to 5 km) lies offshore beyond the shelf break as a continental slope basin overlying uppermost Palaeozoic basement (P-wave velocity 5.5-5.7 km/s). A deeper basement velocity of 6.15-6.35 km/s is prominent. The whole upper crustal basement section thins from 16 km thickness onshore to 3.5 km at 120 km from the coast. The lower crustal velocity of 6.4-6.8 km/s extends down to an upper mantle transition zone 1-2 km thick (6.9-7.8 km/s) overlying the Moho at 30 km depth onshore, shallowing to 12 km in the deep ocean basin. The upper mantle velocity is 8.05 km/s, increasing to 8.3 km/s at 40 km depth.

There is no evidence of a thick, high-velocity, lower crust (>7 km/s) that would indicate that this is a 'volcanic' margin as defined on some North Atlantic margins. The extension in this region was slow prior to the formation of the earliest oceanic crust. Analogues for the Otway margin include the 'non-volcanic' Galicia Bank off the Iberian Peninsula and the Nova Scotia margin off eastern Canada.

Maastrichtian Breakup of the Otway Basin Margin-a Model Developed by Integrating Seismic Interpretation, Sequence Stratigraphy and Thermodynamic Studies

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Abstract

The generally accepted model of a 95 Ma breakup event in the Otway Basin has several unresolved inconsistencies, including evidence of significant post-95 Ma aged crustal extension. An alternative model is proposed: oceanic breakup took place at the end of the Late Cretaceous. A phase of extension during the pre-Aptian was followed by thermal subsidence before renewal of rifting (Cenomanian). Rifting of the already attenuated crust allowed the region to subside below sea level, resulting in marginal to nearshore marine conditions throughout most of the Late Cretaceous.

Continental breakup in the Late Maastrichtian (approximately 67 Ma) was marked by regional uplift along the northern basin margin, and towards the incipient continent-ocean boundary. This uplift is parallel to the present day shelf. The age of this event is derived from palynological and seismic information, and is consistent with thermochronological work. Broad anticlinal features on the basin margin may be associated with ridge-push associated with early oceanic crust development.

The first post-rift depositional cycle was during the latest Maastrichtian. A significant transgression flooded the peneplain (67 Ma unconformity surface). A maximum flooding surface was developed near the Cretaceous/Tertiary boundary, with subsequent highstand deposits developed through most of the basin. A second unconformity marks a depositional hiatus at the end of the deposition of this sequence.

Later cycles of post-rift sedimentation began in the Late Paleocene (55 Ma) with deposition of the 'Wangerrip Megasequence'. Several eustatic sequences were deposited in a deltaic environment during the subsequent 8 million years.

Keywords: Continental Breakup, Otway Basin, Passive Margin, Sherbrook Group, Southern Ocean

Regional geophysics and geology of King Island

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Abstract

King Island lies at the western end of Bass Strait, approximately midway between Tasmania and Victoria. The island is mostly flat and covered by a variable thickness of transported material. Outcrop is generally restricted to the narrow coastal margin. The western half of King island is composed of relatively high grade Proterozoic metasedimentary rocks, intruded by Proterozoic granitoids. In the east, the metasedimentary rocks are of a much lower metamorphic grade and are intruded by Devonian granitoids. A sequence of Proterozoic basaltic units crop out along the southeast coast.

Regional magnetic and gravity data acquired as part of the TASGO National Geoscience Mapping Accord project, have been used to reinterpret the geology of King island and to help place the island in its correct geological context with respect to Tasmania and to the mainland.

The metasedimentary sequences are largely non-magnetic and high frequency linear magnetic anomalies onshore are due mainly to post-tectonic dolerite dykes. The Proterozoic granitoids are strongly deformed and are delineated by N-S trending elliptical zones of reduced total magnetic intensity and small residual Bouguer anomalies. The Devonian granitoids, in contrast, are ovoid in shape and have more pronounced negative gravity anomalies.

A major NNE trending magnetic zone extends from west of Tasmania, just to the east of the King island and north towards Victoria. This feature, which has an associated positive gravity anomaly, marks the thick sequence of steeply dipping NeoProterozoic basalts which crop out on Bald Head. West of the island is a NNW trending magnetic zone which is entirely offshore and separated from the Proterozoic metasedimentary sequence by a major mylonite zone. The source of this anomaly is uncertain but a steeply dipping sequence of mafic rocks is inferred.

Single Pass Airborne Multi Sensor Surveying using the Dighem System

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Abstract

The use of single pass multi-sensor surveys has become more common within the last three years because of improvements to electronic and mechanical designs. In the past, the primary limitation was the high cost of such surveys.

Recent new design has reduced the weight of electromagnetic sensors by the order of 30% through the use of composite fibre technology.

These reductions in system weight and size have allowed multi-sensor systems to be installed into single engine light turbine helicopters such as the Eurocopter SA3 15B (Lama) and AS350B (Squirrel series) helicopters. Operating costs of these machines are typically half of the medium weight twin turbines. In addition, specialised lightweight systems (such as Dighem's Lite and Poem systems) allow the use of the HEM equipment at high altitudes previously considered to be inaccessible.

Multi-frequency resistivity Mapping involves the use of a minimum of three operating frequencies. Raw parameters recorded are the inphase and quadrature of up to five frequencies. These raw channels are then inverted to provide a resistivity and depth for each frequency. Similar to the late and early times in a time domain system, the responses from the lowest frequencies generally reflect a deeper conductive source than the higher frequencies. This difference in response allows the data to be inverted to provide resistivity depth sections. Resistivity data can be presented in a number of ways including plan maps, depth sections, depth slices, three dimensional models and weathering thickness maps.

Standard imaging products such as pseudocolours, shadow and colour composite maps can be produced. In addition, multi-variate statistical analysis techniques have been used to provide an integrated interpretation of such multi-sensor surveys.

The usefulness of airborne resistivity, radiometric and magnetic surveys in a particular geologic environment should be evaluated prior to the actual flying of a survey. Certain geological conditions may preclude the use of a technique. In particular, radiometrics will be of little value in areas of transported materials or where there is little outcrop, electromagnetics in areas of high near surface conductivity such as saline lakes and magnetics in areas where there is no susceptibility contrast between host and target rocks. The utility of a technique in a geological environment can be determined using modelling software.

Multi-sensor systems are now being used more frequently in airborne survey work because of the perceived value of the information gathered. Perceived value is defined as a combination of the value of the information gathered to the exploration program, the time savings achieved by doing airborne work plus the financial savings obtained by reducing the amount of ground work required.

The Effect of Uncertain or Changing System Geometry on Airborne Transient Electromagnetic Data.

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CRC for Australian Mineral Exploration Technologies School of Earth Sciences - Macquarie University

Abstract

The errors due to distortions in a transient AEM system geometry are quantified both in terms of the data and parameters derived from thin sheet inversions. The effects of variation in aircraft altitude and pitch, and bird position and pitch have been modelled for step and impulse responses in the X and Z components. Aircraft

and bird pitching motion has a very detrimental effect on late-time X component measurements over moderately conductive ground. Other distortions cause errors at early time in both X and Z components resulting in poor depth estimates even for quite moderate geometric errors.

GEOTEM$_{DEEP}$ - Technical Advances in Deep Exploration: Australian Case Studies

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Abstract

Incremental advances in airborne electromagnetic (AEM) survey technology over the past decade have led to the development of a superior airborne exploration tool which has application over broad regions of the Australian continent. GEOTEM$_{DEEP}$ is now capable of detecting 'difficult' exploration targets beneath extensive cover. The innovations have focussed on lowering the operating frequency to 25 Hz, increasing the transmitter pulse width to 4 msec and acquiring multicomponent data, all of which have contributed to a substantial increase in effective depth of investigation and in resolution of target conductivity and geometry.

The ultimate test of a new or improved exploration tool is the unambiguous detection of a known target under controlled conditions. Two Australian examples of the application of GEOTEM$_{DEEP}$ in typical areas of interest for exploration illustrate the target detection abilities of the new system. The results for the Southern Extensions area illustrate the resolution of moderate to deeply buried exploration targets. A comparison between the older GEOTEM II and the new GEOTEM$_{DEEP}$ test data over the Walford Creek deposit, shows the advantage of a lower operating frequency and a wider transmitter pulse. An important development for the assessment of the new survey data is the Conductivity Depth Transform (CDT), a technique for imaging conductivity versus depth. The CDT results can be displayed as a colour section plot or vertical Synthetic Section (CDT-VSS) and a colour plan map or Horizontal Synthetic Section (CDT-HSS).

Keywords: GEOTEM$_{DEEP}$, operating frequency, pulse width, Southern Extensions, Walford Creek

The Application of GPR to Large Scale Production Mining of Alluvial Gravels, Bauxite and Laterite Deposits

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Abstract

Although GPR is now commonly used for geotechnical and civil engineering applications, it has not yet been generally applied to large scale production mining operations. This paper describes the use of GPR in three key mining areas

The first application is for mapping the overburden thickness and depth of alluvial gravels at Argyle diamond mine in the Kimberley region of Western Australia. This is the largest diamond mine in the world by volume of production. For ten years we have used GPR with specially developed multifrequency antennae ranging from 30-250Hz to identify and map the presence of buried palaeochannels which contain diamond bearing alluvial gravels. By correlation with some 600 test pits and 45 kms of trenches, a very detailed interpretation model has been built up of the "radar facies" of this region, which incorporates clast size and diamond grade. The GPR work is combined with airphoto interpretation, geologic and geomorphic mapping to produce a 3-D model of the subsurface which shows the position of the buried palaeochannels. It has been demonstrated that where mining is directed by GPR, the diamond grade can be doubled.

The second application described is for bauxite (aluminium oxide) mining. This has been used for 3 years at Weipa Mine in Northern Queensland, which is the largest bauxite mine operating in Australia. GPR is used to measure overburden thickness prior to stripping the top soil and to detect the presence of bauxite. The GPR data is processed to show the thickness of the bauxite ore layer and to map the contact with the underlying ironstone at typically 6-10 m depth. The objective is to avoid mining into the ironstone layer, which causes severe problems with contamination of the bauxite ore. The data is typically recorded on a 10m grid line spacing using dual frequency 500 MHz and 100 MHz antennae. The bauxite/ironstone contact is digitised on screen using in-house software. This data is transferred into a mine planning package and contoured to produce a 3-D model of the subsurface which is used to direct production mining.

We have also applied this technique as an exploration tool for large scale nickel laterite mining operations in the Pacific and South East Asia. Surveying with GPR enables the thickness of the iron cap overburden to be measured, as well as mapping thickness and subtle grade variations in the tropical weathered laterite ore and delineating the underlying bedrock contact to depth of 500 ns (approx 25m).

Stratdat and Resfacs: Relational Databases as Tools in Petroleum Exploration

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Abstract

STRATDAT (biostratigraphy, well picks, events), RESFACS (reservoir, facies, hydrocarbon shows) and ORGCHEM (organic geochemistry) are Oracle relational databases containing collected data from on- and offshore wells from around Australia. The power of the system as an exploration tool lies not only in the accumulated data but in the versatility in the method of retrieval, that stresses the interconnection of storage tables using Structured Query Language (SQL). A value-adding process occurs where apparently unrelated pieces of data may be brought together to provide information.

By interrogating the databases, with for example depth-age or depth-taxon parameters and searching intervals using RESFACS or ORGCHEM data, and plotting the results with structural maps or comparing with seismic profiles, a synergy emerges that provides new insights into the investigated region. A search of hydrocarbon occurrences or specific indices at particular time intervals, for example porosity values in the Asselian or Sakmarian Stage in the Early Permian of the Northwest Shelf of Australia, may uncover previously unforeseen relationships between structural, sequence stratigraphic or facies-related signals and hydrocarbon generation and storage.

Here we take two examples but in reverse directions, one from a depth-age perspective to check a particular interval of time for hydrocarbon occurrence based upon a known discovery, and another to trace reservoir-facies characteristics and search for taxic or time associations. The first is isochronous and the second may be diachronous. Knowledge of associations of hydrocarbon occurrence with particular intervals can be related to interpretations of basin structure and reservoir characteristics. Hydrocarbon indices can be plotted on isopach maps graphically illustrating possible exploration targets.

The resolution of depth-age pairs rests on the quality of the data and this is a critical component of a biostratigraphic database. We also discuss the datum dictionary, the backbone of STRATDAT, that is constantly updated in the light of contemporary taxonomic and geochronological research. Data quality is enhanced with a standardised data entry system that favours a consistently high standard of detailed documentation. Accounts of sample type and confidence ratings together with concise remarks and a biostratigraphic reference capability ensure that all data is accountable. These factors increase the efficacy of the databases, reducing risk and facilitating exploration.

Fluid inclusion record of early oil preserved at Jabiru Field, Vulcan Sub-basin

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Abstract

Oil trapped in fluid inclusions in a sample of Plover Formation sandstone from the main oil zone in Jabiru-1A has been subjected to detailed geochemical comparison with production oil from the well. Fluorescence microscopy of the sandstone showed that predominantly blue-fluorescing oil inclusions occur in 69% of quartz grains, both within quartz overgrowths and on healed fractures within detrital quartz grains. There are some notable similarities and differences between the fluid inclusion oil and the production oil. Similarities include the n-alkane profiles (both maximising at n-C15 with slight odd over even predominance at high molecular weights), n-alkane to isoprenoid ratios and Pr/Ph ratios (2.7±0.04). Hopane and sterane biomarker maturity ratios are at or close to equilibrium values, typical of peak oil generation conditions. The fluid inclusion oil differs from the production oil in containing relatively lower amounts of rearranged hopanes, Ts, C29Ts, C27 steranes and diasteranes. These differences are interpreted to be due to lower maturity rather than source rock facies variation. Aromatic hydrocarbon ratios confirm a small but consistently lower maturity for the fluid inclusion oil. For example, the calibrated methylphenanthrene index shows an equivalent reflectance of 0.84% for the fluid inclusion oil, compared to 0.92% for the production oil. These geochemical data suggest that the oil trapped in fluid inclusions in Jabiru-1A is from the same source rock but was generated at a lower maturity than the average of the oil now in the reservoir, and was trapped soon after initial charge mainly by thin quartz overgrowths. Further charge to the Jabiru structure was of progressively higher maturity oil.

Modelling the Contemporary Stress Field and its Implications for Hydrocarbon Exploration

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Abstract

The forces that act on the Earth's lithospheric plates are responsible for the stress regime within the plates at a regional scale, and thus influence issues pertinent to hydrocarbon exploration-such as the nature of fault reactivation, hydraulic seal integrity, natural and induced fracture orientation and wellbore stability. Four models of the intraplate stress field of the Australian continent have been produced by elastic finite element modelling of the forces acting on the Indo-Australian plate. All four models incorporate the push of mid-ocean ridges and of continental margins. In the four models the magnitude of the poorly constrained convergent boundary and basal drag forces are varied within reasonable limits. Despite being based on significantly different force magnitudes, regional stress orientations predicted by the three models that recognise the heterogeneity of forces acting along the convergent northeastern boundary of the Indo-Australian plate are considered reliable because they are consistent over much of the Australian continent and show broad agreement with the available in situ stress measurements.

In the absence of in situ stress measurements, for example from borehole breakouts, modelled stress orientations should be incorporated into the assessment of issues pertinent to hydrocarbon exploration that are influenced by the contemporary stress field. In the context of fault reactivation, pre-existing vertical faults striking at 30 to 45° to the maximum horizontal stress direction are the most prone to at least a component of strike-slip motion. Planes dipping in the minimum horizontal stress direction are the most suitably oriented to be reactivated in extension, and planes dipping in the maximum horizontal stress direction are the most suitably oriented to be reactivated in compression. Modelled stress orientations can also be used to predict open natural fracture orientation, with the preferred orientation being normal to the minimum horizontal stress, and to help assess the hydraulic integrity of reservoir seals, with faults and fractures normal to the minimum horizontal stress least likely to be sealing.

Display of Airborne Electromagnetic Data as Mutispectral Images

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Abstract

Multi-channel AEM data has much in common with remote sensing and airborne radiometric data. Images of multiple channels can be combined to produce RGB composites which display information about the shape of the EM spectrum (or its time domain equivalent) that is sampled by the technique. However there are important differences which mean that the routine application of image processing techniques taken over from remote sensing can produce unsatisfactory results. The very high between-channel correlation, the wide dynamic range and the unique noise sources mean that careful pre-processing must be performed in order to extract all the useful information in the data. In addition while data compression techniques such as Principal Components Analysis provide good enhancement of variability within the data set, they produce images that are difficult to relate to geophysical parameters such as conductivity and depth. Finally the inherent non-linear relationships arising from the physics of the EM diffusion process mean that the simple linear transformation (eg unmixing) that have been found so useful in the analysis of remote sensing data are of limited benefit without the preliminary application of non-linear rescaling on the AEM data. This paper illustrates each of the above problems and demonstrates new processing methods that to overcome them.

Fast Approximate Inversion of TEM Data

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Abstract

Converting TEM data to an ideal system response removes interpretational problems associated with the characteristics and imperfections of practical waveforms. It also allows the inductive and resistive limits, defined from frequency domain theory to be trivially calculated for input into fast, approximate inversion programs. Rapid, stable conversion can be achieved by decomposition to a set of exponential basis functions preconvolved with the system waveform.

The number and range of time constant (tau) preselected for the exponentials can be optimised by singular value decomposition (SVD) analysis of the basis functions. The field data is then decomposed by solving a system of linear equations for the amplitude coefficient corresponding to each basis function. Three different linear inversion techniques were tested. SVD with a minimum eigenvalue cutoff was found to be unstable in the presence of noise. Least squares with positivity constraints (PLS) was fast and robust but unable to process data with negative "rises" such as decays with overburden blanking. L1 norm techniques were found to be robust for all types of data and noise conditions however the algorithm is much slower than PLS.

The process was applied to 3-D model in loop SIROTEM data for a dipping conductive sheet beneath a thin conductive overburden. Simple routines model the inductive and resistive limits for a thin sheet body and are implemented in an inversion program which utilises the Levenberg - Marquardt method. These returned a position, depth to top and dip comparable with those of the original SIROTEM model. Finally, field SIROTEM data over a sulphide body in Western Australia were transformed and inverted. Removal of inhomogeneous overburden effects remains a major obstacle to automatic interpretation of TEM data.

Time Domain EM For Environmental Targets

Timothy D.J. Pippett and Vincent Bulman

Abstract

During the last decade the electronics for obtaining turn-off times for the EM transmitters have improved greatly. This has given instrument manufacturers the ability to obtain time windows/slices in the very early times region of the EM field decay. With these early time windows has come the ability to 'view' shallow targets with time domain instrumentation.

Some of these instruments have been scaled down from the mineral exploration industry, such as the SIROTEM unit, manufactured by MCI Pty. Ltd. in Adelaide and the PROTEM EM-47 system, manufactured by Geonics Limited in Canada. There are other units which have been developed from scratch for shallow target investigation, these include the EM-61 Deep Metal Detector from Geonics, with similar units anticipated to be on the market in the near future.

ADI have been using the EM-61 over the last 18 months for the investigation of environmental contamination. A number of case studies will be discussed showing the suitability of the time domain systems for environmental targets. These will include recent work undertaken on the clean-up of former military sites overseas and contaminated sites in Australia.

Scale-dependent Electrical Properties of Sulphide Rocks: New Methods and Techniques

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Abstract

A thorough understanding of the influence of geological factors on electrical petrophysical properties of sulphide orebodies requires careful integration of geophysical and geological measurements at a variety of scales. Two new methods for studying the influence of microscopic and mesoscopic ore textures on electrical properties of sulphide rocks have been developed. Voltage contrast microscopy is a scanning electron microscope technique which enables direct imaging of the effects of an applied potential on a polished rock surface. It has been used to investigate the detailed mechanism of electrical

conduction in fine-grained base metal sulphide ores. Initial results suggest that conductive paths may exist along grain boundaries within otherwise resistive minerals such as sphalerite. Continuity mapping uses a modified flat-bed plotter to directly image the electrical continuity of drill core or hand specimens. A spring-loaded copper electrode traverses the polished sample surface on a grid to produce an image. Electrode movement and potential measurement are fully automated. This technique has been used to study the influence of mesoscopic ore textures on the electrical continuity of massive and disseminated sulphide ore samples. Both new methods are still being developed and refined but initial results suggest that they will usefully complement existing laboratory-based petrophysical techniques.

Magnetic Petrology of Granitoids: Implications for Exploration and Magnetic Interpretation

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Abstract

Magnetic petrology integrates rock magnetism and conventional petrology in order to define the processes that create, alter and destroy magnetic minerals in rocks. By relating magnetic mineralogy, bulk magnetic properties, petrology and geochemistry to observed magnetic anomalies an understanding of the geological factors that control magnetic signatures is obtained, which can be used to improve geological interpretation of magnetic surveys.

The magnetic properties of igneous intrusions, and hence the magnetic anomalies associated with them, reflect bulk rock composition, redox state, hydrothermal alteration and metamorphism. These geological variables are in turn controlled by tectonic setting, composition and history of the source region, depth of emplacement and nature of wall rocks. The fundamental control on magnetic mineralogy and bulk magnetic properties is partitioning of iron between silicate and oxide phases, which is strongly influenced by oxidation ratio. This paper reviews and synthesises information on granitoid chemistry, mineralogy, metallogenic association and magnetic properties. Implications for interpretation of magnetic anomalies associated with granitoids and recognition of magnetic signatures of potential intrusive-related ore deposits are adduced.

An iterative method to calculate self-demagnetisation for 3D magnetic bodies, with application to the Osborne copper gold deposit

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Abstract

Current algorithms for computing the magnetic response for complex 3D bodies do not perform well when the body has high susceptibility, since the algorithms do not account for the effects of self-demagnetisation. Most routines can only correct for self-demagnetisation for ellipsoidal and spherical bodies (using an analytic solution) and for dyke-like bodies (using a simple numerical approximation). There have been attempts at correcting for self-demagnetisation for general 3D bodies, but so far these methods have not been suitable for large complex bodies.

A standard surface integral method is used to compute the magnetic response for a 3D body with uniform body magnetisation. The process then approximates the effect of self-demagnetisation by computing an effective magnetisation at each surface source which takes into account the magnetic field of all other surface sources. A term for the self-field at each surface source is also required. The effective magnetisation at each surface source replaces the initial uniform magnetisation. Further iteration of this process results in a minimised magnetostatic self-energy state and a non-uniform magnetisation that is then used to compute the self-demagnetised magnetic field at any internal or external point.

Comparison of test results from models using this process with known analytic solutions showed good agreement. Subsequent application of the method to the modelling of the Osborne ironstone hosted copper gold deposit used a model of the ironstone bodies with over 10 000 facets and a susceptibility of up to 4 SI. Subtracting the self-demagnetisation corrected response from the observed magnetic field and modelling the residual, identified the presence of a previously unrecognised magnetic body. Drilling successfully intersected this body.

Velocity-Porosity Transforms in Gas-Bearing Shaly Sandstones: Field Data Versus Empirical Equations

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Abstract

Acoustic velocity logs commonly contribute to porosity estimation in hydrocarbon wells. Even though other tools are generally superior in evaluating porosity in different rock types, various equations have been proposed to relate sonic travel time to porosity. The observed acoustic velocity (Vp) in a perfect borehole, however, is a function of many other factors apart from porosity, such as matrix mineralogy, effective stress, pore geometry, cement type, clay pore-fill, fluid saturation, and nature of the pore fluid.

The shortcomings of conventional Vp-porosity transforms are more noticeable when they are used for gas bearing reservoirs in shaly sandstone with low to moderate porosities. This paper compares commonly used and published empirical Vp-porosity equations with field data, for a series of gas bearing shaly reservoir sandstones from the Cooper Basin in South Australia.

The application of Vp-porosity transforms such as the time average and Raymer formulas have been extensively discussed in the literature. Although experimental studies in the 80's and early 90's provided a better understanding of the complex nature of elastic wave velocities in reservoir rocks, no empirical equations derived from these studies present a globally acceptable method for porosity estimation from the sonic log. The application of some of these equations to field data in the Cooper Basin has shown that their reliability on other data sets should be considered suspect until a good calibration can be achieved.

Estimation of effective porosity, Tirrawarra Sandstone, Cooper Basin, Australia

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Abstract

Estimation of effective porosity in shaly sand formations is the prime parameter for reserve calculation and for good understanding of the behaviour of a formation during production. The Late Carboniferous to Early Permian, fluvio-deltaic Tirrawarra Sandstone is a kaolinite-bearing sandstone and an important hydrocarbon reservoir in the Cooper Basin. Petrographic point count and image analysis data from 130 samples, together with data from about 650 core samples and wireline log data from 14 wells of the Tirrawarra Sandstone in the Moorari and Fly Lake Fields, has been used to estimate effective porosity from sonic log. Based on integration of all data and with the knowledge of the volume fraction of kaolinite and associated microporosity (20% for kaolinite masses in the Tirrawarra Sandstone in the studied samples) effective porosity can be expressed as:

$$\phi_e = \phi_{sonic} - 0.2V_k$$

where ϕ_e is effective porosity and ϕ_{sonic} is sonic porosity, and V_k is volume fraction of kaolinite.

On average, estimated effective porosity is 2 porosity units less than the total porosity and it varies for each depositional environments which have different kaolinite contents.

Keywords: Tirrawarra Sandstone, microporosity, sonic porosity, effective porosity.

Determination of Permeability Transforms from Geophysical Logs Using Statistics Pattern Recognition

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Abstract

Many permeability models and equations are empirical in log analysis and evaluation. Therefore, their application is restricted to a given set of lithology conditions. It is essential to select the correct transform relationships for each type of lithology in order to determine accurately permeability from well logs. This is especially true in the Mardie Greensand, a lithologically complex formation. There are four porosity and permeability transforms determined based on the core data in the sandstone formations of the Mardie 'B' and 'C' intervals in the Barrow Field, Carnarvon Basin, Western Australia. When determining permeability with these transforms, it should be known which transform is applied at which formation. Therefore, the key problem is how to select the correct transform for a certain formation. Practically, this is a problem of identifying the formation or electrofacies from well logs.

Pattern recognition techniques have been applied in many fields, such as astronomy, medicine and meteorology. They have also been used in different areas of the petroleum industry, especially in petroleum exploration. Due to the complex nature of the Mardie Greensand and the difficulty of reliably estimating permeability from well logs, statistical pattern recognition was used to identify and characterise the pertinent intervals and to select the appropriate transforms for porosity and permeability. The aim in this study was to determine which porosity and permeability transform is applied at which formation from well logs, using statistical pattern recognition of electrofacies. In this paper a number of electrofacies corresponding to these porosity and permeability transforms were determined in the complex formation. The application of pattern recognition to this complex lithology makes it possible to identify electrofacies and select corresponding transforms to calculate permeabilities from well logs. Field examples show that it can reduce the uncertainty of log-derived permeability and help to simplify the problem of complex lithologies in log interpretation, and improve the permeability determination from well logs to identify electrofacies and select the corresponding porosity and permeability transform using statistical pattern recognition.

3-D EM Modelling in Mining Geophysics: When, Where and How Do We Want It?

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Abstract

Current full 3D EM algorithms are limited by hardware and execution-time constraints to the computation of small models of limited application, and are many orders of magnitude away from execution speeds capable of performing routine inversion on targets of realistic size.

Consideration of the differing needs of airborne, ground and borehole EM surveys suggests that important advances in the next few years will come from

- approximate inversion of airborne and reconnaissance ground data, using an inductive-limit (high-frequency) approximation and/or an analog of seismic migration, and
- modelling and inversion of detailed ground and borehole EM data, using algorithms allowing multiple plates in a conductive earth, and with enhanced efficiency obtained from a resistive-limit (low-frequency) approximation.

Full 3D EM modelling will be a vital part of development and validation of the necessary approximations in these products.

Fast and Stable Method For 3-D Modelling of Electromagnetic Field

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Abstract

The energy conservation law restricts the amplitude and the Hilbert space direction of the solution to Maxwell's equations. In this paper, we derive the corresponding constraints and discuss the related implications for the Green's function. It is shown that the distribution of the current induced in an inhomogeneous conductive medium satisfies an integral equation having a contraction kernel. The iterative dissipative method (IDM) can always be used to find a solution to this integral equation. The approach works for arbitrary distributions of the electric conductivity and dielectric permittivity, at an arbitrary frequency of the field variations (or in the time domain). It can also be used to solve Maxwell's equations in an anisotropic medium.

The IDM is numerically robust. This robustness is due to the fact that the system of linear equations that should be solved on a finite numerical grid possesses the same contraction properties as the continuous integral equation. The convergence rate of the generated iteration sequence does not depend on the numerical grid used for calculations. In particular, the number of iterations necessary to achieve the specified accuracy does not depend on the number of numerical nodes used for the computation. In a quasi-static approximation, the convergence rate does not depend on any parameters of the problem but the lateral contrast of the conductivity distribution. The last parameter is usually much smaller than the overall contrast of the conductivity distribution.

The theoretical considerations have been confirmed by a series of successful numerical algorithms developed after 1988 when the authors proposed the method for quasi-static electromagnetic fields. These algorithms have been applied for a number of practical interpretations including electromagnetic induction in a realistic model of the world ocean and continents, deep electromagnetic soundings with natural and controlled sources, and modelling electromagnetic effects of borehole casing imperfections. Numerical simulation even for the global and regional scale geoelectric models does not require large computer resources and have been carried out using a PC.

The IDM-based algorithms can easily sustain a high lateral contrast of the conductivity distribution. To illustrate this property of the IDM, the electromagenetic field induced by geomagnetic variations is calculated for a simplified model of the Australian continent and the surrounding ocean. The lateral contrast of the conductivity distribution in the model exceeds 104.

The Electrical Potential Arising From A Point Source In An Arbitrarily Anisotropic Half-Space With Regolith Cover

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Abstract

Most prospective areas, especially for mineral, in Australia are covered by superficial cover, called the regolith, which can screen or distort the geophysical signals from deeper mineral deposits. Hence knowledge of the behaviour of the electric potential in an anisotropic half-space with a thin cover is of considerable importance in the field of mineral exploration. A previous solution for this problem has been developed by Lindell et. al (1993) for a point source in an anisotropic half-space with an infinitesimally thin boundary layer using the image method. This paper is an improvement on that method. A layer of known thickness is considered to cover the surface of the half-space.

Solutions for the electrical potential and current density due to a point source in an arbitrarily anisotropic half-space with a regolith cover have been obtained, using an image source method. The source function was introduced in this general solution by using a point and line image based on the theory of Lindell et al (1993) and the work of Li and Uren (1996). The images of the point source include a point and line arising from the surface boundary conditions. The source density of the line image obeys an exponential law. The line image position may be described by linear parametric equations. The technique is computationally efficient, compared to numerical methods such as Fourier transforms and finite difference methods. Other numerical experiments show that when the source is located about 50m the surface and the cover thickness is 1m, the results are still correct. Using this basic theory, the performance of any common electrical prospecting geometry may be simulated for the model presented in this paper.

Management of Software for Geophysical Exploration

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Abstract

Information technology has become a significant component of modern geophysical exploration. However, many challenges need to be dealt with if the practising geoscientist is to gain the benefits that ensue from an effectively structured IT environment. Done well, the IT component can give a group a demonstrable competitive advantage. Alternatively, a poorly managed IT environment can only be described as an unmitigated disaster.

One of the major sub-themes within the general topic of geoscience IT is software. While most users will try and use generic software wherever possible, there are a number of specific technical software needs within exploration that are not sourceable from the general pool of business software. These needs have resulted in the

development of what could best be described as a cottage industry that meets many but not all of the exploration industry needs. Most geological and geochemical applications are provided for by this dedicated industry. Geophysical software however, does not fit as neatly into the basket since more companies (both primary explorers and service groups) have software needs that are tied in with hardware or know-how skills that these groups regard as vital parts of their competitive advantage within the industry.

BHP has been dealing with these issues for over a decade and has through what is best described as an iterative approach, evolved a hybrid model to meeting its software needs. Depending on the commercial sensitivity, timing and available resources, BHP will undertake totally captive projects, i.e. all development and maintenance in-house, to semi-captive where the development is internal but with a staged release, or controlled external, where the work is totally outsourced but BHP pro-actively steers the development and finally, simple acquisition of commercial tools.

The evolution of this model over the last decade has not always been an even process or without considerable discomfort on occasion. Learning by crisis management has certainly been a facet in the overall process. However, in the struggle to maintain technical proficiency in an increasingly competitive global business that exploration has become, a group's ability to deal with software technology can be turned into an advantage or a serious liability if ignored or poorly managed.

A Case Study on Geophysical Gridding Techniques: INTREPID Perspective

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Abstract

A wide variety of numerical procedures in potential field geophysics require data modelled on a regular grid. However, airborne data tend to be highly sampled along the flight line and sparsely sampled in the perpendicular direction.

A gridding method commonly called 'bi-cubic spline' is widely used in potential field geophysics. Standard bi-cubic spline methods used on aeromagnetic data produce artefacts when a geological feature's 'line of strike' is not perpendicular to the direction of the acquisition line. This method has a tendency to break up thin elongated magnetic anomalies, at an oblique angle, into a series of bulls eye artefacts. A method of finding local anomalies and their strike along lines based upon minimum variance principles reduces these effects. This technique has significant impact on the quality of output grids.

In association with the Magnetic Image Project (MAGMAGE) developed by Gunn and collaborators, that involved work on complex attributes of aeromagnetic anomalies, the gridding of phase posed some unique problems. Raw phase is a spiralling function which is periodic and cyclic. Unwrapping of the phase, therefore, is necessary to give a spatially coherent grid for interpretation.

By focusing on two developments in gridding - trending in a bi-cubic spline method and unwrapping of cyclic data - these methods are shown to increase the accuracy of representation of actual data being interpolated. Case studies of these solutions are presented using the INTREPID geophysical processing and visualisation system.

A Method for Calculating Equivalent Layers Corresponding to Large Aeromagnetic and Radiometric Grids

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Abstract

It is commonly known that, for every magnetic field, whether observed on a plane surface or not, a distribution of magnetisation can be calculated on a surface below the surface of observation such that the magnetic field produced by the distribution duplicates the observed magnetic field. The distribution of magnetisation, which does not necessarily have any physical reality, is referred to as the "equivalent layer". The value of the equivalent layers is such that, once one has been calculated for an observed magnetic field, it can be used to recompute fields corresponding to the equivalent layer at other magnetic inclinations, on other surfaces of observation or on arbitrary spatial grid intervals. Equivalent layers can thus be used as a basis for reduction to the pole, elevation corrections and gridding algorithms. Equivalent layers can also be calculated for airborne radiometric data. The same properties apply to radiometric equivalent layers as apply to magnetic equivalent layers, with the added significance that a radiometric equivalent layer corresponding to the ground surface gives a mapping of the actual radioelement concentrations corresponding to the airborne observations. Accurate, stable, iteration-based algorithms can be used to calculate magnetic and radiometric equivalent layers corresponding to large grids of aeromagnetic and radiometric data.

CRC AMET Research Workshop

CRC AMET - THE FIRST FOUR YEARS

Dr. Brian Spies, Director

Cooperative Research Centre for Australian Exploration Technologies

CRC AMET RESEARCH PROGRAMS - FROM AIRBORNE TO GROUND TRUTH

Dr Art Raiche, Mathematical Geophysics Program

Dr Jim Macnae, EM Interpretation Program

Mr John Slade, Airborne EM Systems Program

Dr Tim Munday, Regolith Characterisation Program

The Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET) was established in 1992 under the Australian Government's Cooperative Research Centres Program, in response to industry demands for improved geophysical exploration methods adapted to Australian conditions. The Centre is well on track in achieving its key objective - a low-cost airborne EM (AEM) system optimised for geological mapping and mineral exploration with associated processing and interpretational technology, and is progressing well on the development of a deep-probing AEM system designed for exploration at depths of up to 300 m.

CRC AMET projects involve close coordination of a wide variety of skills including hardware design and construction, mathematical modelling, processing, data inversion, and geological interpretation. The Centre's success is based on strong collaboration between its participants: CSIRO Division of Exploration and Mining, Curtin University of Technology, Macquarie University, World Geoscience Corporation Ltd, the Australian Geological Survey Organisation (AGSO), the Geological Survey of Western Australia, and the Australian Mineral Industries Research Association Ltd (AMIRA) which provides vital links with industry. Major achievements of the Centre are highlighted below.

Airborne EM Systems

Development of the Centre's geological mapping prototype AEM system is now substantially complete. Extensive field trials in varying geological environments are planned to evaluate the performance of the system before going to a final design. In the interim, the hardware development program is focusing on deep penetrating, high power electromagnetic systems. A critical research issue identified during the last year is the development of a 3-component towed receiver system capable of much enhanced performance at low frequency (10 to 20 Hz). Research in this area is proceeding well and preliminary developments are already being implemented in commercial QUESTEM surveys by World Geoscience. If this technology can be substantially improved then penetration depth for AEM systems will increase significantly.

While it is clear that a deep penetrating AEM system has other important components, most notably a large aircraft capable of generating a very large transmitter magnetic moment, the development of these items is much more an investment decision than a research task. Existing designs for high power transmitters can be readily expanded to large currents. Consequently the Centre is directing much of its research efforts at improvements in low-noise bird development rather than in capital-intensive aircraft purchase and modification. A substantial improvement in low-noise receiver technology is seen as the major requirement for the development of a much deeper-penetrating airborne EM system.

EM Interpretation and Modelling

In addition to the hardware development program, the Centre has a major effort in interpretation, and new industry-funded projects will started in 1996 on interpretation of airborne electromagnetic data. Major progress has been achieved in the development of a suite of multi-platform computer programs for automated interpretation of large-scale airborne EM data sets. The Centre's program in the mathematical modelling of electromagnetic responses of complex structures continues to attract major industry sponsorship support from Australia and overseas.

A project on development of autonomous aerosondes as low-cost platforms for the acquisition for geophysical data is proceeding very well. Industry sponsorship levels for this project are very strong, and the rapid development of aerosonde technology and advances in digital communication are bringing this important milestone nearer to achievement.

Regolith Characterisation

The Regolith Characterisation Program continues to provide an important link between airborne EM mapping and geological interpretation, by characterising the weathered cover that covers much of Australia's prospective areas. Studies of the Yilgarn Craton and Eastern Goldfields of Western Australia and the Mt Isa Inlier in Queensland, conducted in collaboration with the Australian Geodynamics CRC and the CRC for Landscape Evolution and Mineral Exploration (CRC LEME), reveal a wealth of information on regolith structures across areas important for exploration.

Education

The CRC AMET Education program has seen a steady increase in the numbers of geophysics postgraduate and honours students, which now number 37 at Curtin and Macquarie Universities. The Centre offers seven honours scholarships and six postgraduate scholarships from Centre funds, plus five scholarships funded through industry-supported projects, which are distributed between Macquarie and Curtin Universities. Increasingly, honours students work on company-initiated and jointly supervised projects, as well as projects in CRC AMET research areas.

The Centre also offers a Masters program in Mineral Exploration Technologies (MMET), covering units in geology, geophysics, geochemistry and GIS. Leaders for the courses are drawn from CSIRO, consultancies, contractors, state and federal geological surveys, mining companies and universities. The modules are also offered as individual short courses and receive strong support from major mining companies.

Commercialisation and Technology Transfer

Research outcomes of individual AMIRA-supported projects are transferred to industry by regular meetings and workshops for, and reports to, industry sponsors. Software developed as part of such projects is transferred to a commercial geoscience service company for marketing and user support at the conclusion of a confidentiality period. Developments in the Airborne EM Systems program are commercialised by World Geoscience Corporation. Funds from royalty payments are used by the Centre for further research to improve airborne geophysical technology for mineral exploration.

The Coming Year

The Centre has made excellent progress in all its major program areas, in research, education and commercialisation. In 1997 we plan to host a number of workshops to further develop collaboration with scientists, educators and industry. We will use this opportunity to explore the future needs of the Australian minerals exploration industry in geophysical research and education. It is important to establish a consensus within the Australian mineral exploration industry as to the future directions for applied geophysics research and teaching. Australia's pre-eminent position in geophysical technology and expertise should be viewed as a platform to support and strengthen the Australian mineral exploration industry as it prepares to meet the challenges of the new century.

CRC AMET Research Workshop: Future Trends and Directions in Mineral Exploration Geophysics

This research workshop, organised by the Cooperative Research Centre for Australian Exploration Technologies (CRC AMET) will address the status and future directions of mineral exploration geophysics in Australia.

The workshop consists of a series of short presentations by key scientists and explorationists from industry and academia, who will share their vision of geophysics into the next century. Speakers and panellists will act as discussion leaders to promote strong audience participation.

Invited speakers include:

- Prof Gordon West (Univ. of Toronto)
- Prof Iain Mason (Univ. of Sydney)
- Dr Barry Drummond (AGSO)
- Dr Ken McCracken (Jellore Technologies)
- Ken Witherly (BHP Minerals)
- Prof James Macnae (CRC AMET)
- Mr Nick Sheard (MIM Explor. Pty Ltd)
- Dr Tom Whiting (BHP Minerals Expl.)

Into the Fourth Quarter:- The Next 25 Years of Mining Geophysics.

G. F. West

Geophysics lab., Dept of Physics, University of Toronto

Looking back on the history of geophysics in exploration for metal ores, it is reasonable to characterise the period 1920-1945 as the period of experimentation and invention, 1945-1970 as the flowering of semi-quantitative analogue geophysics, 1970-1995 as the development of computer-based, high fidelity geophysics.

As we look forward to the next quarter century, it is not hard to see where the winds will blow us, if we want to go there. I expect very few (if any) completely novel geophysical methods to appear, but to see considerable changes in the platforms from which data are collected, a routine use of high spatial resolution, high accuracy, multi- sensor, survey techniques; also a routine use of more complex, automatic, computer techniques for producing interpretation images that geologists can easily understand.

But there is one vital field for mining geophysics that may easily get lost in the rush to ever higher tech geophysical systems. It is understanding the relationship between the geological characteristics of earth materials and the physical properties that can be remotely sensed. This can only be improved by organised, systematic feedback from geologists who can measure the geological effectiveness (or ineffectiveness) of geophysical products to geophysicists who design the geophysical methods and surveys and (hopefully) understand the physics involved.

Future Trends and Directions in Mining Geophysics

Ken Witherly

Chief Geophysicist, BHP Minerals, San Francisco, California

Mining geophysics is faced with many challenges and opportunities over the next decade. The development of the next generation of platforms, particularly airborne, seems to be taking two paths; one where the availability of basic information, i.e. magnetics and radiometrics, are becoming commodities and the other path for EM and gravity, where a limited group of companies could control access, at least in the medium term, due to the high cost of the sensors systems themselves. This movement towards a have/have not world is attributed towards the spread of the global capitalist economic model, where governments no longer will (or can not) level the playing field for the smaller players. This gives rise to companies that are committed to success in mining through exploration and will make the investments in technology needed to provide them with what they see as a proprietary advantage.

The processing and visualisation of geoscientific information will become a technical discipline in its own right, much as it did some time ago in the oil and gas exploration business. Significant opportunities to add value in the exploration chain will exist in processing and visualisation area, but like the trends in the sensor technology, considerable resources will be required to manage and integrate such new technologies into the exploration process. Enormous computing resources will be available at modest cost; the challenge will be to harness this resource in ways that truly add value in the exploration process. As with sensors, the major companies that have made the commitment to exploration will access these technologies first, then guard this know-how to maintain their competitive advantage for as long as possible. Unlike the oil & gas business, the drive towards greater technological sophistication in exploration does not carry everyone's vote. This is because there will still be significant mineral resources that i) can be found in virgin areas essentially at outcrop, ii) have already been identified but await some vital logistical or processing development before being mined, or iii) can be more easily purchased rather than found. This means that as today, there will be a spectrum of technologies supported by the exploration industry, some relatively unchanged over the last 30 years, while the newer techniques will border on science fiction.

The Many Dimensions of Seismic and Their Role in The Minerals Industry In the 21st Century

Barry J Drummond

Interim Director, Australian National Seismic Imaging Research Facility, and Australian Geodynamics Cooperative Research Centre, AGSO, Canberra

Seismic reflection profiling is the primary remote sensing tool used by petroleum companies, but seismic methods have not gained the same status in mineral exploration. Seismic velocities are typically much higher in mineral provinces, so wavelengths are greater and both horizontal and vertical resolution are lower than in sedimentary basins. Hence high frequencies are needed to resolve structures the size of ore bodies. Tests using explosives sources in the Mt Isa region showed that the earth, rather than the source and instrumentation, is the ultimate low pass filter. However, high frequency vibratory sources are now available. At least one can be configured to produce both P and S wave energy. High frequency vibrators allow surveys in which repetitive sources can be used to input large amounts of high frequency energy to help overcome the natural attenuation of the earth.

Three scenarios for the future use of seismic in mineral provinces are offered, looking at the pre-competitive stages of exploration, during exploration and at mine development.

Seismic profiling in now used as a standard tool in most of Australia's regional geological mapping programs. Its role is to add the depth dimension to the geological maps. Some geological maps now carry an interpreted seismic section rather that a geologist's cross section. Regional profiling undertaken by AGSO in the Eastern Goldfields of Western Australia, and by the AGCRC in Mt Isa, has indicated that regional scale reflection seismic can discriminate between fault systems which have been conduits for fluids and those which have not. Faults which have been conduits for fluids are intrinsically reflective. The frequency and amplitude of the reflections from the fault surface appear to be determined by the width and intensity of the zone of alteration caused by the fluids. Identifying zones of fluid migration through the crust will allow better area selection for exploration.

Strata-bound ore bodies are potential direct targets for seismic profiling. AGSO recently detected a potential environment for a volcanic hosted massive sulphide deposit along trend from the Hellyer deposit in northwest Tasmania. High resolution seismic profiling can be expensive compared on a per kilometre basis with other geophysical techniques, but its ability to provide a depth image of a target for a drilling program is unsurpassed. In the Tasmanian example, the cost of the seismic once the crew was on site was less than 20% of the estimated fully accrued cost of a single drill hole into the target.

Seismic is also a potential cost saver in the early stages of mine development. Ultra high frequency vibrators recorded by geophones placed down drill holes under known ore bodies could be used to build 3D tomograms of ore bodies. These could be used to better target mine development drilling. The tomograms would define ore body shape, and absolute seismic velocities would give an indication of grade, especially if both P and S velocities were measured. Combining P and S velocity data would also yield elastic properties for use in geotechnical studies.

The Growing Role of Geophysics in the Management of Australian Mines

Iain Mason

Geology and Geophysics, Sydney University

There is a natural tendency to carve the eyes out of any new mine in order to recover setting up costs. As the mine matures, ore breaking depths rise. Ore deposits become more scattered. Head grades drop. Ultimately the mine collapses, unless and until it is revived by new metallurgy, new technology. Mines in which there are many points of production are flexible, but their wage bills are high. There has been a general trend over the past thirty years, at least in high wage economies, to extend mine life and contain costs by mechanising, by progressively raising the horsepower at a miner's elbow. This move is now hitting diminishing returns. The push now in mining is towards semi-automation, aimed at raising both the ease and the precision with which horsepower is applied. Cost effective automation calls for the concentration of both capital and human resources. Automated mines are intolerant of the unexpected.

Miners cannot mine blind. Automation needs very accurate predictions of ground conditions well ahead of current workings. The traditional techniques of mapping by pattern drilling from the surface are starting to fail - on the one hand because they are being stressed by mechanisation, on the other because drillers point sample the ground with a density which drops rapidly as mines deepen and drilling costs rise. Very important features are missed. Structural interpretations fail if the boreholes unwittingly corkscrew. An unexpected one-meter throw in a seam would matter little to an air-leg operator or a continuous miner but if the same throw were encountered in a heavily mechanised coal mine it could bring not only a capital intensive longwall but the entire mining group to its knees. Faults sterilise both capital and reserves.

The oil industry has developed an extensive suite of geophysical tools which are capable of extending a traditional drill-bit survey away from the axis into the volume surrounding the borehole. These tools for the most part are over-engineered for mine borehole depths, they are too fat, are currently far too expensive for a miner to risk their deployment in low cost uncased inclined boreholes at the margins of a mine. Mass production is the only way to drop geophysical tooling costs. Yet one can foresee no mass market in borehole tools unless the software is developed to enable trained drillers to interpret the results, say, of their own cross-borehole surveys. When this happens geophysics and geophysicists (disguised as mine planners) will enter the line management of mines. The intelligent drill bit, capable of sniffing out and directing itself towards ore bodies will no longer a pipe dream.

Geophysics - Future Directions and Threats

Tom Whiting

BHP Minerals Exploration, Brisbane

1) To continue to improve the number, range and effectiveness of geophysical acquisition techniques through improvements in instrumentation. New methods applied at regional scale will provide new insights into geology leading to new discoveries. I think this is most true of an effective airborne EM system. The ideal would be to have a system capable of doing in the air what we can do on the ground for about the same line/km charge of current airborne systems. Airborne gravity of course is a system we all want.

2) Improve the geological mapping capability of geophysical techniques, particularly their ability to discriminate signatures due to mineral deposits from signatures simply due to geology. This will require advances in data processing to accompany better acquisition systems.

3) Improve the interpretation of geophysical data via better integration with geological concepts. Much progress in this area will depend on research on key mineralising processes important in the formation of world class orebodies.

Finally I believe these aspirations will be increasingly difficult to fulfil as there are real threats to research funding in Australia due to the forces of globalisation in the minerals industry. Major Australian mining houses are spreading their exploration funding across the world sphere. This is resulting in less available funding from these companies to tackle the challenges outlined above. When they do it is likely their exploration research will be targeted internally or in the form of strategic alliances on focused projects. This may result in less funding for collaborative, long-term research. Junior companies are extremely aggressive in areas of high prospectivity around the world, where they have proven techniques especially for gold exploration. It is unlikely they will step into the R&D breach except for development of specific techniques. An alternative mode of funding is required for long-term fundamental research.

Electrical Geophysics - Where To From Here?

S. N. Sheard

M.I.M. Exploration Pty. Ltd., Brisbane

Introduction

The explosive use of airborne magnetics has been due largely to the use (and utter misuse) of image techniques. This type of data is strewn across exploration offices and hallways like wallpaper. Some of it is interpreted properly but a large proportion is condemned to life as wallpaper or pretty coloured "base maps". Amazingly though this data has provided the Metalliferous Exploration industry with some successes e.g. Elura, (arguably) Olympic Dam, Cannington, and Osborne.

Why has this occurred with magnetics and not electrical geophysics? Both of these methods are invaluable to metalliferous exploration. This discussion will be targeted at the use (or lack thereof) of electrical geophysics that is considered to have enormous potential for mapping and also for the direct definition of conductive sulphides. Electrical methods are currently being used but are still not widely accepted as routine mapping tools by Exploration Managers who too often considered the methods "bump" spotters.

There are numerous reasons postulated for the lesser use of electrical methods as compared to magnetics, particularly as a mapping aid. Some of these reasons are: cost of acquisition, inadequate visualisation schemes and interpretation procedures, inadequate equipment/obsolete technology, and a lack of understanding in geologists and managers of the value of electrical property mapping. Note this group often pay the bills.

It is contended that the basic problem with electrical techniques is their poor spatial resolution is due to lack of data collected. There is no doubt that with increased data density more detail is observable from far superior presentations, ensuring a much improved interpretation. Airborne magnetics has gone some way to conquer the hurdle of data density, and the value of this data to explorers is reflected in the increased number of detailed surveys used to assist exploration. Airborne electromagnetics has gone someway down this path but not with wide acceptance.

To improve the applicability of electrical geophysics by cost effectively increasing the spatial resolution and data quality will require a major shift in exploration attitude. A quantum level of improvement is required in the interpretative schemes, visual presentation and acquisition equipment. A new vision will provide the confidence that the next century's explorers need to use electrical geophysics. Explorationists will start understanding in that in areas of no magnetic relief, for example, that electrical geophysics can provide high quality, accurate, three dimensional interpretative maps. Electrical data will also be used to minimise the magnetic non-uniqueness problem when interpreting magnetic data alone. It will continue to provide accurate direct targeting. If the new generation acquisition systems are applied from airborne platforms the need for ground invasive technologies will diminish, which alone is considerable environmental incentive to achieve this quantum improvement level.

R & D Philosophy

To produce this quantum improvement will require a major R&D thrust on a much larger scale than currently underway in Australia.

The mineral industry needs some free thinking to awaken the geophysical community from our current conventionalism. A quantum leap forward must be made to push the capability of electrical geophysics to map with good resolution across the depth spectrum from the micro level mine scenario to plus 2000m depths. The data acquisition will need to be low cost and efficient with minimal environmental disruption. The interpretation will have to be three dimensional and relatively fast on standard computers.

This R&D can be undertaken by either Contractors, Government funded Research Institutions eg CSIRO or Universities, or by Industry.

Contractors generally will not tackle major research projects. The market for the geophysical output, e.g., equipment is limited and the returns to the contractors from sale or rentals are marginal.

Research institutions have become stymied by economic requirements for short term funding impositions by the Government. Thus major innovation which generally requires long term planning and commitment becomes difficult.

Industry is driven by the need to increase wealth by mining ore bodies. It does not have the necessity to recoup the R&D expenditure by direct means but by growth through discovery (although government incentive in the past has helped). In the current economic climate it is considered that future innovation will come through industry on an as needs basis.

Industry may be the catalyst through which R&D could be done but not by straight funding alone. Perhaps a new strategy could be adopted by getting industry to directly organise and manage relevant R&D, i.e., use industry's strengths. For example, by entering into strategic alliances on a one-to-one basis, research institutions and contractors could assist industry-managed R&D programs. Grants could be channelled to companies that are proven performers in actually getting large projects up and running rather than Government funded groups who are sometimes less practically oriented. A Company could organise a large scale project by using numerous apparently disparate smaller projects undertaken at various institutions with the "mega" project drawn together by the company. The Company would run the R&D and manage the grants. The outcomes would be of value to both the Company that has taken the risk and ultimately the country, and finally the rest of the industry after some nominated exclusivity period.

Could this be a way of ensuring long term useful research?

Interpretation - Requirements

Interpretation procedures in the base metal exploration industry generally lag equipment advances. This often prohibits the full use of the state of the art equipment with its full potential only realised after the equipment is nearing obsolescence. Processing and interpretation schemes must anticipate hardware trends.

In electrical geophysics there is no doubt that the new wave electrical data collection systems will include high sampling multicomponent multisource - receiver configurations, as discussed below. We need to be ready for the data deluge that will follow. It is paramount that a great effort be put into interpretative and visualisation schemes that will accommodate the gigabytes per square kilometre of multicomponent time series data.

There are no major surprises as what is required to assist interpretation - fast, accurate three dimensional inversion schemes, e.g., software that will invert a 1000m x 1000m by 1000m deep "section of earth" at 25m x 25m x 25m resolution or better, i.e., a minimum of 64,000 cells. Current PC's would take weeks (and considerable resources - human and dollars) to invert to a reasonable solution. This would drive explorers to despair and eventual just drill and abandon geophysics. It should be noted that a 150m drill hole only costs about $5000 or 10 to 15 days of one geophysicist's time. A run time of minutes on a PC would is considered desirable to ensure good use of electrical geophysical exploration technology.

If it is considered that in the next five years the speed of affordable computers will only increase by an order of magnitude then there needs to be a dramatic improvement in the software run-time to invert for a three dimensional space. Is this achievable? At current rates of progress - NO ! So where to from here ?

Possible solutions could include:

- wait for faster computers - loose the incentive
- buy and use supercomputers if the data is so important - expense not likely to be accepted
- improve software - the best hope

The latter is obviously the better solution but it requires a paradigm shift. For example, are we too blinkered in our current approach. Could we go to other sciences to assist solving our problems, e.g., seismic, hydrology, or medical sciences who have had the big dollars thrown at similar problems? We have to do something innovative in readiness for the new era of acquisition systems.

The other key area for great improvement using current technology is visualisation. Visualisation encompasses data display and interpreted map or model display. In our attempt to enhance datasets and produce acceptable, and sometimes spectacular interpretations the original data is too often ignored. Perhaps a valuable lesson should be drawn from magnetics where the two-dimensional image presentation of reasonably "raw" data has changed our approach to exploration. This simple, good quality rapid presentation of data has had an enormous impact on exploration, particularly as a mapping aid.

The new wave electrical data sets could be assessed for spatial information relatively easily. Although the volume of information will be daunting it is considered that data storage will not be major issue. To be ready, we need to be defining standards for data formatting and evaluating three dimensional display mechanisms using the time series information generally attained with electrical data. These types of displays are currently available in the seismic and other non related industries and with some limited effort they could be transported to the electrical exploration industry.

The ultimate aim is to have three dimensional electrical images adorning the offices and be used as the "base maps" of future projects annotated with the next discoveries.

Equipment Requirements

It is considered that current electrical acquisition systems, particularly ground based technology, are generally archaic relying on outdated technology. Airborne systems are marginally better. Current systems are basically upgrades or newer versions of previous equipment that maintain the original design philosophies and inadequacies. Given the advent of computer technology, equipment design and manufacture is not the key issue and impediment as it was a decade ago.

To establish a quantum leap in data quality for ground based systems it is contended that the following changes to equipment are required:

- generic system, i.e., one system does all
- minimum 32-bit A to D processors

- multiple channel, e.g., seismic like
- auto positioning sensors
- smart signal processing
- smart VLF 50Hz/60Hz rejection
- fast (non wire based) telemetry
- telluric cancellation
- cheap disposable sensors of various types
- broad band, sensitive receivers
- clean programmable waveform transmitters
- continuous transmitter waveform monitor recording

For airborne systems generally similar requirements but with some specific items :

- better receiver/transmitter geometries than currently available
- high power transmitter(s)
- three component receiver
- waveform monitor
- attitude sensor
- machine independent
- light weight and easily transportable

The above list is obviously not intended as a recipe for the future and is not original. It is merely a handful of generalities often quoted by practising geophysicists as required to provide orders of magnitude better data from electrical systems. This will allow cheaper, deeper looking with better resolution surveys. A simple goal.

Conclusion

If electrical geophysical techniques are to assist in future exploration programs then a great deal of work needs to be done now. An education campaign for exploration managers and geologists must be undertaken to show that there is more to electrical geophysics than "bump" spotting. Geophysicists must push the R&D groups towards producing useable three dimensional software and good visualisation schemes to make better use of the data. A major effort is required to provide a quantum shift in data quality by building state of the art equipment.

This work may involve a radical change in our approach to R&D so as to bring back longevity and persistence in our efforts.

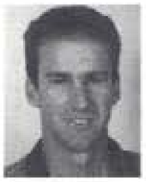
Electrical geophysics does have a future if it can provide cheaper data that is well resolved with increased penetration that is easily visualised and interpreted.

Authors' Biographies

SECTION FOUR

Helen Anderson graduated from the University of Western Australia in 1987 with a B.Sc. in geology. After working for Newmont Australia at the Telfer Gold Mine, she returned to UWA to complete her honours degree. In 1990 she joined World Geoscience Corporation and was based in the Canadian and U.S. offices for 3 years before returning to the Perth office. She is experienced in the interpretation of geophysical and Landsat data for the mineral, petroleum and environmental industries, as well as being involved in WGC's R & D program for airborne electromagnetic.

Brian Anderson began his career in Geophysics in 1980 after receiving his Bachelor of Science degree from the University of Washington. He began with EDCON as a field engineer and then spent several years in seismic field data acquisition with Seismic Profilers A/S and Sonics Exploration, now both part of Geco-Prakla. Immediately prior to joining LCT, he was a consultant to a Singapore shipyard for the rigging of a 70 meter seismic vessel for ONGC of India. Brian was the Operations Manager and 4th employee of LCT in 1987 and is now Vice President of Marketing for LCT. LCT now has a major market share in the area of potential fields geophysics. He is presently a member of the Board of Directors of the International Association of Geophysical Contractors (IAGC).



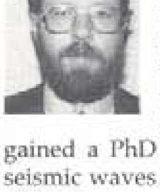
Rob Angus completed a B. Sc. in mathematics at the University of Western Australia in 1989 followed by Honours in applied Science at Curtin University of Technology majoring in geophysics in 1990. He then completed a Master of Science in geophysics at Curtin, graduating in 1992. He joined Placer Exploration Limited in April 1992 as a geophysicist working primarily in Queensland and New South Wales. He is currently a senior geophysicist with Placer and has added the Philippines and Indonesia to his area of influence. Rob is an active member of the ASEG and SEG

James K. Applegate, Reg.Geop., P.Geol., P.E. has over 25 years of experience in applied geophysics. He holds the degrees of Geophysical Engineer, and M.S. and Ph.D. in geophysical engineering from Colorado School of Mines. He is currently Professor, Petroleum Geophysics at NCPGG, University of Adelaide and President, James K. Applegate Associates, Inc (USA). Previous academic experience is with Colorado School of Mines, and Boise State University, Idaho. Dr. Applegate has consulted extensively and also worked for Marathon Oil, Standard Oil Company of California, Atlantic Refining Company, and Geophysical Service Inc. Dr. Applegate has made over 50 presentations at national and international meetings, and has published numerous papers.

Eiichi Arai received his B.Sc. (1991) in the DC resistivity method and his M.Sc. (1993) in the MT method from Kyoto University. In 1993 he joined Metal Mining Agency of Japan (MMAJ) and has been engaged in the development of mineral exploration techniques.

Theodore H. Asch received a BS in geology (1978) from the University of California at Davis and his MS (1981) and Ph.D. (1990) in exploration geophysics from the University of California at Berkeley. He spent 1981-1982 with ElectroMagnetic Surveys doing mineral, groundwater and geothermal exploration in the Western US and 1982 through 1984 he was based in the Negev Desert interpreting geological and geophysical data for the development of hydrogeological and petroleum resources. His Ph.D. topic involved 2-D and 3-d forward and inverse modelling of cross hole and borehole-to-surface dc resistivity. His current interests involve 2-D and 3-D interpretation and decomposition of magnetotelluric data. Since 1994 he has worked in magnetotellurics with both Geothermal Energy and Research Development, Inc. of Tokyo, Japan and ElectroMagnetic Instruments, inc. of El Cerrito, California where he is Operations Geophysicist in charge of magnetotelluric field acquisition and interpretation. He is a member of the SEG.

Yuzuru Ashida received a B.Sc. in geophysics in 1967 from Kyoto University and joined Japan Petroleum Exploration Co. Ltd. (Japex) as a geophysicist from 1967 to 1986. Since 1986 he has been teaching seismic interpretation and data processing as Associate Professor at Kyoto University and was promoted to Professor in 1996. He received a Doctor of Engineering from the University of Tokyo.



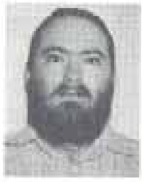
Michael Asten graduated in physics from the University of Tasmania in 1970, and subsequently added majors in Geology and geophysics and BSc (Hons) in Geophysics. He entered post-graduate study at Macquarie University in 1972, and after excursions into magneto-tellurics and DC electrical methods gained a PhD in geophysics on the topic of using microseismic waves as a tool for studying sedimentary basins. In 1977 he took up a two-year appointment lecturing and coordinating an MSc (geophysics) programme at Ahmadu Bello University in Nigeria. After a short period consulting he joined BHP Minerals in 1979 and has worked in coal and base-metal exploration in Australia, East Africa and North America. He is currently a Senior Principal Research Scientist in BHP Research, based in Melbourne. His specialty is in research and its implementation in mineral exploration, particularly electro-magnetic methods, and he is a regular contributor to graduate level courses in EM Methods in Australia. He is a past Vice-President of the ASEG, an Associate Editor of the SEG, and Co-Chairman of the ASEG Conference 1998.

Terence Barr, Lecturer, Dept. of Earth Sciences, Monash University, Clayton, Victoria, 3168, Australia. E-mail: terence@ artemis.earth.monash.edu.au. Employment History: 1990-1993 Research Fellow, Monash University; 1994 to present Lecturer, Monash University. Academic History: Bs Geophysics 1984 Caltech; MSc Geophysics 1986, Princeton; PhD Geophysics 1990 Princeton. Society Affiliations: AGU. Professional Interests: Research in geodynamic modelling, reflection seismology, inversion of geophysical data sets.

Craig J. Beasley, General Manager, Geophysical R& D Western Geophysical, PO Box 2469, Houston TX 77252-2469. Craig Beasley joined Western Geophysical in Houston in 1981 after receiving his Ph.D. in mathematics and served in several capacities in both the Computer Sciences and Geophysical Research and Development departments. He is currently General Manager of Research and Development.

David Bibby obtained a BSc (Geology) from the University of Ballarat in 1994. He joined the geophysics section of the Geological Survey of Victoria in 1994 as a technical officer. He is currently involved in management of airborne geophysical data, image and data processing, and production of Victorian Initiative for Minerals and Petroleum digital and hardcopy products.

John Bishop has a BSc from the University of Sydney and a PhD from Macquarie University. He has had experience working with government and university as well as contracting companies. In 1980, he formed Mitre Geophysics Pty Ltd, which consults to the mineral industry specialising in electrical geophysics. He has given a number of courses in EM and IP both in Australia and overseas and is a member of ASEG, SEG, AIG and the GSA.



Paul Blake acquired an Honours Degree from the University of Queensland in 1990 and began working for the Geological Survey of Queensland in 1991. First major project in the Survey was to map the Devonian to Carboniferous volcanic and sedimentary rocks in the Anakie Project. Has been involved in the Yarrol Project since 1994 mapping the Devonian units. Is currently enrolled at U of Q doing a PhD on the "Middle Palaeozoic corals of the Yarrol Province".

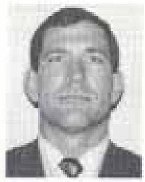
Leigh Brooks received his B.Sc. (Hons) degree in Earth Sciences from the Flinders University of South Australia in 1973. He has 22 years industry experience, including 10 years as a petroleum exploration consultant, in Australia, Southeast Asia and U.S.A. with companies including Exxon, Oil Company of Australia, Robertson Research, TCPL Resources and Petroleum Securities. He has been Manager of Geology and Geophysics for Command Petroleum's Ravva Field development and exploration for the last 2 1/2 years.

Amanda Butt graduated from the University of Queensland with a B.Sc. in 1990. From 1990 to 1995, she was employed by Newcrest Mining Limited, exploring for gold, primarily in Queensland and New South Wales. During this time Amanda managed the geophysical program at the newly discovered Cadia Hill gold deposit. In January 1996, she joined Hamersley Iron Pty. Limited as mine geophysicist. She is currently applying high resolution geophysical techniques to iron ore delineation at Tom Price, Paraburdoo and Marandoo mines. She is a member of the ASEG.

Domenic Calandro graduated in 1993 with a B.Sc. in Geophysics form the Flinders University of South Australia. He is currently employed as a Processing Geophysicist with Mineral Provinces Branch of Mines and Energy South Australia where he processes Airborne Magnetic and Radiometric data acquired through the South Australian Exploration Initiative, Broken Hill Exploration Initiative and company surveys.

Clive Calver graduated from the University of Tasmania with a B.Sc.(Hons) in 1977. Since then he has been employed almost continuously with the Tasmanian Geological Survey, gaining broad experience in Tasmanian geoscience, notably in the stratigraphy, sedimentology and structure of Proterozoic and Palaeozoic successions. In 1991-1994 he undertook a Ph.D. at Macquarie University, studying isotope chemostratigraphy of Tasmanian and mainland Australian late Neoproterozoic sequences.

Shunhua Cao was awarded a PhD degree from the Australian National University in 1991 after graduating with a BSc degree in Geophysics from the China University of Mining and Technology in 1985. He is a Senior Research Associate at the Flinders University of South Australia. His main research interests are numerical modelling of seismic wave propagation, mine geophysics and inverse problems. He is a member of ASEG, AGU and SEG.



Greg M. Carlsen is the Project Manager for the Interior Basins Petroleum Initiatives Project at the Geological Survey of Western Australia. He has a BA in Geology from Augustana College, Rock Island Illinois and an MSc in Geology and Geophysics from Northern Illinois University. Greg joined the Geological Survey in 1994 with over 17 years experience in the international oil and gas exploration industry. He is a member of AAPG and is on the Western Australian PESA committee.

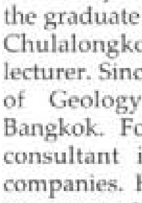
Noel Carroll graduated from Ballarat Institute of Advanced Education (University of Ballarat) in 1975 and completed a M.Sc. at University of NSW in 1981. Between 1980 and 1988, he worked as a mine geologist in the Proterozoic Broken Hill and Palaeozoic Woodlawn base metal deposits in NSW. From 1988 to 1994 he worked in the open pits of the Archaean Mt. Magnet-Meekatharra greenstone belt. Currently he is working in mine exploration at Broken Hill, NSW.

Steven Carroll graduated with B.Sc.(Hons) in Physics from the University of Melbourne in 1990. He is currently completing his final year of a Ph.D. in Geophysics at the University of Melbourne, in a project sponsored by BHP Petroleum. The focus of his investigation is velocity analysis beneath irregular seafloor topography using tomographic methods. Other interests are in the area of seismic modelling and prestack migration. He is a current member of the SEG and ASEG.

F.H. Chamalaun graduated from the University of Leiden (Holland) in 1959 with a B.Sc. in physics and geology. He then undertook a Ph.D. study in paleomagnetism in England and obtained his doctorate from the University of Durham in 1963. Subsequently he continued his palaeomagnetic research as a Research Fellow at the ANU in Canberra. In 1969 he joined Flinders University as senior lecturer in geophysics where he developed research projects in geomagnetic induction studies. They currently have a large array of magnetometers for MV array studies, and are also actively developing a strong MT capability.

Ron Chambers received his B.Sc. in Physics from the Colorado State University in 1964. He began his career with western Geophysical in 1964 with an assignment on a land field crew. He has held various positions in Data acquisition, Data Processing, Seismic Programming, and at present is Chief Geophysicist working out of Research and Development. Mr. Chambers has co-authored a number of technical papers and holds a number of patents in areas ranging from noise removal to 3-D DMO and migration. He is a member of SEG EAEG, Sigma Pi Sigma, and Southwest Quality group. His area of professional interest is seismic exploration viewed as a total system.

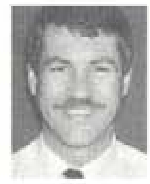
Mr. Punya Charusiri was born in Thonburi, central Thailand on 2 January, 1955. He finished his primary and secondary schools at Buranavit School in Thonburi and finished his high-school at Triam-Udom Suksa School in Bangkok. He held his B.Sc. and M.Sc. degrees in Geology from Chulalongkorn University in 1977 and 1980, respectively. While becoming the graduate student, he joined the Department of Geology, Chulalongkorn University in 1979 as a staff-member lecturer. Since then, he has been working as a staff member of Geology Department, Chulalongkorn University, Bangkok. For the past 7 years, he has been a project consultant in mineral exploration for several private companies. He is very much interested in metallogenesis, remote sensing, mineral exploration, and tectonic setting of SE Asia and has lectured such courses for more than seven years since 1989.



Jiuping Chen received his BS (1984) and MS (1987) in geophysics from China University of Geosciences. From 1987-1995 he worked as an assistant researcher and a lecturer at the same university. In this period, he also worked as a software engineer for one year at Ryobi Systems Ltd., Japan and as a part-time academic fellow for half a year at School of Earth Sciences in Macquarie University, Australia. He is currently a candidate for his PhD degree at Macquarie University. His main interests are in EM modelling and inversion, data interpretation of airborne gravity and aeromagnetics.

Joseph Chiupka has a BSc (1st class Hons) in Geology with Geophysics from the University of Manitoba, Canada, and 6 years of experience exploring for stratigraphic traps in the Western Canadian Sedimentary Basin. He has since worked as an explorationist in most Australian basins for several companies, and for the Victorian Department of Natural Resources and Environment. Joe is the author of VIMP Report 30 on the Gippsland Basin, and is a Ph.D. student at the University of Melbourne, researching the use of seismic to map sequence bound lateral lithology changes. He is a past federal secretary of PESA, and is a member of the ASEG, AIG, CSPG, and PESA.

David Clark obtained a B.Sc.(Hons I) majoring in Physics from Sydney University in 1974 and an M.Sc. in Geophysics from Sydney University in 1983. Since 1978 he has worked in the Rock Magnetism Group of CSIRO Exploration and Mining and its precursor Divisions and is currently a Principal Research Scientist. His research interests include application of magnetic property data to interpretation of magnetic surveys, magnetic petrology, potential field modelling and development of a method for remote determination of magnetic properties of buried magnetic sources.



Dave Cockshell completed his BSc (Hons) degree at University of Adelaide in 1975, majoring in geophysics. He was employed as a Mine Geologist/Grade Control Officer in Western Australia by Windarra Nickel Mines/Western Mining during 1975-76. He joined the South Australian Department of Mines and Energy in 1977 as a geophysicist. He is currently the Chief Geophysicist with the Petroleum Geophysics Branch. Dave has had experience with a wide range of geophysical techniques in the engineering, environmental, hydrological, structural and petroleum fields. His expertise covers data acquisition and interpretation as well as environmental management and petroleum regulation. He is a member of ASEG, SEG, PESA and EIA.

Kenneth L. (Ken) Craft earned his B.Sc. degree in Applied Mathematics at the Georgia Institute of Technology in June, 1975. He began his career in Geophysics in June of 1975 when he joined Geophysical Services Inc. in Houston, Texas. He held various seismic data processing positions in Houston, Calgary and New Orleans while maintaining continuous employment with GSI, Halliburton Geophysical Services and Western Geophysical. In May of 1995, he joined the Research and Development department of Western Geophysical. He has co-authored papers on dip dependent processing and Dip Moveout. He is an active member of SEG. His interests include imaging technology and seismic amplitude studies.

Peter Dart BSc (Hons), Warwick University, UK. Arriving in Australia several years ago Peter gained experience with Lamontagne Geophysics collecting EM data, followed by work with Pasminco Exploration, Melbourne, processing geophysical data. Peter was able to apply several years of computing experience and geophysical knowledge to the development of the INTREPID geophysical and visualisation system on which he has been working for the past 5 years. Currently he manages technical support and maintenance and contributes to the on-going development of specialist geophysical processing software. He is also involved in the MAGMAGE project. Peter enjoys rock climbing, regularly risking life and limb in the pursuit of adventure!

Chris Dauth graduated from the Curtin University of Technology Western Australia in 1993 with B.Sc. (Hons) in Geophysics. He was employed by Rockwater Pty Ltd from 1993 to 1995 principally involved in application of geophysical techniques to groundwater exploration. He is currently employed as a geophysicist by RGC Exploration Pty Ltd based in their Perth exploration office. Chris is a member of the ASEG.

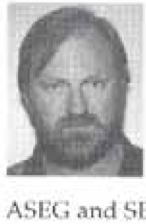
G. C. Davenport, Date of Birth: November 4, 1941. Place of Birth: Newton, Massachusetts, USA. SSN: 026-30-9700. Education: Professional Degree, Geophysical Engineer, Colorado School of Mines, 1964. Relevant Experience and Qualifications: Mr Davenport's career spans more than 32 years of planning, managing and implementing geophysical surveys for criminal, environmental, groundwater, geotechnical, mining, and archaeological investigations. He has managed remote sensing surveys in 10 foreign countries, and at the invitation of private clients and governments has presented seminars and training programs in the U.S., Canada, Mexico, Peru, the Dominican Republic, Korea, Vietnam, South Africa, Saudi Arabia, Iran, Italy, Spain, England, France and Sweden.

Mr. Davenport is a recognised expert in the utilisation of geophysical techniques, including ground penetrating radar (GPR), Electromagnetics (EM) and magnetics to locate clandestine graves and associated evidence. He is one of the founding members of, and on the Permanent Board of Directors of, NecroSearch International. Mr. Davenport has served as a consultant to many law enforcement agencies, including the FBI, DEA, Secret Service, Colorado Bureau of Investigation and Florida Department of Law Enforcement.

Phil Davey graduated in Geology from the University of Wales in 1989 and joined Seismograph Services Limited (SSL) as a processing geophysicist. He worked in Nigeria, West Africa from 1990 to 1992 as seismology processor of VSP and seismic data. He joined Geco-Prakla, United Kingdom, as marine sales geophysicist in 1993, and headed the marine sales department during 1994 and 1995. Presently Mr. Davey is Geco-Prakla's Exploration Services Manager for the Australia-Indonesia-New Zealand and Papua New Guinea (ANZI) group.

Mike Dentith is Senior Lecturer in the Department of Geology & Geophysics, The University of Western Australia. He is Deputy Director of the Special Research Centre in Tectonics and responsible for geophysical projects in the Key Centre for Strategic Mineral Deposits. Current research includes processing and imaging of potential field data using textural filters and wavelets, and geophysical signatures of various types of mineral deposit. He is also involved in crustal-scale geophysical and geodetic studies of the Hamersley Basin and southwestern Yilgarn Craton, Western Australia.

Nick Direen is currently undertaking a PhD in geophysics at the Centre for Ore Deposits and Exploration Studies (CODES) at the University of Tasmania. He received his B.Sc. (Hons) from the University of Tasmania in 1995 for his thesis "Geophysical Modelling of the Longford Basin, Northern Tasmania". His current research involves tectonic modelling derived from integration of potential field, magnetotelluric, GIS and seismic datasets. He is presently applying these methods to the basement of the Murray-Darling Basin in Western NSW and Victoria. His other interests include microseismicity, petroliferous basins, sedimentology, and Asian tectonics.



Owen Dixon graduated from the University of Queensland in 1977 with a BSc App(Geophysics). He has worked within the Geological Survey of Queensland since graduation on a variety projects and is currently a Senior Geophysicist within the Cooper Basin Project. He is a member of ASEG and SEG.

Mark Duffett graduated from the University of Adelaide with a B.Sc. in 1991, and worked during this time as a vacation student with Mines and Energy, South Australia. He completed his Honours year in the Centre for Ore Deposit and Exploration Studies at the University of Tasmania in the following year, using gravity and aeromagnetic datasets to investigate a mineralised region in north-east Tasmania. Currently he is completing a Ph.D. at the University of Tasmania on the application of GIS to Proterozoic sediment-hosted Pb-Zn metallogeny in northern Australia, coupled to interpretations of gravity, magnetic and radiometric data in the region of the Lady Loretta Pb-Zn-Ag deposit.

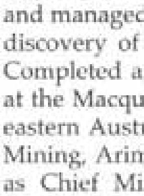
Jarrod Dunne completed a B.Sc. (Hons.) in geophysics at Melbourne University in 1992. He has recently submitted a Ph.D at Melbourne University titled "Subcoal seismic exploration in the Gippsland Basin". The research was sponsored by ESSO and BHPP as part of an attempt to characterise and then suppress the strong noise below the Latrobe Group coal sequence in seismic data throughout the Gippsland Basin. Jarrod is a member of the ASEG and SEG and he recently received an award for the best student poster at the 1995 SEG conference in Houston.

Peter Eadington graduated with B.Sc. and Ph.D. in geology from Newcastle University and Graduate Diploma in Business Administration from Macquarie University. He worked for BHP and GSI. He joined CSIRO in 1970 initially in Divisions conducting minerals exploration research and is now team leader of the Fluid History Analysis group in the Petroleum Division.

Katherine Edwards is a PhD student in the Exploration Geophysics research group in the Physics Department at the University of Queensland, and a research assistant in statistics at the Queensland Institute of Medical Research. She was also an inaugural recipient of the Comalco Smelting Women's Undergraduate Scholarship. Her current interests are in the application of statistical and numerical modelling techniques to geophysical data. Katherine is a student member of the ASEG, and a graduate member of the AIP.

Ole G. Engels received his diploma (1992) in geophysics from the University of Cologne. In 1991 he joined HarbourDom GmbH Germany as a consultant and was promoted to Executive Manager in 1993. His interest is in TEM acquisition, processing and interpretation, presently consulting two LOTEM research projects. He is a member of SEG, DGG and BDG.

Mike Erceg (Age 39) Born in New Zealand and educated at Auckland University. Graduated in 1979 with BSc and 1981 with MSc. MSc thesis entitled "Aspects of the Geology and Geochemistry of the Te Ahumata fossil geothermal system, Great Barrier Island N.Z." Began exploration career as geologist with Amoco Minerals NZ transferring to Amoco Australia in 1982. Seven years spent on exploration, feasibility and development of the Red Dome Gold Mine in north Queensland initially with Amoco/Cyprus then Elders Resources. In 1988, relocated to Lae in Papua New Guinea and managed the Wafi project for 4 years culminating in the discovery of the Rafferties copper-gold porphyry deposit. Completed a post graduate diploma in Mineral Economics at the Macquarie University, Sydney in 1989. Contracted in eastern Australia 1992 - 1993 for CRA Exploration, Niugini Mining, Arimco and Cyprus Minerals. Worked for Plutonic as Chief Mine Geologist at the Lawlers Gold Mine in Western Australia from mid 1993-1994. Accepted current position as Chief Geologist for Chase Minerals Philippines in mid 1994. Presently living in Manila with wife, Tracy and three children, Sarah (8), Stephanie (5) and Matthew (3).



Brian Evans is currently a Senior Lecturer in Geophysics at Curtin University. He graduated as an electrical engineer (Liverpool Univ.), and after initial work in the electronic control industry for GEC-Elliott Automation (UK), he joined Geoservice as a well logging engineer. He worked for Geophysical Service Inc as field engineer, and consulted for eight years in London and Perth. He has a Masters in Geophysics from Curtin, and is studying for a PhD. He is author of the recent SEG publication "Seismic data acquisition in Exploration".

Edward B. Fainberg received his MS (1963) in physics from State University of Turkmenia, his PhD (1969) in physics and mathematics from Institute of Physics of the Earth, and his Doctor of Sciences Diploma (1982) from Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation with Russian Academy of Sciences. He is working for Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation and United Institute of Physics of the Earth, both with Russian Academy of Sciences since 1970. He is professor of Russian Academy of Sciences (1983) and head of Laboratory of Electromagnetic modelling. His scientific interests are mainly focused on global and regional deep electromagnetic explorations. The area of his most recent interest is application of the electromagnetic methods for environmental research.

Roberto Fainstein has more than 30 years experience with the international oil industry most of which were with Petroleo Brasileiro S.A. (PETROBRAS) and Atlantic Richfield International (ARCO). He has also worked in seismological research with Exxon Production Research Company (EPR). He is experienced in Central and South America, West Africa, North America and Southeast Asia. As a seismic interpreter for Arco Indonesia he was responsible for many significant discoveries in the Offshore Northwest Java Sea and in the East Java Sea north of Bali. He was involved in the geophysical development of oil and gas fields in these regions. During his tenure at Petrobas, Mr. Fainstein participated in the pioneering geological and geophysical fieldwork on many of the Brazilian basins. As Petrobas's geophysical manager for the REMAC project, he was responsible for mapping of the entire Brazilian Continental Margin. Mr. Fainstein received his doctorate degree in Geology from Rice University. In 1994 he was awarded a silver certificate from the Society of Exploration Geophysicists (SEG) for twenty-five years of continued active membership in the Society. He has published extensively in international magazines on oil and gas exploration and development and given presentations at international meetings in Brazil, United States, Indonesia and Australia. He is presently an exploration advisor for Geco-Prakla ANZI group.

Sue Farrell, Postgraduate Student, Dept. of Earth Sciences, Monash University, Clayton, Victoria, 3168, Australia. E-mail: sfarrell@callisto.earth.monash. edu.au. Employment History: 1992-1993, 1993-1994 Vacation Research Assistant, CSIRO Division of Exploration and Mining; 1994 to present, Practical Demonstrator (part-time), Monash University. Academic History: BSc(Hons) Geophysics 1994 Monash University. Professional Interests: Geological and geophysical modelling, applications of computer science to earth sciences, geodynamical modelling.

Will Featherstone holds a degree in Geophysics and Planetary Physics for the University of Newcastle upon Tyne and a doctorate in geodesy from the University of Oxford. He is currently Senior Lecturer in Geodesy and Global Positioning Systems in the School of Surveying and Land Information at Curtin University of Technology, Perth. Will's research interests comprise physical geodesy, notably gravimetric geoid determination, satellite positioning and coordinate systems. He is the principal investigator on a project to compute a new gravimetric geoid of Australia, which is due to be released this year.

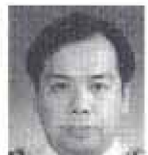
Doug Finlayson graduated from the University of Edinburgh in 1960 with BSc (Honours Physics) and subsequently graduated with MSc and DSc degrees in geophysics. His geophysical career began with the British Antarctic Survey before he joined the Australian Geological Survey Organisation (previously the Bureau of Mineral Resources, Geology & Geophysics), Canberra in 1965. His initial research in Australia involved geomagnetic mapping and interpretation across the continent. His current interests are in determining the major structural features of the continental crust and lithosphere using seismic methods and the tectonic evolution and development of sedimentary basins. He is currently a Principal Research Scientist involved in seismic projects in the Otway Basin, McArthur Basin and at Rabaul, PNG. He is an active member of ASEG, PESA and GSA.

Desmond FitzGerald is Founding Director of Desmond FitzGerald and Associates Pty. Ltd. With over 20 years of experience in the minerals industry, Des has a range of interests in the technical software and instrumentation hardware areas. He is Chairman of Mindata Pty Ltd and International Monitoring Systems; Director of Techbase Australia Pty Ltd and ISS Pacific Pty Ltd. He is also a member of the Mineral Industry Consultants Association and Chair person of GeoJAG Australia. As Principal of Desmond FitzGerald and Associates, Des co-wrote the INTREPID geophysical processing and mapping software product. Current extensions include rewriting the Australian National Gravity data handling for AGSO and also developing automatic interpretation methods for mineralised targets. Other business interests include ISS Pacific - a joint venture with Anglo American Gold & Uranium Division. Using the technology of micro-seismic real time monitoring, they offer coal and metal mines improved safety via early warnings of likely rock burst and wind blast conditions. The Mindata business is committed to sensor development and data collection for mining and water applications. Their instruments can measure stress, displacement, pressure, conductivity and turbidity of water.

Marcus Flis graduated from the University of Adelaide with a B.Sc. (Hons) in 1979. He was employed by CRAE from 1980 to 1989, principally in the search for base metals. In 1985, Marcus was awarded a M.Sc. from the University of Utah for research into IP effects in TEM. From 1989 to 1995 he was employed by Newcrest Mining Limited, exploring for gold in W.A. and the N.T. He is currently employed as Principal Geophysicist for Hamersley Iron Pty Ltd. Marcus is a member of the ASEG, SEG, and EAEG.

Mike Galbraith, Michael Galbraith, P. Geophy., B.Sc. Honours in Mathematical Physics. President, Seismic Image Software Ltd., Calgary, Alberta, Canada. Mike received his B.Sc. (Hons.), Mathematical Physics, from the University of Edinburgh, Scotland in 1967. From 1968 through 1971, he served as a Research Assistant with British Gas Council. In 1971, Mike made his home in Canada and became Programming Manager for R.B. Cruz and Associates - a company later to become Veritas Software Processing. From 1984 to 1987, Mike served as President of Veritas Software Ltd. - a division of the Veritas Group dedicated to the research and development of Geophysical software. He is now President of Seismic Image Software Ltd., a company he founded in 1987 located in Calgary, Canada.

With 25 years of experience in the geophysical area, particularly in the research and development of geophysical software, Mike's interests are widespread - wavelet theory, signal processing algorithms, migration and DMO, 3D processing in general and the design of 3D surveys. Mike first developed a 3D design program in 1985 and has had strong interest in the topic ever since. He has delivered numerous talks at conventions, SEG Society luncheons and other venues. He also developed a course on 3D design which as been presented many times since 1993. Mike is a member of CSEG, SEG, EAGE, ASEG, PESGB, AGU, IEEE and APEGGA.



Mr. Weera Galong was born in Bangkok on 20 February 1952 and commenced his elementary and high schools from Wat Mongkut Kasattiyaram School in Bangkok in 1958 and 1968, respectively. He received his B.Sc. in physics from Chulalongkorn University in 1973. Since then he worked in Economic Geology Division, Department of Mineral Resources (DMR) as an exploration geophysicist. With the Thai government scholarships, he subsequently received his Master Degree in Geology from Laurentia University, Sudbury, Ontario, Canada. After returning to Thailand in 1991, he joined DMR as an exploration geophysicist, and with his 20-yr experience on this field, he has been promoted as the head of Ground Follow-up Survey I Section (Geophysics), Mineral Resources Development Division, DMR. His major interest is the application of enhanced airborne geophysical data to regional - and local-scale mineral exploration.

David Gamble is currently Computer Services Manager with Acacia Resources. He graduated from Melbourne University in 1965, and was involved in the early work on Kambalda, Nepean, and Greenvale. In 1969 he completed his M.Sc. at the Royal School of Mines in London, and worked in Fiji, Canada and Oman before returning to Australia in 1974. Since then he has worked extensively in exploration through out Australia, specialising in exploration data processing. He was a member of the ASEG Federal Executive while it was based in Melbourne, and is now Secretary of the Victorian branch.

Simon George was awarded a B.Sc. (Hons) degree in geology from St. Andrews University in Scotland in 1985 and subsequently worked as a mudlogger out of Aberdeen. He obtained his Ph.D. (1990) in organic geochemistry from the University of Newcastle upon Tyne for his work on the influence of igneous activity on petroleum generation and accumulation. He is currently a Senior Research Scientist at the CSIRO Division of Petroleum Resources where he undertakes research into the molecular geochemistry of petroleum and petroleum source rocks. He is a member of the AAPG, PESA and the European Association of Organic Geochemists.

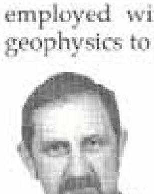
Stewart Greenhalgh is Professor of Geophysics and Head of the School of Earth Sciences at Flinders University of South Australia. He holds an MSc degree in Geophysics from the University of Sydney and a PhD degree from the University of Minnesota. He has been employed by the Department of Mines, N.S.W., the University of Sydney, and has worked as consultant with several oil and mining companies and government agencies. He has been associated with Flinders since 1981. He is a member of SEG, EAEG, SSA, and AGU. His research interests are primarily in seismic and electrical imaging.

Paul Greenwood obtained a B.Sc. from the University of Melbourne and a B.Sc. and Ph.D. (1992) in Physical Chemistry from the University of NSW. On the completion of his studies he joined the organic geochemistry group at CSIRO. An overseas component of an initial CSIRO postdoctoral fellowship award allowed visits to the Fuel Science laboratories at Pennsylvania State University (US) for a year (1992) and the Mass Spectrometric laboratories at Warwick University (UK) for the first half of 1993. His main research interests are laser and other fast pyrolysis GC(-MS) methods and their use in organic geochemistry.

Cedric M. Griffiths worked for the Norwegian Continental Shelf Institute from 1983-88 and was Nordic Council Research Professor at the Norwegian Institute of Technology from 1988-91. He joined BP research in 1991 and worked on stratigraphic modelling with BP/Statoil until becoming a co-director of Stratigraphic Research International in 1993. He has held the State Chair in Petroleum Geology at the National Centre for Petroleum Geology and Geophysics since November 1994.

Peter Gunn studied at the Universities of Melbourne, Manitoba (Canada) and Durham (U.K.) He has undergraduate majors in physics, mathematics, geology and geophysics and MSc and PhD degrees in geophysics and recently completed a graduate Diploma in Applied Finance. He worked world-wide for 17 years with the Elf Aquitaine Group reaching chief geophysicist level in both their petroleum and mineral activities. He has also worked with BHP Minerals, West Australian Petroleum and Geoterrex, in Ottawa, Canada, where he was responsible for data processing. Peter is currently Head of the geophysical Mapping section of the Australian Geological Survey Organisation.

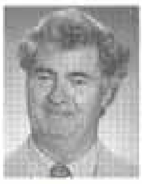
N. R. Gyngell graduated with B. Sc. (Hons.) in Geophysics from Flinders University (South Australia) in 1993. Worked for the Geophysical Research Institute and Pancontinental Mining Ltd. in 1994. Pancontinental Mining Ltd. merged with RGC Exploration Pty. Ltd. in 1995, whom he is currently employed with. He is involved with the application of geophysics to gold exploration in W.A.



Mike Hall, Vice President of Geoscience Integration, Seismic Image Software Ltd., Calgary, Alberta, Canada. Mike has been in the seismic industry for 25 years and has worked in all areas from acquisition to interpretation. He has always had a strong interest in integration between the various disciplines and has significant experience in designing acquisition programs and seismic sequences to meet the needs of the interpreter.

Mike has been very active in interpretive processing both as part of the development side and the user's side. He is very much aware that integration is as much, if not more, a matter of people than technology. His sensitivity to this issue has won him many friends in the industry. Much of Mike's experience has been spent in R&D and its management, a considerable amount of this involved with software both from the viewpoint of the programmer and the user. Mike was very active in the ProMAX user's group, being its Chairman in 1994. He is very much of the opinion that software should make life easier, not harder, for the user. For the last few years Mike was an industry representative on the Programme Management Committee for the Hydrocarbon Reservoirs Programme under the U.K. government LINK scheme. Mike worked in Canada for a while, following his successful graduation there with a Master's degree. Then to England where he worked 15 years with Horizon - later to become Simon Petroleum Technology - ending up as the Director of Integrated Geoscience. He was most recently with Energy Innovations as the Chief Geophysicist for the EAME region.

Michael Hallett received his B.Sc. with Honours from the University of Sydney in 1988. He was recently awarded his M.Sc. in Geophysics, Geology and Petrophysics of the Koongarra Orebody, NT and was a contributor to the ASEG Special Publication #8, a case study of the Koongarra Orebody. Michael has worked as an Interpretation Geophysicist at Geoterrex Pty Ltd for the past three years and has travelled to Canada, South America and Indonesia for various geophysical surveys. He is actively involved in the use of airborne geophysics coupled with other related fields for groundwater and land management studies. He has published articles for various magazines on the subject, working cooperatively with the Department of Land and Water Conservation and various Landcare groups on groundwater salinity projects. At the 11th ASEG Conference in Adelaide, 1994 he was presented with the Laric Hawkins Award for the most innovative use of a geophysical technique, for his paper on a groundwater salinity study using airborne time-domain EM.



Dick Haren obtained a first class honours degree and University Medal in Physics and a Ph D in geophysics from the University of NSW, with Laric Hawkins as supervisor. His Ph D research focused on the electromagnetic response of the Elura and Woodlawn orebodies using analogue and computer modelling to verify field observations. He worked at CSIRO for 7 years as a research scientist and project leader involved with electrical and electromagnetic methods. Dick left Sydney for Perth and 10 years of industrial consulting (often insulting) working in many parts of the world, discovering gold and diamond resources that were subsequently mined in Western Australia and Brazil. Much of his work involved the interpretation of magnetic data and its structural implications, exploring for gold, base metals, rare earths, platinum and diamonds. Dick headed to Canberra in mid 1995 and spent 18 months initiating and managing the Broken Hill Exploration Initiative at AGSO. His contract with AGSO ended in December 1996 and Dick is back in Perth as a Director of two public companies.

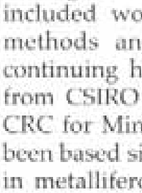
Cole Harris, Digicon Geophysical Corporation, 3710 Kirby Drive, Suite 600, Houston, TX 77098-3982. Telephone: 713-512-8584 Facsimile: 713-512-8770. Email: cory@digicon-hou.com. Education: M.A. Physics, The Johns Hopkins University, 1990. Employment: Digicon Geophysical Corporation, 1993-present - Research Geophysicist, 1990-1993 - Processing Geophysicist. Professional Affiliations: Society of Exploration Geophysicists.

Esther Harris completed her B.Sc. in geology at Monash University in 1994. She is currently undertaking an M.Sc.in geophysics at Monash University, and her interests include potential field geophysics, particularly forward modelling and depth-to-basement analysis.

Lynn M. Hastie received his B.Sc.(Hons) from the University of Tasmania, after which he worked for three years for the Bureau of Mineral Resources. Following this he entered graduate school in the University of Toronto, Canada, where he completed an M.A. followed by a Ph.D. in 1970. He is currently a senior lecturer in physics at the University of Queensland. His main interests are in signal processing and magnetotelluric methods. He is a member of the ASEG, SEG and the GSA.

Michael Hatch is managing geophysicist at Zonge Engineering Australia. He completed a B.S. degree in geology at the University of Pennsylvania (1983), and a M.S. degree in geosciences at the University of Arizona (1991). He has worked as an exploration geophysicist since 1985, with his first field job for Zonge Engineering in Tucson, Arizona. He then worked for St. Joe American for three years, and full-time for Zonge Engineering since 1992. He has managed the Zonge Australia office since 1994.

Peter Hatherly holds a BSc (Hons) from the University of Sydney and a PhD from Macquarie University. Between 1975 and 1983 he worked as an engineering geophysicist with the Geological Survey of NSW. He then moved to Australian Coal Industry Research Laboratories where he worked until 1993 on developing techniques and applications in coal mining for a wide range of geophysical methods. This included work on in-seam seismic methods, 3D seismic methods and the radio imaging method. He is now continuing his campaign to bring geophysics into mining from CSIRO Division of Exploration and Mining and the CRC for Mining Technology and Equipment where he has been based since 1993. There he has also established projects in metalliferous mines and for geotechnical investigations involving seismic monitoring.



Philip Hawke graduated from the University of Adelaide with a B.Sc. (Hons) in 1993. He worked for CRAE during 1992, exploring for base metals in the Mt Isa district. He is currently employed as an exploration geophysicist for Hamersley Iron Pty Ltd., and is involved in the search for bedded and detrital iron ore.

Suzanne Haydon completed her BSc (Hons) in geophysics at the University of Melbourne in 1993. She then spent the 1993/94 summer in Antarctica collecting gravity data near Casey Station for the University of Melbourne and ANARE. Suzanne is currently working for the Department of Natural Resources and Environment as a geophysicist with the Geological Survey of Victoria. She spent two years helping to develop the GSV gravity acquisition program and is now working on airborne geophysical data interpretation. She is a current member of the ASEG.

Steve Hearn holds Applied Science (Hons 1) and Ph.D. degrees in geophysics from the University of Queensland and has 15 years experience in the seismic industry. Since 1990 he has been a consultant with Wavebaud Associates specialising in borehole seismology. He holds a fractional appointment at the University of Queensland, and is Development Geophysicist with Digicon Geophysical Limited.

Roger Henderson is a Senior Geophysicist with 30 years experience in many parts of the world. He holds an M.Sc. from Sydney University and was a lecturer at Macquarie University in Sydney from 1968 until 1971, after which he spent three years in the UK as a geophysicist, first with Hunting Geology and Geophysics and then Barringer Research of Canada. He then moved to Toronto with Barringer for three years before returning to Australia to join Geoex Pty Ltd of Adelaide as a Director. In May 1982 he became V.P. of Geometrics International Corporation, a subsidiary of EG&G Geometrics of the USA. When G.I.C. was purchased by the Kevron Group of Perth in 1986, Roger was appointed General Manager of the newly formed Geo Instruments, and has held the position ever since. Roger has published on a range of subjects, in Geophysics, Geoexploration, Australian Journal of Science, and Exploration Geophysics. He has twice been President of the Australian Society of Exploration Geophysicists and Co-Chairman of two of its conferences. For his dedication to the ASEG he was awarded Honorary Membership in 1994.

Ray J. Hetu, Present Employer: Geological Survey of Canada, AGGS, Airborne Geophysics Section, 1986-present. Position: Geophysicist/Airborne Analyst. Mailing Address: 601 Booth St., Room 598, Ottawa, Ontario, Canada, K1A 0E8. Employment History: As summer student employed underground as labour and mine survey assistant. Worked as junior geologist and senior geologist doing mapping. After graduation 1975-1985, employed as geophysicist/project leader with Geoterrex Limited, doing Airborne Time Domain EM (INPUT) surveys in US(Alaska, California, Wisconsin, Texas, Georgia, etc), Brazil, Kenya, France, Portugal, Ireland and Greenland. Academic History: Laurentian University, BSc(Honours), 1973, Geology. Professional Interests: Airborne Geophysical data collection, reduction, analysis and interpretation. e-mail: rhetu@gsc.nrcan.gc.ca Voice: (613) 992-4279 Fax: (613) 996-3726.

Peter Hill is a research scientist (geophysicist) in the Petroleum and Marine Division of the Australian Geological Survey Organisation (AGSO) in Canberra. He graduated from the Australian National University (ANU) in 1967 with a B.Sc., and subsequently completed a B.Appl.Sc. (geology) at the University of Canberra and M.Sc. at the ANU. In 1970, he joined AGSO (then BMR) as engineering geophysicist. On secondment to ANARE, he was in charge of Australia's geophysical observatories at Macquarie Island (1973) and Mawson (1975). During 1979-82, he was Senior Geophysicist with the Geological Survey of Papua New Guinea. He joined AGSO's marine geoscience group in 1983, and has since worked on projects researching the development of the Australian continental margin, mostly using AGSO's research vessel Rig Seismic for data acquisition. He has also had considerable involvement in SW Pacific marine geoscience and has participated in a number of international research cruises in this region - investigating seafloor mineral resources, tectonics and other aspects of marine geology, using geophysical, seafloor sampling and swath-mapping techniques.

Richard Hillis is a senior lecturer in exploration geophysics at the University of Adelaide. He graduated BSc (Hons) from the Royal School of Mines, University of London in 1985, and PhD from the University of Edinburgh in 1989. After research positions at Flinders University, Adelaide, and at the British Geological Survey, Edinburgh, Richard joined the University of Adelaide in 1992. His main research interests are in contemporary stresses and sedimentary basin dynamics. Richard is a member of AAPG, AGU, ASEG, EAGE, FESSA, GSA, GSL, PESA and SEG.

Zheng Hongqin graduated with a BS in geophysics from the China University of Geosciences in Wuhan in 199O, an MS from the China University of Geosciences in Beijing in 1993, and a diploma in geoscience research from the Institute of Geology at the State Seismological Bureau in Beijing, in 1995. He has held teaching positions at the China University of Geosciences, and research positions at the State Seismological Bureau. His main areas of interest are the processing and interpretation of exploration geophysical data. He is a member of the Chinese Geophysical Society and the Chinese Association of GIS. He is currently studying for a PhD at UNSW.

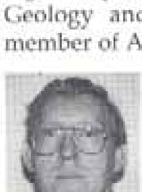
Gary Humphreys has an Engineering degree from University of Western Australia and a Graduate Diploma in Applied Geophysics from W.A. Institute of Technology (now Curtin Uni). He worked with Scintrex as a contractor/consultant for 14 years, with projects in Australia and Asia (including China, Japan, Malaysia, Laos and Pakistan), specialising in mineral exploration, groundwater studies and technical training. He joined Water Resources Division of Power and Water Authority in Darwin in 1993, and leads a team in the application of geophysical techniques to groundwater exploration and evaluation. The Division recently moved into the Department of Lands, Planning and Environment. Current interests include integrating geophysical and groundwater datasets, sounding methods and geophysical approaches to estimating groundwater quality and quantity. He is a member of ASEG, SEG, EAEG and IAH.

Robert Iasky graduated from the WA Institute of Technology with a B.App.Sc. (1978), a Grad Dip Sc in Physics (1979, Geophysics major) and, in 1991, a M.App.Sc. in Geophysics from Curtin University. He worked for Scintrex in 1980 and CSIRO in 1981 before joining the Geological Survey of Western Australia in 1982 where he is currently a senior geophysicist. With the Geological Survey, he has conducted basin studies in the Officer, Perth, Canning and Carnarvon Basins. He is a member of ASEG, AAPG and PESA.

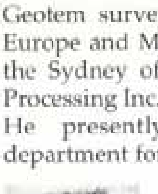
Eiji Ishii graduated with a BE from Akita University in 1974. He worked for the Osaka Soil Test Laboratory from 1974 to 1976. He completed a ME in mining geology from Akita University in 1980. He has since worked at Suncoh Consultants Co. Ltd. as a geophysicist. He is a member of SEGJ and ASEG.

Mark Jessell, Senior Lecturer, Dept. of Earth Sciences, Monash University, Clayton, Victoria, 3168, Australia. E-mail: mark@artemis. earth.monash.edu.au. Employment History: 1987-1990 Post-doctoral Fellow, Monash University; 1990-1995 Lecturer, Monash University; 1996 to present Senior Lecturer Monash University. Academic History: BSc Geology 1980 Leicester University, MSc Structural Geology and Rock Mechanics 1981 University of London, PhD 1986 State University of New York at Albany. Society Affiliations: IASTG, Professional Interests: Geological and geophysical modelling, deformation microstructures, metamorphic textures.

Abbas Khaksar graduated from Tehran University, 1990, in Mining Engineering-Exploration, worked as explorationist for potash and phosphate projects in Iran from 1990 to 1992. He received his MSc in Petroleum Geology and Geophysics, University of Adelaide, Australia in 1994 and currently is a PhD candidate studying petrophysics and well log interpretation at the National Centre for Petroleum Geology and Geophysics in Adelaide. He is a student member of ASEG and PESA.

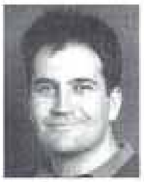


Stephen Kilty is a graduate of the University of Western Ontario (Honours B.Sc., Geophysics). He has been involved in the acquisition, processing and interpretation of airborne frequency and time domain electromagnetic surveying since 1975. Steve has been involved in Dighem, and Input/Geotem surveys in Australia, North and South America, Europe and Middle East and Africa. He was transferred to the Sydney office of Geoterrex when Dighem Surveys & Processing Inc. was acquired by the Geoterrex group in 1994. He presently manages the helicopter geophysical department for Geoterrex Pty Limited.



Johnathan Kirby is currently Research Associate in physical geodesy at Curtin University, working on the new Australian geoid project. He received a B.Sc. (Hons) in Physics from the University of Durham, UK, in 1989, and went on to undertake an M.Sc. in Exploration Geophysics at the University of Leeds, where he began his speciality in satellite altimetry and its applications to determination of the Earth's gravity field. In 1991 Johnathan began studying for a Ph.D. in gravity and physical geodesy, at the Department of Geology & Geophysics at the University of Edinburgh. He took up the position at Curtin immediately after obtaining his doctorate. During the course of his studies, Johnathan has also gained much varied geophysical exploration experience.

Mr. Suwith Kosuwan was born in Khon Kaen province, north eastern Thailand on October 20, 1962. He studied at Siriwitayakorn School for the pre- university education in Nakhon Ratchasima province, NE Thailand. He graduated with a B.Sc. degree in Geology from Khon Kaen University in 1984. He has been working as a field geologist at Geological Survey, Division, Department of Mineral Resources (DMR) in Bangkok since 1987. He received his M.Sc. degree in Geology, from Chulalongkorn University in 1996. With his 10 years experience on geological structures, he has been assigned to work on the active fault project in northern Thailand, in Environmental Geology Section, Geological Survey Division, DMR.



Frank Krieger graduated from Massey University, New Zealand in 1992 with a B.Sc. (1989) and M.Sc. (Hons) in Geology. He joined the CSIRO in 1993 and is currently a research geologist with the Division of Petroleum Resources. Frank is also completing a Ph.D. part time at the University of New South Wales, Centre for Petroleum Engineering on the palaeo-pore water evolution and hydrocarbon charge history of the Papuan Basin. He is a member of the Petroleum Exploration Society of Australia and the American Association of Petroleum Geologists.

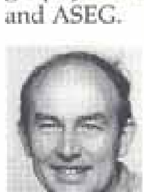
Ciaran Lavin received a BSc(Hons) in Geology at University of Melbourne in 1992. In 1993 he started an MSc at Monash University, which he is currently completing. Ciaran is presently employed by the Petroleum Development Unit of the Department of Natural Resources and the Environment, Victoria, where he is currently working as a geoscientist conducting sequence stratigraphic studies in the Otway Basin. Ciaran is a member of ASEG and PESA.

David Leaman received a B. Sc.(Hons) and PhD from the university of Tasmania. From 1966 to 1981 he worked for the Geological Survey of Tasmania on many applied geophysical, hydrological and structural projects. Since mid 1981 he has been a consultant specialising in the application of gravity and magnetic methods to the appraisal of structural setting and control of ore deposits, coal and petroleum basin studies, and basin evolution. He has wide experience in Australia and is visiting senior lecturer in geophysics and tectonics at the centre for Ore Deposit and Exploration Studies at the University of Tasmania. He is a member of ASEG, SEG, EAEG, PESA and GSA.

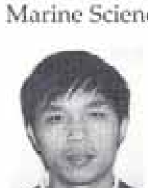
Nicholas Lemon studied undergraduate and Honours geology at the University of Adelaide during the nickel boom before commencing work with BHP Minerals. He worked in iron ore, coal and shale exploration for 10 years before returning to the University of Adelaide to undertake PhD studies with intention of switching from minerals to oil exploration. Nick has been associated with the National Centre for Petroleum Geology and Geophysics since its inception and he is now a Senior Lecturer. Nick is a member of PESA, GSA and AAPG and serves on the State committee of PESA.

Michael Leys joined the New South Wales Department of Mineral Resources after graduating from Macquarie University in 1970. His early experiences covered a wide range of geophysical techniques - regional gravity road traverses, seismic refraction on engineering sites, and marine magnetic and shallow marine seismic reflection surveys for coal and engineering projects. A change of emphasis within the Department led to well logging in the Great Australian Basin and later in Department coal exploration drilling. More recently Michael has been involved in the presentation and interpretation of airborne magnetic and radiometric data as part of the regional mapping team based in Orange, New South Wales. Michael is a member of the ASEG.

Ping Li received his BSc in physics from Inner Mongolia University, China, 1982. From 1983 to 1992 he worked for Research Institute of Environmental Science of Inner Mongolia of China as a researcher involved in Environmental Systems Engineering. From 1993 to 1994 he was a visiting scientist in James Cook University and researched on groundwater mathematical modelling. He is currently a PhD student in geophysics at Curtin University. He is a member of SEG and ASEG.



Ted Lilley. Following education at Hutchins School in Hobart, Ted Lilley was awarded a cadetship in geophysics by the Australian Atomic Energy Commission, and graduated B.Sc. (Hons) from the University of Sydney. After experience in aeromagnetic surveying with the Bureau of Mineral Resources (now the Australian Geological Survey Organisation), he undertook graduate study in geophysics at the University of Western Ontario, Canada, where he graduated M.Sc. and Ph.D. Postdoctoral work at the University of Cambridge in England followed, before he returned to the Australian National University, where he is now a Senior Fellow in the Research School of Earth Sciences. He has worked particularly on measurements of natural electromagnetic induction in the Earth. Lilley was ASEG Editor from 1981 to 1983, and has been an office-bearer in the Australian Capital Territory branch. He served as Chair of the Specialist Group on Solid-Earth Geophysics of the Geological Society of Australia from 1988 to 1992. In addition to the ASEG and the GSA, he is a member of the SEG, the American Geophysical Union, the Canadian Geophysical Union and the Australian Marine Sciences Association.



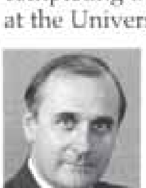
Zhihong Lin, received his BSc (1983) in geophysics from Chengdu Institute of Geology, PRC and his MSc (1986) in nuclear physics from China Institute of Atomic Energy. He recently submitted his PhD thesis in geophysics to Macquarie University. From 1986 until 1991 he worked on application of nuclear techniques at CIAE. Between 1992 and 1995 he worked on application of LOTEM to hydrocarbon exploration and EM modelling and inversion. He currently works at CRC for Australian Mineral Exploration Technologies. He is a member of SEG and ASEG. His main interests are radiometric, EM modelling and inversion.

Mark Lisk graduated from Auckland University in 1990 with a B.Sc. (1988) and M.Sc. (Hons) in geology. After working briefly in New Zealand on epithermal gold systems he joined the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in late 1990 and is currently employed as a research geologist with the Division of Petroleum Resources. His research interests centre on the application of fluid inclusion techniques to petroleum exploration and appraisal, particularly the assessment of hydrocarbon charge.

Keiran Logan completed his BSc degree with the University of Sydney in 1984, majoring in geophysics and applied mathematics. After initial employment with CRA in late 1984, he joined Placer Pacific Limited in early 1985 as the geophysicist responsible for surveys in Australia, Asia and the Pacific. He is currently a senior geophysicist with Placer Pacific Limited coordinating a team of geoscientists on Placer owned projects and mines in PNG and Asia. He is also completing a PhD in geophysics at the University of Sydney. Keiran is an active member of the ASEG, SEG and AGU.

Warawutti Lohawijarn. Education: 1978 B.Sc. (Physics), Prince of Songkla University, Thailand; 1983 Diploma (Exploration Geophysics), ITC, The Netherlands; 1984 M. Sc. (Applied Geophysics), University of Birmingham, UK; 1992 Ph.D. (Applied Geophysics) LuLea University of Technology, Sweden. Organisation: Department of Physics, Faculty of Science, Prince of Songkla University, Hat Yai, Thailand. Experience: 1978-present, Lecturer Physics Department, Faculty of Science, Prince of Songkla University, Thailand. Geophysical Research Activities: Applied Geophysics, Boundary delineation of coal basins and hydrological basins with gravity measurement; a study of regional geological structure of Peninsular Thailand with gravity and airborne geophysical data. Underground water prospecting with electrical and seismic methods. Applied geophysics for mining, engineering and environmental problems.

Patrick Lollback received his BE degree in Electrical Engineering in 1980, an MBA in 1991 and a Graduate Diploma in Petroleum Engineering in 1993. From 1980-1988 he worked for Schlumberger as a logging engineer throughout the Far East, Australia and New Zealand. After completing an MBA he opted to return to Petroleum Engineering where he has undertaken research in well log interpretation and sucker-rod pumping. He is currently completing a Ph.D. at the Centre for Petroleum Engineering at the University of New South Wales. Member of SPE.



Dr. Gary Lowder, from early 1993 until very recently, was Director General of the NSW Department of Mineral Resources. In that position he was responsible for the management and administration of mining legislation, geological and geophysical surveys, exploration and mining titles, mine safety awareness and inspection, environment protection and rehabilitation at mine sites, and the dissemination of geoscience and mining information in the form of maps, reports and other forms of publication. He resigned as Director General at the end of January this year in order to pursue a new role in mineral exploration.

Before joining the NSW Government, Dr Lowder spent more than 25 years in the Australian and international resources industry, both in mining companies and as a consultant. For most of that time he worked as a geologist in mineral exploration and related research in Australia, Papua New Guinea, Indonesia and the United States. From 1980 to 1991 he held senior positions with Pancontinental Mining Limited, initially in exploration management and later in a much broader context as Group General Manager - Corporate Development. Earlier he spent several years with Kennecott Copper and he has consulted in both management and geological areas.

As an exploration geologist, Dr Lowder can claim success with key roles in the discovery of several substantial ore deposits, including the Northparkes copper-gold mine and the Lake Cowal gold deposit in NSW, the Paddington gold mine in WA, the Sulawesi copper deposits in Indonesia and the Wodgina tantalum mine in WA.

Dr Lowder is a graduate of the University of Sydney, the University of California at Berkeley and the Advanced Management Program at the Harvard Business School.

Scott Macinnes received his BA in geology from Middlebury College, Vermont in 1975. He worked as a minerals explorationist in Alaska for five years before returning to school for a graduate degree. He received a PhD in geophysics from the University of Arizona in 1988. Since graduating, Scott has been employed full time at Zonge Engineering and Research. Scott worked in Zonge's Tucson office from 1988 to 1991. He then moved to Adelaide to manage Zonge's Australian office from 1991 to 1992. He is currently stationed in Anchorage, Alaska. His current interests include program development for inversion of resistivity/IP, CSAMT and TEM data.

Timothy Mackey obtained a B.Sc.(Hons.) from Monash University in 1993, with majors in geophysics and geology. His First Class honours thesis was in potential field geophysics, studying the affects of current aeromagnetic processing techniques. In 1994, Timothy joined the Geophysical Mapping Section of AGSO as a geophysicist. He has been involved with image processing; post-processing of airborne geophysical data and digital GIS interpretation of potential field geophysics and geology.

Troy Macklin graduated with a B.Sc.(Hons.) in geophysics from the University of Adelaide in 1994. He joined the New South Wales Department of Mineral Resources' regional mapping team in 1995. Troy aided geological mapping through airborne geophysical data processing, imaging and interpretation techniques. Troy is a member of ASEG and PESA. Troy is now employed by Western Geophysical in Perth.

James Macnae is a Professorial Fellow at Macquarie University, and is responsible for the EM interpretation program of the Cooperative Research Centre for Australian Mineral Exploration Technologies. He has wide research interests in exploration geophysics, with most experience in Africa, Canada and Australia..

Subhashis Mallick, Research & Development Western Geophysical. Subhashis Mallick graduated with B.Sc. (Honors in Geological Sciences) in 1976 and M.Sc. (Exploration Geophysics) in 1978, both from the Indian Institute of Technology (IIT), Kharagpur, India. After being employed with IIT and with Indicos Computer Services in India and the Schlumberger Technical Services in the Persian Gulf, he joined the University of Hawaii at Manoa in 1983 and obtained a Ph.D. degree in Geology and Geophysics in 1987. From 1988-1990 he worked as assistant seismologist at the School of Ocean Earth Science and Technology, University of Hawaii. Beginning 1991, he joined Western Atlas International, initially with Western Atlas Software and was later transferred to Western Geophysical. Dr. Mallick's research interests include seismic data processing, modelling, inversion, and anisotropy. He is a member of SEG and AGU.

Marcus McClenaghan Graduated with a B.Sc. (Hons) in geology from Trinity College, University of Dublin in 1966 and obtained a Ph.D. from the University of London in 1971. His Ph.D. research involved mapping faulted Tertiary volcanic and sedimentary rocks in the northern Kenya Rift Valley; the work subsequently published as maps by the Kenya Geological Survey. In 1972 he joined the Mines Department in Tasmania where, in the geological survey section, he has mapped Precambrian and Lower Palaeozoic rocks in various parts of the State. His particular interest has been in the petrology and geochemistry of the Devonian granitoids. As a Senior Geologist he has been working on the conversion of geological data to GIS format and involved with the NETGOLD project to study gold mineralisation and encourage gold exploration in NE Tasmania.

John A. McDonald, Professor geophysics, Curtin University of Technology (CUT), GPO Box U 1987, Perth 6001, Australia. Employment History: 1956-64 UK Atomic Energy Authority, 1964-65 Geotechnical Corp., 1966-67 Teledyne Geotech, 1971-74 Southern Methodist University (SMU), 1974-79 Gulf Oil, 1979-95 University of Houston, 1995-present CUT. Academic History: HNC applied physics 1959, MS physics 1966, PhD geophysics 1972 SMU. Honors and Awards: 1974 Fellowship, Institute of Physics, London. Society Affiliations: SEG, AGU. Professional interests: 3-D methods of data acquisition/processing.

Paul McDonald obtained his BSc (Hons) in geophysics from La Trobe University in 1988. He joined the Geological Survey of Victoria in 1989 as a contract geophysicist working in borehole geophysics. He has continued to work for the GSV as a geophysicist and now works mainly with potential field data. His present interests include the use of geophysics to aid mineral and petroleum exploration, and in particular, the use of gravity data to resolve basement geology. He is currently the Vice President of the Victorian ASEG and a member of the Mineralogical Society of Victoria.

Laurent J. Meister, Research & Development Western Geophysical. Laurent J. Meister received a Geophysical Engineering Degree from the Ecole Nationale Superieure du Petrole et des Moteurs (IFP), Rueil Malmaison, France in 1959. After completing his military service as Research Scientist in a Geophysical Research Program in the Kerguelen Islands, Antarctica, he joined Stanford University as Fulbright exchange student in 1962 and obtained Master of Science and Ph.D. degrees respectively in 1964 and 1967. He began his career as research geophysicist with Geophysical Services Inc. in Dallas in 1967, held various positions in Research and Development in GSI and later in Halliburton Geophysical Services before becoming Senior Scientist at Western Geophysical. He is a member of the SEG and EAGE. His area of professional interest is seismic data processing, inversion and seismic reservoir monitoring.

Tony Meixner completed the degree of Bachelor of Science majoring in geology at the Australian National University in 1991. The following year he studied honours at the Research School of Earth Sciences, ANU, involving the three dimensional kinematic modelling of the magnetic field of the southern Joseph Bonaparte Gulf. At the beginning of 1996 he began employment in the Airborne Geophysics Section of the Australian Geological Survey Organisation. During this time he has been involved with the modelling of potential field data as an aid to the interpretation of regional data sets.

Noel Merrick is Senior Lecturer in Groundwater Modelling and Geophysics at the National Centre for Groundwater Management, University of Technology, Sydney in Australia. Prior to this appointment in 1992, he was Senior Lecturer in Geophysics at the University of New South Wales, Kensington. From 1972 to 1987, he worked for the New South Wales government water resources authority as a geophysicist and as a groundwater modeller. His particular interests are computer modelling (geophysical and hydrogeological), numerical inversion, optimisation and groundwater geophysics. As an educator he has taught courses on groundwater modelling, optimisation applications, computer programming and all aspects of geophysics. He consults widely in environmental impact and resource assessment studies and is active in developing software systems for the environmental market. He holds a Masters Degree in Science and a Graduate Diploma in Data Processing.

Jane Mitchell graduated in Bsc(Hons) from The Earth Science Department at Monash University, Clayton in 1993. Major areas of study were Geology and Geophysics with an honours study in The Petrophysical constraints on Aeromagnetic Interpretation. In 1994 she began work in the Geophysical Mapping section of AGSO and has continued Aeromagnetic Interpretation of several areas including Bass Basin, Otway Basin. Her duties at AGSO include data acquisition, quality control of contract data, processing of magnetics, Radiometrics, and Digital Elevation data, Interpretation on GIS and Database management.

Everett Mobley, Senior Programmer, Research & Development Western Geophysical. Everett Mobely received his B.S. degree in Mathematics in 1974 from Rhodes College and received his M.S. degree in Computer Science in 1982 from Emory University. He joined Western Geophysical in 1984 and has worked in the CSD and R&D departments. His main interests lie in migration and DMO. He is a member of SEG and ACM

Jim Montalbetti obtained his B.Sc. (Hons) in Physics from the University of Alberta, Edmonton, in 1967 and an M.Sc. in Physics and Geophysics from the University of Alberta in 1969. His main interests have been in seismic data acquisition and processing. He has worked for and as a consultant to, a number of geophysical contractors in Canada including Digitech Systems, Veritas Seismic Ltd, Pulsonic Geophysical and Geo-X Systems. Now permanently resident in Sydney, Australia, he provides petroleum exploration consultancy services to the industry, primarily in the areas of seismic processing of both 3D and 2D data, depth conversion and 3D acquisition design.

David Moore graduated from the Australian National University in 1968. He has worked as a geologist with Geopeko Ltd., the Australian Atomic Energy Commission, the Northern Territory Geological Survey, and BHP Minerals Ltd. in a wide range of mineral exploration and production positions. He is presently Senior Project Geophysicist with the Geological Survey of Victoria. Since 1990 he has interpreted regional geophysical datasets, making geologically meaningful interpretations that can be used in mineral exploration. He is a member of the AIG and the GSA, where he served as Councillor of the Executive Division from 1992 to 1994.

Arthur Mory is a senior geologist with the Western Margin Team in the Geological Survey of Western Australia. He has a B.Sc. (1976) and a Ph.D. (1980) from the University of Sydney. Arthur joined the Geological Survey in 1980 and has worked on the Bonaparte Basin (1980-1988), Perth Basin (1988-1994) and Carnarvon Basin (1994-present). He is a member of PESA and GSA.

Graham Moss obtained a BSc. (Hons. 1st) and a Ph.D. at The University of Adelaide and is a Senior Research Scientist at the Australian Geological Survey Organisation. He joined the National Biostratigraphic and Reservoir Database Project in 1995. He is currently engaged in managing STRATDAT, the national biostratigraphic database, that has been initially developed as a co-operative venture between government and industry.

Stephen Mudge, RGC Exploration Pty Ltd, PO Box 322, Victoria Park WA 6100. Stephen graduated with a BSc(Hons) degree in Geophysics from the University of New England, Armidale in 1976. He spent several years with Geopeko and after completing further full time study for a Diploma of Computing Science in Canberra he joined RGC Exploration Pty Ltd in 1981. He is currently employed as Chief Geophysicist at RGC where he is responsible for all of RGC's geophysical work throughout Australia, Asia, South West Pacific, South America and the USA. He is also Associate Editor of Preview, the bi-monthly publication of the Australian Society of Exploration Geophysicists (ASEG).

C. Jonathan Mwenifumbo received his B.Sc. (1972) in geology from the University of British Columbia, an M.Sc. (1974) in applied geophysics from the university of Birmingham, and a Ph. D. (1980) in geophysics from the university of Western Ontario. Since 1980, Dr. Mwenifumbo has been with the Geological Survey of Canada as a research scientist. His research activities are in the application of borehole geophysics to mineral, coal and uranium exploration, and to geotechnical and environmental problems. Dr. Mwenifumbo has also been involved in the Ocean Drilling Program. He is a member of SEG, EAEG and MGLS.

Osamu Nakano received a B.Sc. in geophysics in 1974 from Hokkaido University. Since 1974 has worked for DIA Consultants Co. Ltd. as a geophysicist. He is currently the project leader of the research and development project into high resolution seismic survey methods for coal resource evaluation. He is a member of SEGJ and ASEG.

Edward Nichols has twelve years of experience in designing, developing, and testing new geophysical instrumentation for electrical and electromagnetic methods. He was digital electronic and software designer for EMI's MT-1 magnetotelluric receiver now the industry standard for geophysical contractors in magnetotelluric exploration. His ongoing research at University of California, Berkeley focuses on identifying noise sources and contaminating measurements of electromagnetic fields using a high accuracy super conducting SQUID magnetometer array. Professional Honours and Awards: Jane Lewis Fellowship, Chevron Award, N.B. Professional Engineer Award.

Professional Society Affiliations: SEG, AGU, California Groundwater. Professional Interests: EM and electrical exploration techniques, instrumentation

Anna Oranskaia graduated with a BSc in geology and exploration geophysics from Moscow State University in 1988. From 1988 to 1992, she worked as a geophysicist with Marine Oil and Gas Company on Sakhalin Island, Russia. Her duties included data processing and interpretation of marine gravity and magnetic data. Anna studied at the University of Adelaide where she graduated with a BSc (Hons.) degree in geophysics in 1994. Currently she is employed as a geophysicist with the Geological Survey of Victoria. She is involved in the interpretation of aeromagnetic and radiometric data for mineral exploration and is a member of the ASEG.

Derecke Palmer graduated from The University of Sydney in 1967 with a B.Sc. (Hons. 1), and was awarded an M.Sc. from the same university in 1976. He began his career as a geophysicist with the NSW Geological Survey, and obtained broad experience in a wide range of geophysical techniques for engineering, groundwater, coal, and mineral exploration. Currently he is a Senior Lecturer in Geophysics in the Department of Applied Geology at the University of New South Wales. He is best known for his development of the generalized reciprocal method (GRM) for processing seismic refraction data. He was awarded the Grahame Sands Award from the ASEG in 1992 and the Reginald Fessenden Award from the SEG in 1995 for the development of the GRM. He has also developed considerable expertise in seismic reflection methods, particularly in high resolution applications in coal exploration, coal mining and petroleum exploration. He is a member of the SEG, the ASEG, a fellow of the AIG, and currently president of the NSW Branch of the ASEG.

Mau U. Papio (40) A registered geologist in the Philippines with varied experiences (18 years) in mine geology and mineral exploration. Worked in different operating mines and exploration companies in the Philippines, Malaysia and Indonesia. Started as a Mine Geologist for Lepanto Consolidated Mining Company; rose to the rank of Resident Geologist, Masbate Gold Operation and became Chief Geologist for Bukit Young Goldmine Sdn. Bhd (Bau, Sarawak, Malaysia). Accepted current position as Project Geologist for Chase Minerals Philippines' Batangas Exploration Project in early 1994.

Lloyd G. Peardon, Schlumberger House, Buckingham Gate, Gatwick Air-port, West Sussex RH6 0NZ UK Email: peardl@gatwick.geco-prakla.slb.com.

Work Summary: 1977-80 Research Geophysicist, Seismograph Service Ltd; 1980-86 Research Geophysicist, Britoil; 1986-87 Consultant Geophysicist, Shade Computer Consultants; 1987-92 Manager Research, Seismograph Service Ltd; 1993-94 Program Leader, Schlumberger Cambridge Research; 1994- present Manager Geosupport, Schlumberger Geco-Prakla. Academia: BSc (Hons) math, 1975; M.Phil 1979 Portsmouth Polytechnic. Membership: SEG, EAEG. Interests: Acquisition, processing, survey design.

Timothy Pippett graduated with a B.App.Sc. from Canberra College of Advanced Education in 1974. He was employed by Layton Geophysical International from 1975 until 1981 when he joined Geometrics International Corporation. Timothy worked with Geo Instruments (previously Geometrics) as the Sales Manager and undertook system development/integration and training courses on geophysical instrumentation and software. He is currently employed by ADI Limited - Technology Group as the Manager Sub Surface Imaging, using geophysics for the location of environmental targets including unexploded ordnance.

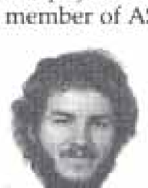
Evgueni Poezd has a PhD in Computational Physics. After graduation, he worked as a senior scientific fellow in the Academy of Sciences of the former USSR. From 1994 he has worked in Australia with C Vision Pty Ltd, where he is responsible for scientific software development with advanced Windows user interfaces. He is working on a number of geophysical software products with Windows interfaces. His current interests are Windows programming in Visual C++, Delphi and Visual Basic. Evgueni has about 30 scientific papers to his credit.

Robinson Quezada graduated from the University of Chile as an analytical chemist with further postgraduate studies in analytical instrumental analysis at the NSW Institute of Technology. He joined the CSIRO analytical group, specialising initially in coal chemistry, and currently operates the magnetic sector AutoSpec GC-MS at the Division of Petroleum Resources, investigating the molecular geochemistry of petroleum and source rock materials. He is a member of ACS, IHSS and EAOG.

Shanti Rajagopalan graduated with a B.Sc. degree in Mathematics from the University of Madras. She was attracted to a career in Exploration Geophysics as it appeared to be an excellent way to combine her interest in Mathematics and Physics with practical problem-solving. Shanti specialised in the interpretation of aeromagnetic data for her Ph.D. and has worked with the National Geophysical Research Institute in India, the Bureau of Mineral Resources, and the University of Adelaide prior to joining the Exploration Technology and Information Group at RTZ-CRA. She is presently based in Melbourne, Australia.

Mohammad Reza Rezaee completed his BSc and MSc in geology from the University of Mashad and Tehran Teacher Training University, Iran. Currently, he is doing PhD in the National Centre for Petroleum Geology and Geophysics, Adelaide. His field of study is reservoir characterisation and integration of rock data with wire-line log information. He has worked as a Senior Lecturer in the University of Hamadan, Iran from 1988-1991.

Robert G. Richardson received his B.Sc. (Hons) and Ph.D. from the University of Tasmania. He joined the Tasmanian Mines Department in 1978 as a geophysicist and worked initially in high-resolution seismic reflection techniques and computer software development. More recently he has worked in acquisition, processing and interpretation of gravity and aeromagnetic data. He is currently Manager, GIS and Geophysics with the Tasmanian Geological Survey and is a member of ASEG and SEG.



Michael Roach received his B.Sc. (Hons.) in 1987 from the University of Newcastle and Ph.D. in geophysics from the University of Tasmania in 1994. He joined BHP Research as a trainee in 1979 and transferred to BHP Collieries in 1981 where he worked on coal exploration in the Hunter Valley including surface geophysical and in-seam seismic surveys. Michael is currently lecturer in geophysics at the University of Tasmania. His main research interests are in the processing and interpretation of regional potential field data and in petrophysical measurements.

Sam Roberts, RGC Exploration Pty Ltd, PO Box 7141, Garbutt QLD 4814. Sam graduated with a BSc(Hons) degree in Geophysics from the University of Adelaide in 1989. He spent several years working for Geoterrex Pty Ltd in the Ground Geophysics department before joining RGC Exploration Pty Ltd in 1993. He is currently employed as Geophysicist at RGC where he is responsible for RGC's geophysical work programs in Queensland and New South Wales. He is a member of the Australian Society of Exploration Geophysicists (ASEG).

David Robson is Chief Geophysicist of the NSW Department of Mineral Resources. He graduated from the University of NSW with a B.Sc. (joint major of geology and physics) in 1975, and a Grad. Dip. App. Geophys. in 1976. He then worked with Scintrex for 2 years before joining the Metalliferous sub-section of the BMR (now AGSO). David spent nearly 4 years with the BMR where he worked in the Georgetown and Alligator Rivers areas before joining WMC. With WMC, David was part of the mineral exploration team and worked throughout Australia (especially the WA Goldfields) and the Philippines. In 1994 he joined the Department. David's interests are potential field modelling and low latitude magnetics. He is a member of ASEG.

Jeffrey Rowe graduated from Temple University, Philadelphia, USA, with a degree in geology. The companies he has worked with are Aero Service Corporation, Geometrics, CGG and Geoterrex. The duties have included processing and interpreting magnetic and radiometric data acquired in North America, Africa and Asia. He has also worked on data acquisition and interpretation of airborne and ground electromagnetic surveys in North America, Europe, and Africa. Rowe's work experience involves the marketing of geophysical data acquisition projects to the mining and petroleum industries. He also has considerable experience with large regional surveys acquired for government agencies. His interests are in the interpretation of airborne magnetic and electromagnetic (GEOTEM) data collected for the purpose of mapping hydrocarbon alteration.

David Rowland graduated with an Associate Diploma of Applied Science in Geoscience (Canberra Institute of Technology) and an Advanced Certificate in Applied Computing (C.I.T.). He has three years experience in the Western Australian Goldfields as a Geological Technical Officer with Central Norseman Gold Corp., and Pit Technician in Coolgardie Gold N.L. open cut mine. Dave joined the National Biostratigraphic and Reservoir Database Project at AGSO in March 1995.

Henry Salisch has a B.E. degree in Geological Engineering and did his postgraduate studies in Petroleum Engineering, University of Oklahoma. He has worked with Schlumberger in log interpretation and development from 1954 to 1977. From 1977 to 1986 he was in charge of well log research at Intevep, the research affiliate of Petroleos de Venezuela. In 1986 he joined the University of New South Wales in Sydney, Australia where he is in charge of teaching and research in petrophysics at the Centre for Petroleum Engineering. Member of SPE, SPWLA, Pi Epsilon Tau.

Konrad Schmidt received a B.Sc. in Physics and Geophysics from Monash University. He then completed his Honours year in 1991 at the University of Queensland. After working with Auslog developing electric logging tools and log enhancement software, he worked with Digicon and Encom Technology. He is currently completing an M.Sc. at Monash University while working with Acacia Resources. His interests include development of potential field interpretation aids and technology transfer between geophysics and other disciplines.

Phil Schmidt graduated from UNE in 1973 with a BSc (Hons) in geophysics and from ANU in 1976 with a PhD specialising in palaeomagnetism. After a post-doc with the Earth Physics Branch in Ottawa, Canada, he returned to Australia in 1978 to take up a position with the CSIRO Division of Mineral Physics (now Exploration and Mining). Phil is currently leader of the Rock Magnetism Group at North Ryde. Along with inmates, the laboratory is highly regarded worldwide for original research and for application to the exploration industry.

Dr Jorg Schulz-Rojahn is a Development Geologist at West Australian Petroleum Pty. Ltd. (WAPET), Perth, responsible for Barrow Island Asset and providing regional exploration support. Previously a Formation Evaluation Geologist at WAPET, he has worked on sequence stratigraphy, petrophysics and regional reservoir mapping of the Mardie Greensand, Carnarvon Basin. His principal research interests include integrated reservoir studies, formation evaluation and basin analysis, with work experience in numerous international settings. He holds a PhD from the National Centre for Petroleum Geology & Geophysics (NCPGG), Adelaide, and a MSc in Petroleum Exploratory Studies from Aberdeen University. He is a member of the AAPG and FESWA (email: jsr@wapet.com.au).

Ian R. Scott, Schlumberger House, Buckingham Gate, Gatwick Airport, West Sussex RH6 0NZ, UK. Email: ians@gatwick. geco-prakla. slb.com

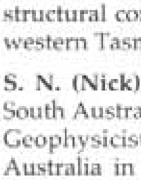
Work Summary: 1981-91 DP Manager, Merlin Geophysical; 1991-present Supervisor Systems and Technique, Schlumberger Geco-Prakla; Academia: BSc Geol/ Geoph Imperial College, London. Membership: EAEG, Fellow of Geol Society UK. Interests: Seismic data processing.

K. K. Sekharan, Sr. research scientist, AGL, University of Houston, AGL Bldg., Houston, TX 77204-4231. Employment History: 1976-77 Texas A&M, 1977-80 Selma University, 1980-present University of Houston. Academic History: PhD 1976 University of Kentucky, Society Affiliations: SEG. Professional interests: Physical modelling of geological structures, processing of seismic data, exploration for hydrocarbons.

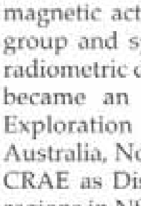
Gavin Robert Selfe was born in 1964 in Johannesburg, South Africa, and completed his schooling in South Africa in 1981. He took his studies further and graduated from the University of the Witwatersrand, Johannesburg, in 1987 with a first class BSc Honours in Geology and Geophysics. He then spent two years working for Transvaal Diamond Exploration as a field geologist before resigning to travel overseas for a year in Europe and South America. On his return he joined Anglo American Corporation as a field geophysicist and has spent the last six years there, working mainly in diamond exploration in southern Africa. His international experience includes short spells in South America, Russia and Canada. He is currently a Section Geophysicist with De Beers, and leads their geophysical section for diamond exploration in Africa.

David Seymour obtained his main qualifications at University of Tasmania, being awarded B.Sc. (Hons.) in 1975 and Ph.D. in 1980, specialising in structural geology in both cases. The associated project work focused on Devonian regional orogenesis in northwestern Tasmania. His post-academic employment record commenced with 5 years with the Geological Survey of Western Australia, working on a major tectonic project on the Proterozoic Ashburton Fold Belt in the Pilbara region. For the 12 years since then he has worked continuously with the Tasmanian Geological Survey in its numerous recent guises, gaining extensive experience in the structural complexities of the pre-Carboniferous geology of western Tasmania.

S. N. (Nick) Sheard Graduated from Flinders University, South Australia (B.Sc. HONS) in 1974. Started his career as a Geophysicist with the Bureau of Mineral Resources Australia in Papua New Guinea, monitoring seismic and magnetic activity. In 1977 joined the Airborne Geophysics group and spent 5 years acquiring airborne magnetic and radiometric data all over the Australian continent. In 1981 he became an exploration geophysicist with Carpentaria Exploration Company and explored throughout South Australia, Northern Territory and Western Australia. Joined CRAE as District Geophysicist for Broken Hill and Cobar regions in NSW in 1987. Accepted role as Chief Geophysicist for MIM Exploration Pty Ltd in 1990 and assumed responsibility for the global geophysical activities, and its own R&D.

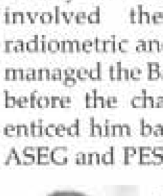


Sergey Shevchenko received a B.Sc. (1980) in Geophysics from Tashkent University of former USSR, and immediately after graduating he joined Tashkentgeology Company in 1980. With this company, he conducted mineral and petroleum exploration by using potential-field data. He was involved in all aspects of gravity and magnetic methods from managing field crews through to the interpretation stage, and developed software to capture and process these data. He migrated to Australia in 1993 and joined GSWA in 1994 where he continued to work with potential-field data in Perth, Carnarvon, Officer and Canning Basins for the Petroleum Intiative Teams. He is a member of ASEG.



Dr. Zhiqun Shi graduated in 1976 from Changchun Institute of Geology, China, with a B.Sc. in exploration geophysics. She worked as a geophysicist for Beijing Computer Centre of Ministry of Geology and Mineral Resources, China from 1976 to 1988 into potential field doing method research and data processing. In 1988, she came to the University of Adelaide as a visiting scholar and completed her Ph.D. in 1993 undertaking geophysical potential field research. She worked as a post-doctoral fellow at the University of Adelaide then joined MIM Exploration in 1995 where she is a senior Geophysicist. Her interests include development and application of advanced techniques of potential field to mineral and petroleum explorations, as well as data interpretation and processing.

Bruce Simons obtained a BSc in geology from the Australian National University in 1979. He joined Layton Geophysical International in 1979 as a geophysicist, conducting, processing and interpreting a variety of ground based geophysical surveys. In 1982 he joined the Northern Territory Geological Survey, and in 1990 the Geological Survey of Victoria. His work in both these organisations involved the interpretation of regional magnetic, radiometric and gravity data to aid geological mapping. He managed the Basin Studies Section of the GSV for three years before the challenge of the new Victorian airborne data enticed him back into geophysics. He is a member of GSA, ASEG and PESA.



Bension Sh. Singer received his MS (1971) in physics from Moscow State University and his PhD (1981) in physics and mathematics from Russian Academy of Sciences. From 1977 to 1991 he worked as a junior, later as a senior research scientist for Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation in Moscow with Russian Academy of Sciences. Since May 1993 till December 1995 he was a senior research scientist in the through-casing resistivity project for Western Atlas Logging Services, WAII in Houston, Texas. He joined CSIRO in November 1995 where he currently holds a position of a senior research geophysicist. His scientific interests are mainly focused on development of methods for modelling and inversion of electromagnetic data. He is a member of AGU and SEG.

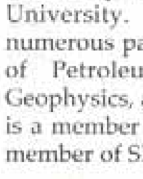
Kerry Slater graduated with a BSc. (Hons) in geophysics from Sydney University in 1993. Her first year after graduating she worked as a geophysicist with Australian Defence Industries in Australia, USA and Germany. This involved the acquisition and processing of high resolution magnetic data for environmental purposes. Currently she works as a geophysicist with the Geological Survey of Victoria. She is involved in the interpretation of airborne geophysical data for mineral exploration, geological and soil mapping, and is a member of the ASEG.

Geoffrey Smith received his BSc (1968) and MSc (1970) degrees from the University of Witwatersrand, South Africa. In 1977 he received a PhD in mathematics from the University of New South Wales. He obtained a graduate diploma in geoscience from Macquarie University, Australia in 1985. He currently lectures in mathematics at the University of Technology, Sydney. He is a member of ASEG and the Australian Mathematics Society.

Mike Smith has worked as Chief Geophysicist or Exploration Manager for public companies throughout Australia and the Western Pacific region as well as in Europe and South America. He has over 25 years experience in exploration for a wide range of commodities and deposit styles. He holds an M.Sc. from Sydney University and gained initial geophysical experience at the Bureau of Mineral Resources. He spent 14 years with Exxon Minerals Company based in Sydney, Perth, New York and Madrid with responsibilities for the design, implementation and interpretation of ground and airborne surveys in many countries. In August, 1985 Mike joined Austpac Gold NL as Exploration Manager of the company's gold exploration programs in PNG, Solomon Islands, Vanuatu, Fiji and New Zealand, later expanding these activities to Japan, the Philippines and Bolivia. In March 1996 he joined Geo Instruments as Manager, for Marketing and Sales of helicopter-borne magnetic and radiometric surveys. Mike served three terms as President of the Australian Institute of Geoscientists (AIG), and is currently Vice President. He is a former Vice President and Treasurer of ASEG and has served on many conference and symposium organising committees.

Richard Smith gained undergraduate and post-graduate degrees in geophysics from the University of Adelaide, and subsequently an M.Sc. and a Ph.D. from the University of Toronto. He has worked as a research geophysicist at Lamontagne Geophysics in Toronto, as a post-doctoral fellow at Macquarie University in Sydney, and as a project geophysicist at Pasminco Exploration in Melbourne. Currently he is the Research Coordinator at Geoterrex in Ottawa. His interests are in the acquisition, processing and interpretation of airborne magnetic and electromagnetic (GEOTEM) data.

Brian Spies is Director of the CRC for Australian Mineral Exploration Technologies, and is employed by CSIRO at Macquarie University. His research interests include mineral exploration geophysics, reservoir characterisation and monitoring, and integrated interpretation of geophysical, geological and engineering data. Before joining the CRC he worked in various research and management positions in the USA and Australia, primarily Schlumberger-Doll Research, Arco Oil and Gas Company and the Bureau of Mineral Resources. He received a B.Sc. in 1970 from the University of NSW and his Ph.D. in 1980 from Macquarie University. Author of 40 publications and holder of numerous patents, Brian has served on the editorial boards of Petroleum Geoscience, The Leading Edge and Geophysics, and is currently Secretary-Treasurer of SEG. He is a member of ASEG, SPWLA, AGU and EAGE and a life member of SEG.



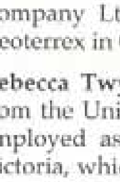
Ned Stolz graduated from the University of Adelaide in 1985 with an honours degree in geophysics. For the following five years he was employed by CRA Exploration and worked on projects in Western Australia, Northwest Queensland and the Northern Territory. In 1991 he left CRA and began a PhD at the Cooperative Research Centre for Australian mineral exploration technologies, Macquarie University. His research topic is automatic interpretation of EM data. Ned is an active member of the ASEG and SEG.

Xiaowen Sun was a Research Associate in the Nanjing Institute of Geology & Palaeontology, Academia Sinica after receiving her M.Sc. in China. Since arriving in Australia, she has been involved in several geological research projects in the AGSO (formerly BMR) and Australian National University. She has recently completed her PhD at the NCPGG, University of Adelaide on a multidisciplinary study of the Warburton Basin, S.A.. Xiaowen is a member of AAPG and PESA.

Belinda Suthers graduated from the University of Queensland in 1995 with first class honours in Applied Science (Geophysics). She is currently employed in the special projects group at Digicon Geophysical Limited. Her interests include seismic imaging, wavelet transforms and inverse problems.

Sharma Tadepalli, Petroleum Geophysicist, Amoco Production Company, 501 WestLake Park Boulevard, Houston, TX 77253-3092. Employment History: 1984-89 ONGC India, 1989-92 University of Oklahoma, 1992-95 University of Houston, 1996-present Amoco Production Company. Academic History: MSc exploration geophysics 1984 Osmania University India, MS geophysics 1992 University of Oklahoma, PhD geophysics 1995 University of Houston. Honors and Awards: Outstanding Student 1995-96, SEG Scholarship 1990-94, Society Affiliations: SEG, GSH. Professional interests: 3-D AVO, 3-D seismic interpretation, Anisotropy and Fracture imaging.

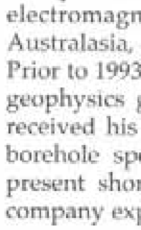
Robert H. Tatham, Research Consultant, Texaco Inc., P.O. Box 770070, Houston, TX 77215-0070, Employment History: 1967-71, 1975-80, 1986-present Texaco, 1971-75 Lamont-Doherty Geological Observatory, 1980-86 Geosource. Academic History: BS physics 1967 Cal State-Northridge, MS geophysics 1970 University of Houston, PhD seismology 1975 Columbia University. Society Affiliations: SEG, EAEG, AAPG, IEEE, SSA. Professional interests: Research into techniques of seismic interpretation.



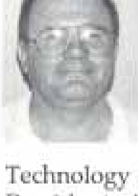
Jeff Thurston graduated with a B.Sc. (1988) in Physics from the University of Calgary and an M.Sc. (1991) in Geophysics from the University of Alberta. Since then he has worked with the lithoprobe Seismic Processing Facility at the University of Calgary and at Commonwealth Geophysical Company Ltd. in Alberta. He is currently employed by Geoterrex in Ottawa. Jeff is a member of APEGGA and SEG.

Rebecca Twyford obtained her BSc (Hons) in geophysics from the University of Melbourne in 1995. She is currently employed as a geophysicist at the Geological Survey of Victoria, which she joined in 1995. She has been involved in the collection of gravity data, and the interpretation of magnetic data obtained as part of the Victorian Initiative for Minerals.

Edward Tyne has gained extensive experience over 25 years in the application of airborne, ground and borehole geophysics to mapping and exploration mainly for base and precious metals. He recently joined Encom Technology Pty. Ltd. as a principal geophysical consultant with the primary role of Manager, Business Development, responsible for the international marketing of Encom's geophysical software and consulting services. From 1993-1996 he was the Manager of Data Processing and Interpretation group for Geoterrex Australia where he supervised the compilation and interpretation of airborne magnetic, radiometric and electromagnetic (GEOTEM and DIGHEM) surveys in Australasia, Africa, South America and North America. Prior to 1993, he was Principal Geophysicist in charge of the geophysics group in the Geological Survey of NSW. He received his Ph.D. for the development of a computerised borehole spectral IP logging system. He continues to present short courses on IP and EM to universities and company exploration groups.



Norm Uren received his BSc and DipEd from the University of Western Australia, his PGD App Phys and M App Sc from the Western Australian Institute of Technology and his PhD from the University of Houston. He is currently Head of Department of Exploration Geophysics at Curtin University of Technology in Perth. Formerly President of ASEG, Branch President ASEG(WA), and Vice President SEG, he is currently a member of ASEG, SEG, EAGE, PESA, AIP, AusIMM, AGU, FESWA and GSA.



Lisa Vella graduated from the University of Sydney in 1991 with a B.Sc (Hons.) in Geophysics. Upon graduating, she worked with Newcrest Mining Limited on a variety of exploration projects, with the majority of her work being for Telfer and Tuckabianna gold mines. In 1994 she joined WMC Resources Ltd. and worked as a Geophysicist for Hill 50 Gold Mine NL, for two and a half years. Recently, Lisa has tranferred into the position of Geophysicist - Africa

Keeva Vozoff, born Minneapolis, 26 January 1928, attended university of Minnesota (Physics), Penn State (Geophysics), MIT (Geophysics). Worked in exploration and mine geophysics (Phelps Dodge Corp '51 - '52, McPhar Geophysics/Nucom Ltd '55 - '57), geophysical R&D (Geoscience Inc. Boston '64 - '69, HarbourDom Consulting '90-present), consulting '69 - '71, taught physics and geophysics (Univ. of Alberta '58 - '64, Macquarie Uni '72 - '94, Uni of Cologne '89 - '95). Presently Director, HarbourDom GmbH and HarbourDom Pty Limited, Consultant, Western Atlas Logging Systems, Adjunct Professor, Curtin Uni. Member SPE, EAEG, AAPG, AGI. Honorary Member ASEG, SEG, AEG (India). Fellow Aust. Acad. Tech. Sci & Engr'g, Humboldt Prize 1993. Interests - transport properties of rocks, monitoring reservoir changes from surface.

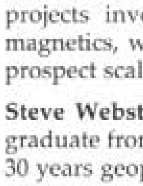
Dr Christopher David Terence Walker. With more than 20 years experience in the geophysical industry Chris Walker is Vice President for Geophysics for PGS Exploration with worldwide responsibility for the geophysical aspects of towed streamer operations. He has a B.Sc. (Honours First Class) in Physics from the New University of Ulster (1972) and a Ph.D. in Marine Geophysics (1977) from the University of Durham. After spending two years in cloistered academia at Bath University in England as a post doctoral fellow Chris came down to earth with a thud when he joined the UK National Coal Board in 1978 where he was responsible for surface seismic data acquisition and processing. From there in late 1980 he moved to Houston, Texas where he was appointed Manager of Special Projects in the GeoSource R&D group and worked on a wide variety of topics including high resolution 2D seismics, VSP acquisition and processing, interactive workstations and marine 3D processing. He joined Geco in 1984 and held a number of positions in different locations around the globe including R& D Manager and Marketing Manager before joining PGS Exploration in 1991 where for a number of years he was the only geophysicist in the company! A member of the SEG, the EAGE and the PESGB Chris has also had keen involvement in the EAME Chapter of the IAGC where he was Chapter Chairman in 1994 and 1995. He has a wide range of technical interests but his primary focus is marine seismic acquisition.

Lie Jun Wang received his B.Tech. degree in geophysics from Guilin Institute of Technology in 1983, and an M.Sc. degree in geophysics from Flinders University of South Australia in 1995. From 1983 to 1992 he was a geophysicist at the Research Institute of Geology for Mineral Resources, Guilin, China, in the area of mineral exploration using TEM, IP and Resistivity soundings. He is currently a Ph.D. student at the Research School of Earth Sciences, Australian National University. His main interests are in the interpretation of EM induction data using new techniques which are being developed, and in the application of EM methods in mineral and oil exploration.

Neil Watson graduated from the University of Sydney in 1990 with a B.Sc(Hons) in Geophysics. The first two years of his professional career were spent with Geoterrex, involved with acquisition and processing of ground geophysical surveys within Australia and overseas. After this he left Australia for an extended working holiday throughout SouthEast and Central Asia before spending a year in London. Forced by a combination of English weather and financial insolvency to return to Australia in late 1994, he joined the NSW Department of Mineral Resources in March 1995, where his focus has been primarily on providing geophysical interpretation for regional mapping projects. Neil is a member of the ASEG.

Mark Weber received his Bachelor of Science degree in Geophysical Engineering from the Colorado School of Mines in 1984. He began his career with EDCON as a geophysicist specialising in marine gravity and magnetic data acquisition and processing for the Gulf of Mexico region. In 1987, Mark joined Barringer Geoservices where he performed acquisition, quality control and interpretation services for airborne and land geophysics surveys throughout the US and Canada. Immediately prior to joining LCT, he was a consultant for mining exploration companies utilising potential fields methods. Mark became the Land Operations Manager for LCT in 1990 and is now the Manager of the Software division. His recent interpretation experiences have included a series of Gulf of Mexico sub-salt exploration projects involving the integrated modelling of gravity, magnetics, well log and seismic data on both regional and prospect scales.

Steve Webster is a B.Sc. (geology) and M.Sc. (geophysics) graduate from the University of Sydney and has in excess of 30 years geophysical experience in industry, university and government service. He commenced employment with World Geoscience Corporation in 1988 as General Manager of Sydney based subsidiary, Austirex International Ltd. Prior to joining WGC he was Principal Geophysicist with the NSW Geological Survey for 9 years. Steve has been involved with the WGC airborne and ground operations in the Sultanate of Oman since 1991.



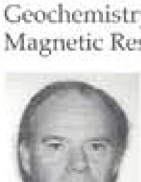
Bob Whiteley graduated from the University of Sydney with a B.Sc. honours degree in geology and geophysics in 1968. He was awarded an M.Sc. degree in geology and geophysics from the same university in 1973 and holds a Ph.D. degree in applied geophysics from the University of New South Wales. From 1968-1971 he worked with the Bureau of Mineral Resources (now AGSO) in Canberra, and with two Australian public mining companies. He taught at the University of New South Wales from 1972-1989 and was seconded by the Australian Government (AIDAB) as Associate Professor in Geotechnical Engineering to the Asian Institute of technology (AIT), Bangkok, from 1984-1986. He has also been involved in international research projects and has consulted in the fields of mineral exploration, geotechnical engineering and environmental and mine development. He is the author of over 50 scientific papers and articles. He is currently Principal Geophysicist with Coffey Partners International Pty Ltd.

Peter Whiting obtained a B.Sc. (Geophysics) in 1983 from the University of Sydney, an M.Sc. (Geophysics) in 1989 from Macquarie University and a Ph.D. (Appl. Mathematics) in 1993 from the University of Sydney. From 1984 to 1993 he held various positions with GSI and HGS in Sydney and Perth. In 1992 he joined Digicon and is currently their Processing Manager of the Brisbane processing centre. He is a member of the SEG and the ASEG and his main interests are exploration seismology, reflection tomography and imaging.

Richard G. Williams received his PhD from Southampton University in 1979. He has worked for Digicon since 1991 as a Research Geophysicist. From 1985 to 1987 he was Research Manager for Digicon's Far East Division and is currently Research and Marketing Manager for Europe, Africa and Middle East division of Digicon.

Alan Willocks is a graduate from LaTrobe University with a B Sc (Honours) in geology in 1975 (the first year of graduates from LaTrobe). After four years of secondary teaching he joined the Geological Survey of Victoria in 1981. Initially, he worked as a geophysicist on groundwater and engineering problems and later potential field interpretation. He worked as a geologist with the Basin Studies group for two years. He has a keen interest in GIS and information management and joined the department's GEDIS project in 1989 undertaking systems design and database modelling. He became Manager Geophysics in 1991 where he is developing the application of modern high resolution airborne geophysical surveying to geological mapping. He is currently coordinating the geophysical component of the VIMP program.

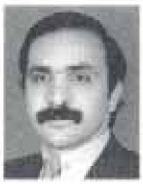
Michael Wilson obtained his Ph.D. at Auckland University, New Zealand in Physical Organic Chemistry in 1974 and spent four years as a lecturer in Chemistry at Canterbury University, Lincoln, New Zealand. He was employed in the Chemical Industry in antibiotic production at May and Bakers (UK) for one year, and has also worked at the United States Geological Survey and in research in solid state NMR at the University of Utah. He has also been in five CSIRO Divisions where he reached the position of Chief Research Scientist. Mick was formerly a senior lecturer and later a Visiting Professor at the University of New South Wales, School of Chemistry and is now Professor of Chemistry at the University of Technology, Sydney. Mick's main interests are in Organic Geochemistry, Applied solid state NMR and fullerene science. He has published a monograph on the applications of NMR in Geochemistry and 240 scientific papers and has a D.Sc. from the University of Auckland (1988). Mick is on the editorial boards of the journals Organic Geochemistry, Energy and Fuels and Solid State Nuclear Magnetic Resonance.



Ken Witherly. Following graduation (BSc from UBC, 1971), he was employed by Utah Construction and Mining as a field geophysicist. During the next 25 years has worked on a variety of projects throughout North and South America, Africa, Europe, Australia and Asia, exploring for copper, iron, coal, gold, zinc, diamonds and uranium in a variety of deposit settings. Appointed Chief Geophysicist in 1995, Ken's professional interests include the application of new technology to exploration geophysics and the use of innovative visualization technology to bridge the gap between geophysics measurement and geology understanding.

Xiaoli Xie received her BSc (1982) and MSc (1986) degrees in Geophysics from Chengdu Institute of Technology, PRC. From 1986 to 1992, she was a lecturer in geophysics at Chengdu Institute of Technology, and conducting also research into geophysical inversion. These researches mainly relate to potential fields, earthquake location and seismic tomography. She completed a Postgraduate Diploma in Geothermal Energy Technology at the University of Auckland, New Zealand in 1993, including a project on seismic tomography. Currently she is enrolled for a PhD degree at CRC AMET, Macquarie University, working in both refraction data processing, electromagnetic data modelling and interpretation of regolith structure. She is a member of the ASEG and the SEG.

Baolin Yang received his BS (1983) in geophysics from University of Petroleum, China. He was at Geophysical Research Institute from 1983 to 1995 as a processing geophysicist, research geophysicist and senior software engineer. He is currently engaged in Ph.D. study in petroleum geophysics at NCPGG. His interests are in geophysical data processing, geological/geophysical interpretation, AVO analysis, and computer application in petroleum exploration. Baolin is a student member of SEG and PESA.



Nabeel Yassi received a BSc. (1974) in Geology-Geophysics and MSc. (1977) in Magnetics from Baghdad University, Iraq. He obtained his PhD (1984) in Exploration Geophysics from the University of Newcastle Upon Tyne, England. During 1978-1992 he lectured in Geophysics at Baghdad University and also consulted on many industrial projects. In 1989 he became Associate Professor in Geophysics. Nabeel's main interests include interpretation of aeromagnetic, magnetic and gravity fields in mineral exploration both at prospect scale and regional basin studies. Currently he is Chief Geophysicist at Desmond FitzGerald and Associates Pty Ltd, Melbourne.

Tony Yeates is a senior regional geologist at AGSO. After graduating with first class honours from UNE in 1970, the next dozen years were spent on geological mapping of basins and provinces. From a geophysical project, gamma-ray spectrometry was developed for Sn exploration, exploiting the Sn-U connection in granites. He then led segments of the industry-supported former BMR Palaeogeographic Maps project. After stints in operational management, marketing and an exchange in the agricultural sector, he returned to AGSO to coordinate "TASGO", an NGMA project in Tasmania.

Jeanne Young received a B.A.Sc. (Hons) from the University of Toronto in 1983. After working for Digicon Geophysical Corporation as a seismic programmer from 1983 to 1984, she received a Ph.D. in geophysics from Macquarie University in 1991. In 1989 she joined the CSIRO Division of Radiophysics to work on a project on the radio imaging method. She is presently a senior research scientist in the CSIRO Division of Telecommunications and Industrial Physics, working on tomographic imaging and image processing. She is a member of the ASEG, the SEG, the EEGS and the EAGE.

Yujin Zhang received a BSc (1983) and an MSc (1989) degree in petrophysics from Daqing Petroleum Institute P. R. China. He taught and did research in petrophysics at the Daqing Petroleum Institute from 1983 to 1994. He then joined the research staff of the Centre for Petroleum Engineering at the University of New South Wales in Sydney, Australia, where he is presently working on his Ph.D. He is the author of several scientific papers.

Bing Zhou received his BSc (1982) and MSc (1989) in geophysics from Chengdu Institute of Technology (CDIT), PRC. From 1990 to 1991, he was engaged in researching into seismological tomography with surface-wave data in Institute of Geology and Geophysics of the Earth's interior, CDIT. In 1992, he was involved in crosshole seismic tomography at Flinders University of South Australia. From 1993 to 1995, he was associate professor in Geophysics at CDIT. In 1994, as a visiting scholar, he joined Seismology group at International Centre of Theoretical Physics, Trieste, Italy and was involved in synthetic modelling for the 3-D lithosphere with multi-mode/multi-structure summation algorithm. Now, he is a candidature of PhD at Flinders University of South Australia. His major interests of research are wave-equation modelling and inversion, seismic and resistivity tomography and surface-wave theory and applications.