Australian
Society of
Exploration
Geophysicists
ACN 008 876 040

Preview

February 1998

Issue No. 72

New South Wales Fires
See page 14

Special Feature:

In This Issue:

Contents

Feature Article

Special Features

Regular Features

HEAD OFFICE:
Suite 14, Portman Place, 220 Boundary Street, Spring Hill Qld 4000
Postal: GPO Box 2179, Brisbane Qld 4001
Tel: 61 7 3832 8607, Fax: 61 7 3832 8245
Email: aseg@enterprisingevents.com.au

PRESIDENT: Mr. Nick Sheard, Tel: (07) 3214 9129
Fax (07) 3214 9122. Email: snsheard@compuserve.com

HON SECRETARY: Mrs. Robyn Scott, Tel: (07) 3307 9663
Fax: (07) 3307 9500. Email: scott.robyn.rl@bhp.com.au

EDITOR: Mr. Henk van Paridon, Tel: (07) 3371 0244
Fax: (07) 3371 0114. Email: henkvanparidon@compuserve.com

ASSOCIATE EDITORS:
Petroleum: Rob Kirk, Tel: (03) 9652 6750 Fax: (03) 9652 6325
Email: kirk.rob.r@bhp.com.au
Position Vacant!
Minerals: Steve Mudge, Tel: (09) 442 8100 Fax: (09) 442 8181
Engineering, Environmental & Groundwater: Geoff Pettifer,
Tel: (03) 5133 9511, Fax: (03) 5133 9579
Email: geoffp@geo-eng.com.au

Print Post Approved - PP3272687 / 0052. PREVIEW is a publication of the Australian Society of Exploration Geophysicists, circulated to a membership of approximately 1350.

Artwork and Printing by Jenkin Buxton Printers Pty Ltd
263 Middleborough Road, Box Hill, Victoria 3128
Contact Kyla Hughes, Tel: (03) 9890 4711, Fax: (03) 9898 9677.

Editor's Desk

Welcome to the first *Preview* for 1998. This will be a big year for the ASEG and it is my intention to make *Preview* reflect that. The key to my success is your input (as always) so please keep up the good work.

In this issue I have showcased the work that geophysical students are doing across Australia and plan to keep the first issue of each year focused on student issues without trying to limit the definition of 'student issues'. I have been helped in my efforts by Natasha Hendrick and you will see more from her in the future.

The front cover picture was previously published in The Australian newspaper in early December courtesy CSIRO. Nowhere in the caption did it mention the word 'geophysics'. Remote sensing could be a good alternative definition of geophysics. It reminded me that we work in an invisible section of our industry. Everyone knows oil and minerals come out of the ground but nothing of the science that discovers it .

My 9 year old son was surprised to learn that I was a scientist. Sure he knows I'm a dab hand on the computer. But doesn't a scientist wear a white coat and flush toxins into the sewerage? Two letters published in this *Preview* examine some of the issues facing our profession at the moment. Lindsay Thomas writes that students are disinclined in general to study science. Bill Langron suggests that we get out tell our neighbours and friends about our science. Des Fitzgerald calls on us to nurture and promote our innovators.

Last year in *Preview* I published some articles and letters that I thought would solicit some response but didn't:

- ASEG library (Koya Suto)
- ASEG prize for students (Ted Lilley letter)
- ASEG tie design (plenty of time before the conference)

Like the constitutional election the lack of response can be used to support every point of view. I think I'll ask Derecke Palmer to write more this year, at least he knows how to provoke a response!

Regards
Henk van Paridon, Editor

PS. Apologies to Scintrex for failing to acknowledge their corporate membership in the last volume of Exploration Geophysics.

President's Piece

The ASEG Executive is currently battling with the "Sub-Committee" syndrome. Various committees have been spawned throughout our existence. Some actually do work but others have just ground to a halt. We are tracking down members and by April we hope to have rekindled the useful one and killed off the remnants.

There has been some response to my comments regarding the SEG and their lack of commitment to "Hard Rockers". Perhaps the most positive was that we get off our collective backsides and show that the basemetal/gold side of the geophysical fence is an important arm of exploration geophysics and contributes handsomely to various economic regions around the globe. The message could be passed on in numerous ways but a good idea put forward was to encourage participation in the 1998 SEG conference i.e. attend or submit a paper to the conference. This conference will be having a strong (in SEG terms) mining emphasis with hard rock papers submitted before March being gladly accepted.

This mining push is really due to the activities of Colin Barnet and Joe Inman who deserve credit for their efforts - good luck.

On home soil the Airborne Electromagnetic Conference sponsored by the CRCAMET and the ASEG is proving to be a great draw card to overseas geophysicists. Obviously, due to the quality of technical information and not the venue. The post conference Radiometric Workshop (again sponsored by ASEG) is also proving popular. The technical aspects from these events will be made widely available to all ASEG through geophysics and "*Preview*".

On a different housekeeping pack, I would like to remind (Queensland in particular) members that the Federal Executive is due for re-election in April and new blood is being sought - any nominations?

S.N. (Nick) Sheard, ASEG President

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

NOTICE OF GENERAL MEETING

A General Meeting will be held In Brisbane on April 7 1998 for the purposes of electing the Executive Officers for the forthcoming year.

Anyone wishing to make a nomination should contact Robyn Scott, the Hon Secretary.

Venue will be Oxley's restaurant commencing 6:00 PM.

Executive Brief

This year we welcome Natasha Hendricks to the Federal Executive Committee. Natasha is currently studying at the University of Queensland and will fulfil a new role of Student Liaison officer on the committee.In addition she will assist Henk with *Preview* where she has already made a significant contribution including crossword generation.

Some of our goals for this year are to implement the new Corporate membership levels and substantially boost funding to the ASEG Research Foundation, produce Federal and State budgets, investigate the merits of a National PCO, further develop the Web Page and get involved in the Gamma Ray workshop, Airborne EM Conference and our Hobart ASEG Conference.

By now you will all have received a letter outlining the new Corporate membership levels. I hope some companies have been inspired to join the Corporate Member category which offers several benefits such as discounted advertising in *Preview* and *Exploration Geophysics*, a hot link from ASEG Web Page, listing in the 1998 membership booklet "yellow pages" and most importantly, for the Society, a tax-deductible $2000 donation to the ASEG Research Foundation. The purpose of this new structure is to provide a stable and increased donation to the ASEG Research Foundation. At this stage we are aiming to commit $80,000 per year to the Research Foundation through Corporate Memberships, donations from the SEG and an increased sustainable donation from the ASEG Federal funds. That figure will be finalised when our 1998 budget is completed. If you want more information on corporate memberships, contact the Secretariat.

It occurred to us at our last meeting that we were somewhat out of touch with all the Sub-committees lurking in the ASEG. We are now making an effort to update ourselves with each committee's status and these will be reported in the next edition of *Preview*.

The November Hobart Conference planning is going well. Western Geophysical again has come forward as the winning Principal Sponsor and we gratefully acknowledge their long standing support of ASEG. Silicon Graphics, UTS, Geosoft and Digicon have taken up the four Major Sponsorships packages.

As at 20th November, 1997 the Financial Status of the society was as follows:

Cheque account (0080 0044) balance	$85,613
Cash management account (0079 1483) balance	$77,481
Term deposit (CBA commercial bill)	$158,000
Cash management (Sands 0079 1475) balance	$10,804
Term deposit (Sands 4008 4219) balance	$40,000
Net cash:	~$371,898

Robyn Scott
Honorary Secretary

Society Briefs

This column is intended for news from Society members that will be of interest to others. Topics can be about personal, kindred society or company information. It will also act as a Stop Press. Please send in your briefs!

Ed

The Society of Exploration Geophysicists of Japan (SEGJ) has announced a call for papers for their International Symposium on Fracture Imaging. The ASEG and SEG are co-sponsors of this event. John McDonald is the Australian contact for the conference and he has initiated a search for invited speakers. Please look in the Calendar of Events for more details.

Jim Dirstein has become President of the WA Branch. The WA branch are always the pacesetters in the appointing of a new executive. This year State Branches will need to get their act together before April if they want to have their details published in membership handbook.

Shanti Rajagopalan has joined Flagstaff Geoconsultants in Melbourne.

Nick Fitzgerald has left Santos and moved to Woodside in Perth.

Authors wanted for Science Magazine. Australasian Science has been merged with the journal Search and will be published monthly. Potential authors are sought to submit feature articles on new Australian scientific research.

Contact the editor, Guy Nolch, 03 9848 9041 or mobile 0411 235 771.

Lynn Hastie and Joe Williams, long time ASEG contributors, have sadly passed away recently. Obituaries will appear in the next issue.

Exploration Geophysics will be published in three parts this year. The first issue Vol. 29/1 will be a 'normal' edition and is expected to be published around April/May. Vol. 29/2 will be the special AEM edition where papers from the AEM conference will be published. Brian Spies will assist in the editing of this edition. Publication is expected around July/August. The Conference Edition will be published as a double edition Vol. 29/3-4. As always this will be on time and will be distributed at the conference.

Debbie May has resigned from Jenkin Buxton and will take up a new life as a missionary in Fiji from February. Her replacement Kyla Hughes will be introduced in the next issue. Meanwhile we wish her well.

Preview Deadlines – 1998

April	**March 15**
June	**May 15**
August	**July 15**

Calendar Clips

1998

March 8-11
APPEA Convention, Canberra

Mar 23-25
International Conference on Coal Seam Gas & Oil, Brisbane

April 30
First call for papers SEGJ Fracture Imaging Symposium

Jun 20-26
SEGJ/SEG Beijing. Beijing 98 Conference and Exhibition

July 21-24
Western Pacific Geophysics Meeting, Taipei

August
West Australian Basins Symposium, Perth

Sept 13-18
SEG Conference, New Orleans

October 28-30
Gas Habitats of SE Asia &Australasia, Jakarta

November 8-12
Australian Society of Exploration Geophysicists 13th International Conference and Exhibition. Hobart, Tasmania Australia

Dec 10-12
SEGJ/SEG/ASEG 4th Int Symposium Fracture Imaging, Tokyo

Details and more events on Page 46.

ASEG Branch News

Queensland

Contact details:

President: Gary Fallon
Phone: (07) 3214 9170
Fax: (07) 3214 9111
Email: gnfallon@mim.com.au

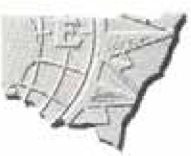
Secretary: Andrew Davids
Phone: (07) 3858 0659
Fax: (07) 3369 7840
Email: Andrew.Davids@oca.boral.com.au

Recent highlights for the local Branch have been the Christmas party at Walkabout Creek restaurant, and a technical meeting in December. Thanks to Howard Bassingthwaite for organising yet another successful Christmas party. It was good to see a number of new faces attending the party. As usual, the night was well supported by industrial sponsorship. On behalf of the local Branch I would like to thank Schlumberger (Geco-Prakla), Seismic Supply, Oil Company of Australia, Velseis, Velseis Processing, Auslog and Digicon for supporting the Christmas party and other events during the year.

The December technical meeting was a presentation from a delegation of visiting Chinese geoscientists. The Coal-seam Methane topic was particularly relevant to the Queensland gas exploration and production industry. Despite language difficulties and the need for an interpreter, an interesting presentation was given on coalseam gas exploitation in China.

Andrew Davids
Branch Secretary

New South Wales



Contact details:

President: Timothy Pippett
Phone: (02) 9522 3133
Fax: (02) 9544 9335
Email: tpippett@mail.com

Secretary: Dave Robson
Phone: (02) 9901 8342
Fax: (02) 9901 8777
Email: robsond@nswgs.nsw.gov.au

The NSW branch wound up the year with a very interesting talk by Keeva Vozoff on the use of LOTEM for mapping coal seams.

In 1998, the NSW branch will be continuing to hold meetings on the third Wednesday of each month (except January) and we will be starting the year off with the February meeting that will include a short AGM and election of office bearers for the next 12 months. Dr Brian Spies will address this meeting on the topic of "The Current Status and Future Direction of the CRC-AMET". He will also give an overview of the Airborne EM Workshop which has had over 250 registrations.

Derecke Palmer has been spending time on geophysical activities for high school students and is encouraging members to support this cause as there is a real need to generate a up-and coming generation of geophysicists to replace those that have moved on. If you can assist Derecke, please give him a call on (02) 9385 4275 or email on d.palmer@unsw.edu.au.

On a personal note, I have moved on to 'bigger and better things' and am now a consultant with Alpha Geoscience Pty. Limited, involved in environ mental and engineering applications for geophysics. Please note the change in contact details.

Timothy Pippett
NSW Branch President

ACT

Contact details:

Hon. Secretary: Tim Mackey
Phone: (02) 6249 9813
Fax: (02) 6249 9986
Email: tmackey@agso.gov.au

President: Kevin Wake-Dyster
Phone: (02) 6249 9401
Fax: (02) 6249 9972
Email: kwakedys@agso.gov.au

On 16 December the ACT branch held its Christmas party BBQ. The event was very successful, with about 40 people attending. Everyone enjoyed the fine weather and festivities as we celebrated the end of another year. We are all looking forward to a great year in 1998.

Tim Mackey
Hon. Secretary
ACT Branch ASEG

Western Australia

Contact details:

President: Jim Dirstein
Phone: (08) 9382 4307
Fax: (08) 9382 4308
Email: dirstein@iinet.au

Secretary: Terry Crabb
(Australian Geophysical Surveys)
Phone: (08) 9414 1266
Fax: (08) 9414 1277
Email: crabb@austsurv.com.au

VicePresident: John McDonald (08) 9266 7194 / Fax: (08) 9266 3407
Treasurer: Bob Groves (08) 9370 1273 / Fax: (08) 9370 1273

On November 25 a very successful ASEG Short Course was held with 78 attendees appreciating Brian Russell's presentation on "Reservoir parameter estimation using 3D seismic multiattribute analysis". In fact the course was oversubscribed with a number of disappointed geophysicists being sent refunds.

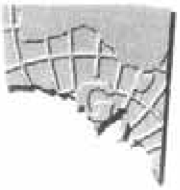
Our Branch AGM was held on December 10 with the following committee members being elected: **Mike Benefiel, Sam Bullock, Graham Elliott, Tony Endres, Nick Fitzgerald, David Howard, Greg Street, Mark Russell, John Watt**.

Markku Peltoniemi visiting Perth on February 18 gave a pre-Sydney AEM Workshop presentation of his poster – "Depth penetration of frequency-domain airborne electromagnetics".

Kim Frankcombe and Mike Sayers Chairmen of the Perth 2000 Conference, have established a committee consisting of John McDonald (Treasurer), Mike Dentith (Editor, Social Program), Mark Russell (Exhibitions), Peter Williams (Technical Papers, Nick Hoskins and Wendy Symonds (Sponsorship), Norm Uren (Student Coordinator), Andy Padman (Workshops), Mike McLerie (Publicity) and Don Pierce of PROMACO is the Professional Conference Organiser (tel (08) 9332 2900/Fax: (08) 9332 2911).

The Conference theme is *"Exploration Beyond 2000"* and it is scheduled for March 2000 in the Burswood Super Dome. Exciting exhibition possibilities exist to take advantage of this huge (high) venue.

South Australia



Contact details:

President: Mark Taylor
(Boral Energy Resources Ltd)
Phone: (08) 8235 3827
Fax: (08) 8223 1851
Email: met@sagres.com.au

Secretary: Andrew Shearer
Phone: (08) 8274 7730 Fax: (08) 8373 3269
Email: ashearer@msgate.mesa.sa.gov.au.

The SA Branch hopes that everyone had a great holiday. Nothing like Christmas in summer.

Our November general meeting consisted of our Annual Student Night, and was both entertaining and interesting. Five local honours students presented short talks on their research topics for the year. The first speaker was Scott Reynolds of the University of Adelaide, whose talk was titled "A Gravity and Aeromagnetic Investigation of Sub-surface Granitoids in the Pine Creek Gesosyncline." The next speaker was Adrian Purdy of the National Centre for Petroleum Geology and Geophysics (NCPGG), whose talk was titled "Factors Impacting the Variation in Phase of the Top Coarse Clastucs Seismic Pick, Central Fields Region, Gippsland Basin". The third speaker was Tom Kivior of the NCPGG, whose talk was titled "Structure and Petroleum Potential of the Eastern Margin of Tasmania". The fourth speaker was Matt Densley of the University of Adelaide, whose talk was titled "The Use of Interval Velocities for Determining Uplift and Depth Conversion in the Northern Carnarvon Basin". The final speaker was Iestyn Broomfield of the University of South Australia, whose talk was titled "Petroleum Potential of the Moorowie Sub-basin". The judging committee conferred for quite some time as the overall level of the presentations was quite good. They finally decided that Adrian Purdy should be receive the award for Best Presentation, and Matt Densley should receive the the award for Best Paper. Congratulations to both of them for their excellent work, and many thanks to all of the speakers for their fine presentations.

Our Christmas Party was held at Mark Taylor's house on the 10th of December, and while not as many attended as have in the past, the food was excellent, and the company lively. An excellent evening was had by all who did make it.

Our next meeting is our AGM, scheduled for mid-February. Everyone will be receiving information on the date and venue in the near future.

Also this month we continue to keep you posted on who is moving around the industry (especially in the Adelaide area). In no particular order: Nick Fitzgerald left SANTOS in Adelaide to work with Woodside Petroleum. Mike Szczepaniak also left SANTOS in Adelaide to work with Woodside. Mark Taylor will be moving from Boral Energy to CGG in Paris, France for a two year stint there. Mark has been involved with the local ASEG for many, many years, and has been president for the last two. He (and his family) will be sorely missed when they leave.

Michael Hatch
Branch Preview Scribe

Victoria

Contact details:

President: Shanti Rajagopalan
c/o Flagstaff Geo-Consultants
Phone: (03) 9421 1000
Fax: (03) 9421 1099
Email: (new address)

Secretary: Dave Boothroyd
Phone: (03) 9412 5685 Fax: (03) 9412 7803
Email: boothroydd@wizza.agvic.gov.au

The Victorian Branch's Christmas party was held at Craig and Helen Dempsey's home in Balwyn. Many thanks must go to Craig and Helen and their three children for kindly allowing us to use their house and garden for our Christmas celebrations. Thanks also to the committee members who organised drinks and catering.

The Victorian Branch committee held a well attended lunchtime meeting at The Phantom India Restaurant in Carlton. We came up with many ideas to get the year off to a good start. Among them was using the opportunity that AEM '98 presents to get some international and interstate speakers to Victoria. We will also be organising an "industry night" which will be a forum for the Victorian geophysics community to showcase itself. We expect good attendance from exploration and mining companies, contractors, government and the universities. We are also be on the lookout for any visiting geophysicists who may be able to present to the local branch meeting. So if you are expecting a visitor, who may be prepared to give a presentation, please contact Shanti Rajagopalan (now at Flagstaff Geo-Consultants).

Suzanne Haydon
Geophysicist
Geological Survey of Victoria
3/115 Victoria Parade, FITZROY, 3056
ph: (03) 9412 7843 fax: (03) 9412 7803

The 1997/1998 Victorian ASEG Committee are:

President:	Shanti Rajagopalan	(03) 9421 1000
Vice-President:	Geoff Pettifer	(03) 5133 9511
Secretary:	Dave Boothroyd	(03) 9412 5685
Treasurer:	Dave Gamble	(03) 9684 4925
Committee:	Geoff Dunn	(03) 9478 3415
	Mark Dransfield	(03) 9230 1261
	Suzanne Haydon	(03) 9412 7843
	Ciaran Lavin	(03) 9412 5676
	Trevor Lobo	(03) 9799 2192
	Paul McDonald	(03) 9412 7866
	Ron Palmer	(03) 9863 5208

Industry Brief

MAPLE V RELEASE 5: A POWERFUL PROBLEM SOLVING TOOL FOR TECHNICAL PROFESSIONALS

CEANET is pleased to announce the release of Maple V Release 5, the latest edition of the world's most powerful technical computing environment.

Maple V Release 5 has continued the evolution of a technical computing environment that will allow users to learn one interface but interact with a large number of commercially available packages.

Exciting new features of Maple V Release 5 include:

- MATLAB link: users can now execute their favourite MATLAB commands from inside Maple V
- Spreadsheet Functionality: create spreadsheets within Maple V; environment is designed to be familiar to Excel (TM) users
- Export to HTML: using Maple V Release 5 users can create HTML pages that include mathematical expressions and graphics
- Enhanced graphical user interface: Maple V is designed as a worksheet-based environment, the most efficient way to perform complex computations

These and many more features enhance the ease-of-use and flexibility of Maple V.

For more information please contact:
Ken Dunstan, Product Manager at CEANET
info@ceanet.com.au, freecall 1-800-628-320

Sneak Preview

1998 will be a big year!

- *Round up of forthcoming AEM Workshop and Radiometrics Workshop.*
- *4D Seismic.*
- *More stories from the 'Leading Edge'.*
- *Membership handbook.*
- *Corporate Member Listing.*

Electromagnetic Compatability Regulations

Electromagnetic Compatibility regulations of the European Commission – problems in sight?

Markku Peltoniemi, Helsinki University of Technology, Espoo, Finland
Peter Fenning, Earth Science Systems Ltd, Herts, England
Peter Annan, Sensors & Software Inc., Mississauga, Canada

In May 1989 the European Economic Community EEC accepted the directive 89/336/EEC which relates to electromagnetic compatibility (EMC). The directive is applied to all electrical and electronic devices which cause electromagnetic disturbance or the performance of which is affected by such disturbance. The main objective of the EMC directive is to guarantee the free movement of such devices and to create an acceptable electromagnetic environment in the EEA (European Economic Area) territory. The directive does not impose any lower or upper limits as regards power output or frequency range.

Another relevant directive, the low voltage directive 73/23/EEC (LVD) accepted already in 1973, became into full force from the beginning of 1997. This directive covers the safety of electrical equipment which operates in the ranges of 50-1000 VAC and 75-1500 VDC.

There was a transition time until the end of year 1995 for the EMC directive to take into force. After that, the directive overrule any national legislation or regulation of this issue in all EEA member states. Since then, all devices except those specifically exempted from this requirement should meet them and should bear a "CE" product marking as a sign of approval and compliance. Since January 1st 1997, the same is true for the LVD directive. Non-compliance with the EMC/LVD directives is in all EEA states a legal offense attracting heavy financial penalties.

The fundamental problem of the EMC and LVD directives for the geophysical industry lies in the fact that all geophysical instruments for EM and electrical exploration transmit EM fields, and these fields are normally the more advantageous from the surveying point of view the stronger they are. The next major problem in trying to get an overview of the directives and related standards is volume and complexity of the documentation. Other industries which are in a similar situation (medical, telecommunications, broadcasting) have managed to negotiate exceptions to the directives by having their own specific standards.

The directives are brought into practice through various standards, formulated by the European Committee for Electrotechnical Standardization (CELENEC), the European Telecommunications Standards Institute and the European Committee for Standardization. National standards have now been overruled by these standards. At least the EN-55011 EMC standard is relevant to geophysical industry; there are also others.

Only a very limited number of geophysical instruments have got the CE marking so far, and for many types of instruments it seems to be virtually impossible to reach under the current standards. Because of the general concern for the whole geophysical industry, bodies like ASEG, EAGE, EEGS, IAGC and SEG in cooperation might make a suitable forum to coordinate efforts in this matter.

While the focus of the discussion here is Europe, similar standards exist in most countries. To date, the geophysical community has been immune primarily because geophysical practice is usually in remote areas causing no detectable interference. Since regulatory agencies usually spring into action when detectable infractions occur or regulation changes result in close scrutiny of devices (as in the EEC), the geophysical community has been fortunate not to be facing this issue earlier. With the debate now in full swing in Europe, the international geophysical community should work together to see that a sensible standard is established in Europe and that this standard becomes globally acceptable. Geophysical instruments do not recognize political boundaries and most of us in the geophysical community depend on being able to conduct surveys with our instruments of choice in any area of the world. If a patchwork of variable standards comes into force, we will all face tremendous logistical difficulties.

The best case for geophysical industry would be if we could show that geophysical instrumentation does indeed fall into the exempts category of the existing directives and standards. If that is not possible, then the recommendation so far has been to get a new geophysical standard through the EC CELENEC body.

The first meeting of the industry representatives to discuss this problem was held during the EAGE meeting in Amsterdam in June 1996. Since then, brief meetings have been held in the Geneva 1997 EAGE Meeting and in the Arhus 1997 EEGS ES Meeting. If you are interested in getting or submitting more information about the EMC / LVD issue and would like to join the efforts to get it solved for the geophysical community, please contact

Peter Fenning (EMC WG Chairman)
Earth Science Systems Ltd
Unit 1, Kimpton Enterprise Park
Claggy Road, Kimpton, Herts
England SG4 8HP
Fax: Intl+44-1438-833 541
Email: Peter Fenning <ESS_Ltd@compuserve.com>

Professor Vittorio Iliceto
Dept of Geology & Geophysics
University of Padova
Via Rudena 3, 35123 Padova
Italy
Fax: Intl+39-49-871 3422
Email:Vittorio Iliceto <iliceto@epidote.dmp.unipd.it>

A more detailed description of EMC/LVD problems is given in a review submitted to First Break, scheduled into the February 1998 issue. The full text of the review is already available at the EAGE www site, URL address <http://www.accu.nl/eage/EMC/>.

On Better Communication of Geophysics to Geologists

In my opinion, we Geophysicists do not communicate our exploration geophysical information to the geological fraternity very well, at least not in hard-rock geophysics. (I am inclined to think this is done better in soft-rock geophysics with, for example, adequate use of geological interpretations of seismic sections.) Firstly, we should remember that we are all explorationists or geoscientists together and it does not help to foster a distinction. Many geologists realise that they need to have some geophysical knowledge and some of them are quite well versed in geophysics. Indeed with increased proficiency in the use of personal computers, many geologists request airborne geophysical grids only and make their own images. Therefore it is incorrect to assume that all geologists will know nothing about geophysics or will not be able to understand any of it.

The following are some suggested **Do's and Don'ts** when communicating to geologists. If you have some others or any other comments on this topic please "communicate" them to the Editor.

1. We **should not** sound like we are putting geologists down. For example, I have actually heard in presentations, "This slide is for the geophysicists in the audience only; or worse still, "The geologists in the audience won't understand this".

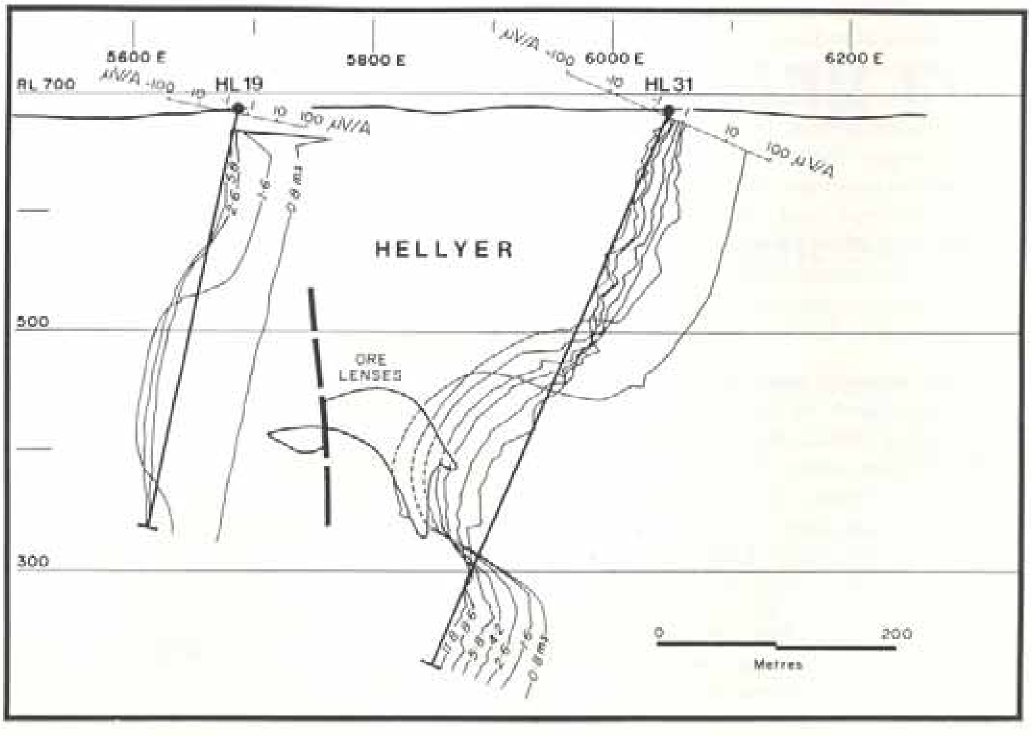
2. We **should** encourage geologists to be interested in geophysics and we should expose them to it in as understandable a way as possible. Ways of synthesising a number of methods could be suggested. For example, if the many different electrical and electromagnetic methods are confusing, they can be explained as all being in an electromagnetic spectrum from zero frequency (dc current) to the very high frequencies at the radar end.

3. We **should not** be deliberately obscure with our presentations. We should explain 'reduction to the pole', 'analytic signal', '1VD' and other such jargon and why such processes are useful. For example, '1VD' is a way of emphasising gradients which in turn reveal the boundaries between different physical characteristics. Some of the terms that we use every day may sound very strange to the uninitiated. One, for example, is 'time constant' in transient electro magnetics - a geologist could well ask why time is standing still.

1. We **should** use illustrations that are as much like geological sections as possible. For example, drill hole data could be shown with the depth increasing downwards, rather than as is often the case with the depth increasing across the page horizontally. Better still, the results should be shown on a section in the actual drill hole configuration (see an example below taken from the front page of Exploration Geophysics, V18, No.3). Radar sections should be migrated to reveal true shapes of target cross-sections (circles not parabolas). Pseudo-sections should be explained as being not true depths.

2. We **should** relate our geophysical results to geology as much as possible. Magnetics and radiometric images can be shown as overlays on geological maps and it can also be good to show geophysical data draped over topography. False anomalies arising from the manner of plotting, such as the "pants-leg" anomaly in Induced Polarisation, should be explained or preferably avoided. (I understand there is at last, a method for migrating I.P. anomalies into the correct positions).

Roger Henderson



ANSIR – What Does it Mean for Australia?

Prepared for the International Association of Geophysical Contractors, by Barry J DRUMMOND1, September, 1997

"I learned from my own early days in research that if one lacks adequate equipment - eg., an ultracentrifuge or facilities for radioactive labelling and counting - then some internal censorship of unknown circuitry prevents one having ideas of the kind that could only be evaluated by means of such equipment. Money can't buy ideas, that's for sure, but lack of it can prevent one having them."

Sir Peter Medawar, "The cost benefit analysis of pure research", in The Threat and the Glory: Reflections on Science and Scientists, Oxford University Press, 1990, p220.

AGSO and the Australian National University recently signed agreements with the Commonwealth Department of Industry, Science & Tourism (DIST) to set up a Major National Research Facility (MNRF) in seismic imaging. Called the Australian National Seismic Imaging Resource (ANSIR), the facility will create a centre of excellence capable of pursuing world class research and education in the field of seismic imaging. The establishment of this MNRF marks a milestone in Australian science as the Earth sciences join other scientific disciplines in having access to major domestic research infrastructure.

The need

Australia generates the majority of its external earnings through mineral and energy products extracted from the ground and agricultural produce grown in the ground. Our primary producers are efficient and work in mostly deregulated world markets. We have a cosmopolitan population most of whom live in modern cities, but our rural communities are facing increasing pressure from the effects of drought and the drift of younger people to the cities.

- Australia's export earnings from mining and related services was $36 billion in 1996/97, amounting to 36% of our exports, but produced by only 1.1% of the work force. Our mineral and energy producers are world competitive, and we need them to remain so, because for every 100 jobs created in the industry, 1133 jobs are created elsewhere in the community.
- Land degradation, even when caused by natural processes, creates an opportunity for our trade competitors to impose non-tariff barriers to our farm products. Dry land salinity affects not only our farmers' international competitiveness and productivity but also breaks down the capital infrastructure supporting our rural communities. Salt damage alone to roads and bridges in the Murray Basin costs local councils and commun-ities $7.9 million annually. Billions of dollars in building permits along the eastern seaboard are affected by concerns that the ground water could be acidic.
- Many of our major population centres have a finite risk from earthquakes. The Newcastle earthquake in 1989 caused loss of life and $1.5 billion in damage.

While the solutions to these issues require both technological and social approaches, they all have something in common: they all require sound geo-scientific information focussing on the subsurface.

The new ANSIR facility will help address a long recognised need for Australian researchers to have access to state-of-the-art geophysical equipment. The need was highlighted in the Australian Geoscience Council report *'Towards 2005: A prospectus for research and research training in the Australian Earth sciences'* (National Board of Employment, Education and Training, AGPS, 1992). It stressed the importance of modern instrumentation and facilities for research in the Earth sciences, and the importance of cross-fertilisation of research programs involving shared access to major instrumental facilities. In recent years the Australian Research Council has given geophysics research and education a high priority for funding support, with limited success.

The scientific program

Scientific and educational programs that arise because of these research needs will build on existing strengths.

- The short term scientific program will have a focus on providing pre-competitive information aimed at helping our mineral and energy sectors. Studies of the framework of the continent leading to predictive models of its evolution and contained mineral and energy systems will be a major component of the research. Such studies will use the traditional tool of deep reflection profiling, but will incorporate more 2D and 3D tomography studies probing to great depths. These studies will use vibratory, explosive and earthquake energy sources.
- The facility will contribute to an understanding of the systems which control the movement of ground water through palaeoenvironments. High resolution reflection profiling will play the major role in the short term.
- Hazard mitigation will be addressed through providing knowledge of ground stability as input to local building codes.
- Experience overseas has shown that carefully targeted research in seismic imaging can provide the 'glue' to unite many of the Earth science disciplines into true multidisciplinary 'big' science, leading to enhanced research opportunities and stronger teaching of geophysics.

What is the ANSIR?

The key to the success of all of this research is access to appropriate research infrastructure. DIST will provide $5 million to equip the facility. AGSO will provide an additional $415,000. The new equipment will include:

- a state-of-the-art seismic reflection recording system suitable for mounting large scale regional transects: these would support studies into the structure and evolution of Australia's geological provinces;
- a small scale high resolution seismic reflection recording system suitable for mine-scale, environmental and ground water research;

- stand-alone short period and broad band data loggers; this equipment will have the capability of recording energy from vibratory sources, explosions, and earthquakes, and will be used for a range of local and regional tomography studies;
- large vibratory P-wave energy sources for use in regional studies; and
- a small high frequency vibrator that can produce both P-wave and S-wave energy for environ-mental, ground water and hazard studies.
- AGSO will maintain its current capabilities for drilling shot holes for explosive sources.

The intention will be that once the facility is established it will be capable of imaging the Earth at a range of scales, and the variety of research that can be undertaken will be limited not by a lack of access to infrastructure but only by the imagination of our researchers.

How will it work?

AGSO will operate the reflection recording equipment, and ANU will maintain the pool of data loggers. ANSIR will accept proposals from researchers in other Australian and overseas institutions. Research that builds collaborative links between Australian government, university and industry researchers and those overseas is critical for the success of the facility.

The facility will have a Management Board with an independent Chairman, and representatives from the mining and energy industries, universities and the Cooperative Research Centres Program. Research proposals will be vetted by an independent Access Committee to ensure that those of the highest merit are accepted - merit is the only criterion for determining priority for access to the facility.

Benefits

Benefits which flow directly to the mining and energy sectors include:

- pre-competitive information on Australia's geological framework and its mineral and energy resources;
- a strong domestic research base, with research focussed on issues particularly relevant to Australian problems and conditions;
- access to graduates trained in the latest techniques with modern equipment;
- a healthy mining and energy sector, guaranteeing the exploration industry a long term future; and
- an Australian community served by a strong research and education base in one of its most important industries.

Current activities

Current priorities for the facility include getting the management infrastructure in place to oversee the purchase and construction of the equipment, and, in parallel, developing a forward research and educational program that is both broadly based and focused on the needs of the education and industry stake holders. The equipment is expected to be ready for commissioning in 1998.

Research programs that have started or are in planning include studies of mineral systems in Broken Hill, central New South Wales, Victoria and Western Australia and tomography studies to mitigate earthquake hazards in Papua New Guinea.

For more information, contact Dr Barry Drummond, facility Director at AGSO (tel. +61 6 249 9381 or e-mail drummond@agso.gov.au), Prof. Brian Kennett, facility Deputy Director at the ANU Research School of Earth Sciences (tel. +61 6 249 4621 or e-mail Brian.Kennett@anu.edu.au).

Geophysicist appointed to the Mawson Chair at the University of Adelaide

Stewart Greenhalgh, who is currently Professor of Geophysics and Head of the School of Earth Sciences at Flinders University, has accepted the offer of appointment to the Mawson Chair at the University of Adelaide. He commenced his new position in mid-November 1997.

The Mawson Chair is a prestigious one, named in honour of the famous Antartic explorer, Sir Douglas Mawson, FRS, who was Professor of Geology and Mineralogy at the University of Adelaide from 1921-1952. Sir Douglas was educated at the University of Sydney , with degrees in both engineering and science. He studied under the father of Australian geology, Sir Edgeworth David, accompanying him on Sir Ernest Shackelton's Antartic Expedition of 1907. Mawson's notable achievements during this expedition were the finding and marking of the South Magnetic Pole (a geophysical triumph !) and surviving the longest unsupported man-hauling sledge journey on record - 1260 miles, 122 days. He led later expeditions to the Antarctic in 1911 and 1929/31. Sir Douglas Mawson is also remembered for his major contributions to the field of geology.

Stewart received a B.Sc. (Hons I) degree in geophysics/applied mathematics from the University of Sydney in 1972. Subsequently he worked as a geophysicist for the Department of Mines, N.S.W. and the Department of Main Roads,N.S.W. He received his M.Sc. degree in geophysics from Sydney University in 1976 and his Ph.D. in geophysics/mathematics from the University of Minnesota in 1979 (as a Fulbright Fellow). In 1997 he was awarded the D.Sc. degree from the University of Sydney for his published works in geophysics.

From 1979 to 1981 Stewart was a postdoctoral fellow in seismic imaging at the Earth Resources Foundation, University of Sydney. Since then he has been at The Flinders University of South Australia, except for sabbaticals at Oxford university,U.K., and the University of Minnesota,U.S.A. He rose through the ranks of Lecturer, Senior Lecturer, Reader to become Professor (Personal Chair) in 1993.

In the geophysical industry, Stewart has been a consultant for a number of mining and petroleum companies, geophysical service companies and government agencies. His experience in applied geophysics covers engineering, marine, coal, petroleum, mining and groundwater applications. He has also worked in earthquake seismology and crustal geophysics. Professor Greenhalgh has published over 120 refereed journal articles/book chapters in theoretical and experimental geophysics. He has also been the author of 50 conference presentations and 100 technical (consulting) reports. He is a member of ASEG, SEG, EAEG, AGU and SSA.

His contact details are:
Stewart Greenhalgh,
University of Adelaide,
Department of Geophysics,
Adelaide SA 5005.
Tel (08) 8303 4960 Fax (08) 8303 4347

ASEG RF – Donations

ASEG RESEARCH FOUNDATION

Post to: Treasurer, ASEG Research Foundation
Peter Priest, Ste 3, 17 Hackney Rd,
Hackney SA 5069

NAME: ....

....

COMPANY: ....

....

ADDRESS: (for receipt purposes)

....

....

....

AMOUNT OF DONATION: $ ....

Do not detach – To be completed by ASEG Research Foundation

ASEG RESEARCH FOUNDATION

Receipt of donation

Received from ....

....

The Sum of ....

....

dollars being a donation to the ASEG RESEARCH FOUNDATION

$ ....

In accordance with Income Tax Assessment Act S73A, this donation to the ASEG Research Foundation is tax deductible.

Signed: ....

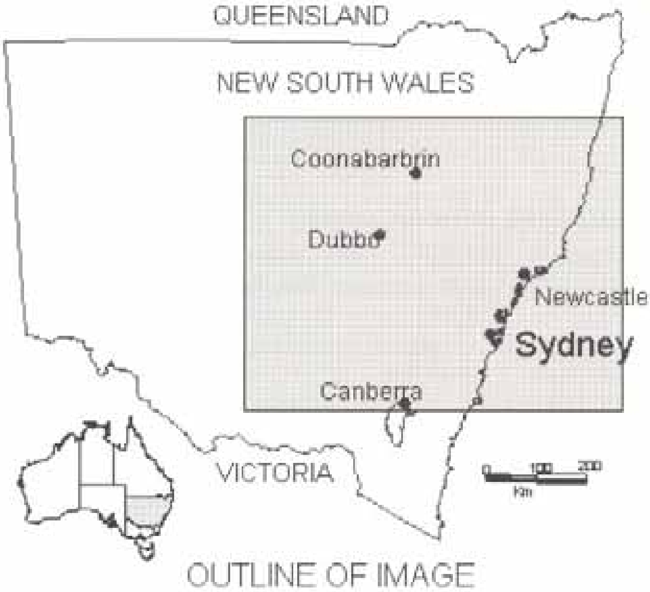
(This form should be retained for tax purposes)

New South Wales Fires

Images of NSW bush fires were shown on the front page of "The Australian " newspaper on December 3, 1997 and caught the attention of your editor. One because they were dramatic and two because they were published with virtually no information about them. Hope this helps those who were curious like me. Ed

The images shown are from NOAA# AVHRR* data received and processed by the CSIRO Marine Research Remote Sensing Facility, Hobart.

(http://www.marine.csiro.au/~lband)



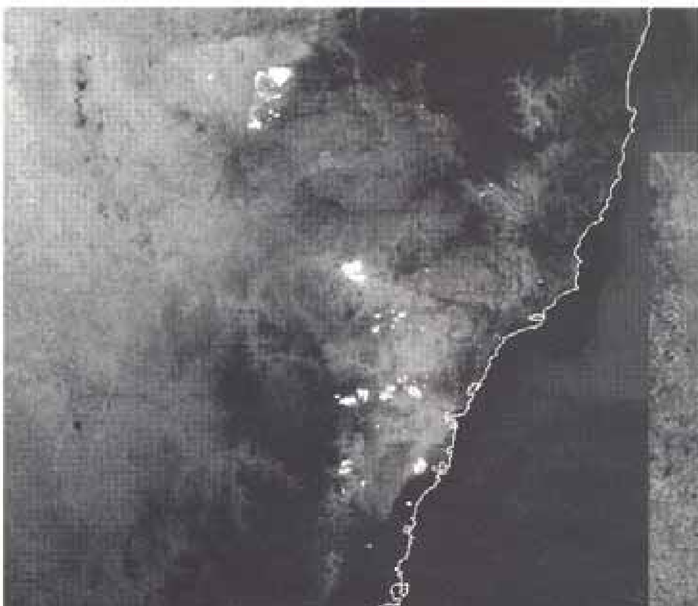
The application of multiple polar-orbiting NOAA satellites enable earth observers numerous views of a region within a short time-frame. This makes them ideal for monitoring large and dynamic events such as floods, cyclones, dust-storms and bushfires. These images of the NSW region for December 2nd 1997 were made from data received within a four hour period from the NOAA14 and NOAA12 satellites. The NOAA14 scene was taken at 0455 GMT or 1555 AEST and contains visible information from the AVHRR channel 1 sensor. Here the very bright pixels describe the smoke plumes which indicate the very strong westerly winds at the time. The NOAA12 scene was taken at 0835 GMT or 1935 AEST and contains thermal information from the AVHRR channel 3 sensor. Here the very bright pixels show the actual fire fronts. Please note each pixel is ~ 1.1 Km square.

NOAA data is a 1.1 km ground resolution dataset that is predominantly used for regional land use and management, for example drought monitoring, vegetation vigour and fire mapping. A major benefit of NOAA data to these applications is the frequent visit time.

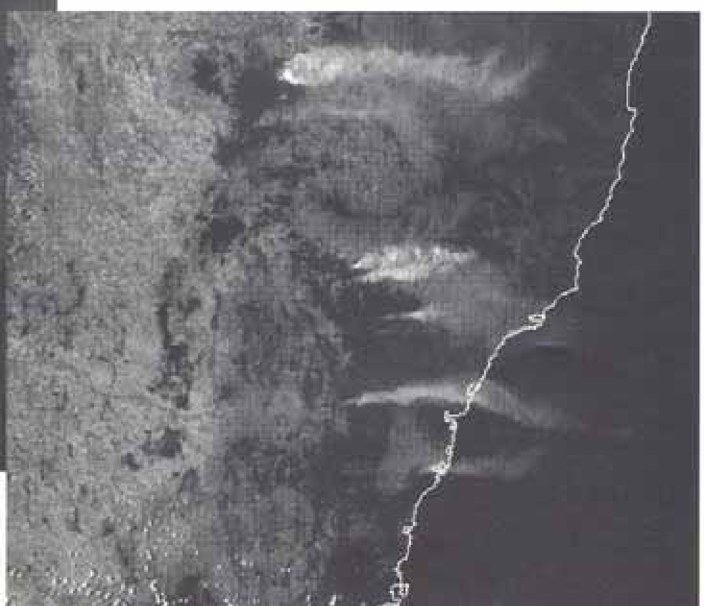
For geoscience applications, recent captures and frequent visit times are usually of less importance . NOAA data is suitable for regional ground cover assessment or for palaeochannel definition using the night-time thermal band at state or continental scales. Other, more detailed datasets, including Landsat MSS and TM and SPOT Pan and XS are more useful for geoscience applications given their higher ground resolution (10 metres to 100 metres) and spectral characteristics (in particular Landsat TM).

NOAA: National Oceanographic and Atmospheric Administration
* AVHRR: Advanced Very High Resolution Radiometer

Henk van Paridon / Sylvia Micheal



NOAA12 thermal 02 Dec 97 0836Z
Copyright 1997, CSIRO Division of Marine Research, Hobart



NOAA14 albedo 02 Dec 97 0455Z
Copyright 1997, CSIRO Division of Marine Research, Hobart

Geophysical Websites

by Natasha Hendicks

Below is a short compilation of geophysical websites available on the Internet. This list is by no means exhaustive. Instead it aims to give just a brief introduction to the type of information now available on the net that could be of particular interest to undergraduate and postgraduate geophysics students.

http://pursuit.rehab.uiuc.edu/pursuit/sem/careers/geo.html

WHAT DO GEOLOGISTS AND GEOPHYSICISTS DO? - PURSUIT

This webpage, although only a basic text page with no graphics, gives an excellent overview of what a geophysicist does, where geophysicists work and what training is required to become a geophysicist. This resource is provided by Pursuit - an American organisation dedicated to helping students with disabilities pursue careers in engineering, science and mathematics. A good introductory resource for any student considering taking up a career in geophysics.

http://www.met.unimelb.edu.au/~aseg/aseged3.html

AUSTRALIAN INSTITUTIONS WITH GEOPHYSICS COURSES

The ASEG has a comprehensive list of Australian Universities that offer studies in geophysics. What little information is available regarding contact details for course enquiries are listed by State. Check individual university sites for more detailed information. Universities that now have specific geophysics websites include:

Australian National University:
http://rses.anu.edu.au/seismology/seismology.html

The University of Sydney:
http://omphacite.es.su.oz.au/

The University of Queensland:
http://www.geoph.uq.edu.au/

Flinders University:
http://www.es.flinders.edu.au/

The University of Adelaide:
http://www.geology.adelaide.edu.au/

Curtin University of Technology:
http://www.curtin.edu.au/curtin/dept/geophy/

The University of Western Australia:
http://www.geol.uwa.edu.au/geol/research/geophys.htm

http://sepwww.stanford.edu/sep/prof/index.html

JON CLAERBOUT'S CLASSROOM: FREE BOOKS

Jon Claerbout from the Stanford Exploration Project, Stanford University offers copies of his geophysical textbooks free on the World Wide Web. Currently illustrations are not available interactively on the web but can be downloaded with copies of the text.

http://magma.Mines.EDU/fs_home/tboyd/GP311/

INTRODUCTION TO GEOPHYSICAL EXPLORATION

This website is part of the Society of Exploration Geophysicists Multi-Disciplinary Initiative. Thomas Boyd from the Colorado School of Mines has written a short course introducing the fundamentals of geophysical exploration. The course contains modules covering the basics of gravity, magnetics, DC resistivity and seismic refraction. Useful references are provided for each topic. The course is based on the case-study approach. Students are provided with course notes covering each geophysical tool and then have to work through a series of exercises focused on a real-world geophysical exploration problem. Students control the relevant survey design parameters used for acquisition, they control decisions regarding processing of the data, and they interpret the results.

Information may be freely copied and distributed for academic and educational purposes. Commercial interests must obtain the express written permission of the developers for copying and distribution rights.

http://www.offshore-technology.com/industry/index.html

THE WEBSITE FOR THE OFFSHORE OIL AND GAS INDUSTRY

This site is just one of a number of informative webpages grouped together under the Offshore Technology homepage - a website for the offshore oil and gas industry. Contact details of geophysical, geological and other related associations, institutes, societies and government departments are listed by country. Interestingly ASEG was not found on the Australian list!

http://beerfrdg.tamu.edu/

ELECTRICAL METHODS IN GEOPHYSICS RESEARCH: TEXAS A&M UNIVERSITY

This webpage serves as a platform for introducing students to the application of electromagnetic (EM) methods in classic solid earth and environmental geophysics. A brief overview of the EM method is given, together with a link to MTNET - an international electronic forum for the free exchange of knowledge, programs and data between scientists engaged in the study of the Earth using EM methods. There is also a list of current related research projects being carried out within the Department of Geology and Geophysics at the Texas A&M University.

http://www.uh.edu/~jbutler/geophysics/freeware.html

GEOPHYSICAL FREEWARE

This webpage belongs to a larger website entitled Geophysics on the Internet - a site dedicated to providing access to the wealth of geophysical information on the Internet. These pages have been created by John Butler from the University of Houston with financial support from the Society of Exploration Geophysicists. The Geophysical Freeware page provides links to free software and publications available via the Internet which may be of interest to practising geophysicists and students.

http://www.science.ubc.ca/~eoswr/geop/appgeop/ch-list.html

CASE HISTORIES IN APPLIED GEOPHYSICS

This webpage is part of the University of British Columbia Applied Geophysics website and provides links to detailed geophysical case histories. There are three types of case histories provided (i) summaries from literature, (ii) case histories written at the University of British Columbia and (Niii) links to case histories at other websites. Case histories are sorted by geophysical methods including gravity, magnetics, seismic methods, DC resistivity, IP, GPR and inversion methods. Material is primarily intended for undergraduate geophysics students.

Seismic monitoring of the Duri steamflood: Application to reservoir management

M.W. Waite and Rusdinadar Sigit
Caltex Pacific Indonesia, Sumatra, Indonesia

This story is reprinted from The Leading Edge.

The Duri Steamflood, operated by Caltex Pacific Indonesia, has employed time-lapse seismic monitoring technology as an important component of its reservoir management process since the completion of a successful pilot study in 1995 (See "Seismic monitoring of the Duri steamflood: A pilot and feasibility case study" in this issue of TLE). Time-lapse seismic surveys have been shot in six areas of varying steamflood maturity, and new surveys will be acquired as undeveloped areas are placed on steam injection (Figure 1). Multinational teams of engineers and earth scientists are learning ways to integrate the continuous flow of seismic information into the reservoir management process. Successful implementation of the technology promises to help recover the very large reserves of low viscosity oil that are beyond the reach of conventional techniques.

The Duri Field is an engineering marvel, with the largest steam generation and distribution system in the world. A dense honeycomb of uniformly spaced well patterns and a sprawling distribution network of steam and oil pipelines belie the unpredictable nature of the recovery process below. Some 900 steam injection wells distribute steam to reservoirs 100 - 300 m below the surface, driving heated oil to nearly 2700 producer wells. Steam movement through the reservoirs often departs from the ideal, causing an uneven distribution of heat, and resulting in inefficient energy utilization and unswept regions of oil. Steam-flow owes its unpredictable nature to the geologic complexities of deltaic depositional environment, operational-induced pressure variations, and the nonlinearity of fluid-flow dynamics. Continuous surveillance of evolving reservoir conditions is key to efficiently managing the elusive steam. Monitoring techniques are used to identify areas of poor steamflood conformance (vertical and horizontal sweep), and then to design strategies to coerce the steam into a more uniform and energy-efficient distribution.

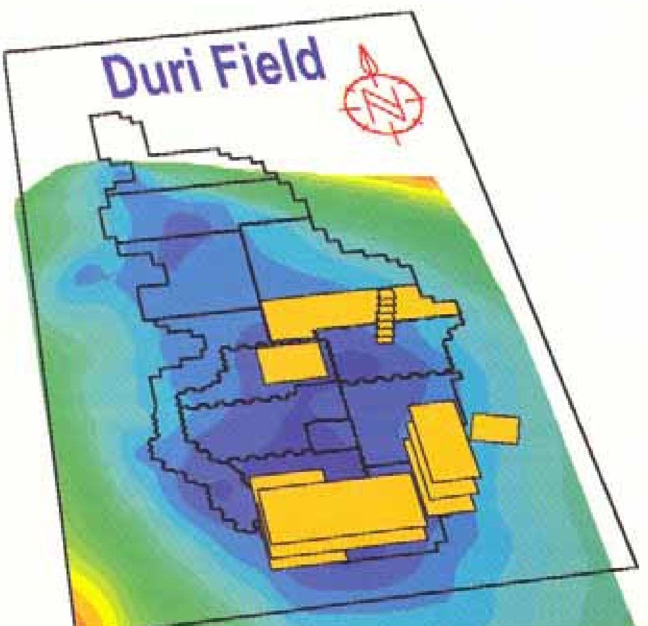


Figure 1. Locations of active 4-D surveys in Duri Field. The program is expanding into newly injected areas for conformance optimization, and into more mature areas to identify by-passed oil.

In the past, engineers and geoscientists have relied on well-based monitoring methods to manage the Duri steamflood. These reveal, to varying degrees of resolution and certainty, the reservoir conditions in the immediate vicinity of the well bore. But in many cases, well bore sampling is not sufficient to construct a unique and accurate picture of steamflood conformance. Failure to correctly assess steamflood conformance can lead to unsuccessful well work-overs, wasted heat energy, and unrecognized regions of by-passed oil. Seismic data, when combined with conventional surveillance, provides a means to image the recovery process. The following example illustrates the added value of seismic data to the reservoir management process.

Piecing the puzzle together

Figure 2 is a map over several Duri Field well patterns. Each is composed of a central injector well surrounded by producer wells on the corners and sides of a square (total area is 15.5 acres). Producing wells are indicated by "bubbles" whose diameters are proportional to the temperature of the fluid stream produced at the well-head after seven months of steam injection. Producers P2 and P3 register flow-line temperatures greater than 250° F, as compared to the ambient reservoir temperature of about 100° F. The high temperature is characteristic of steam "breaking through" to the producer well and mixing with the commingled fluid stream. Under ideal conditions, with symmetrical areal steam growth and high vertical sweep efficiency, break-through is not expected until 4-5 years of steam injection. The much-earlier-than-expected high temperatures for these wells suggests suboptimal steamflood conformance in the area; i.e. the steam is not growing uniformly in all directions. Once steam communication is established between an injector well and a producer well, resistance to steam flow between the two wells is substantially reduced. This produces a tendency for steam to continue to flow to the break-through producer well. Thus, early

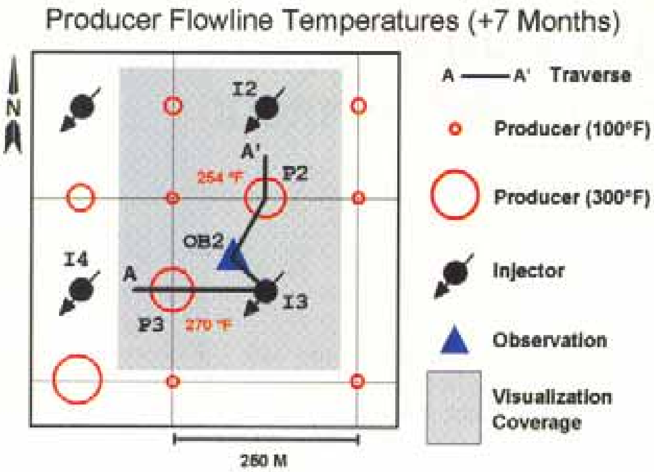


Figure 2. A pattern-scale base map showing location of wells and the traverse A-A'. The size of producer well symbols is proportional to the flow-line temperatures after seven months of steam injection. Several producer wells show steam-related heat (>250° F), indicating undesirable steam flow anisotropy.

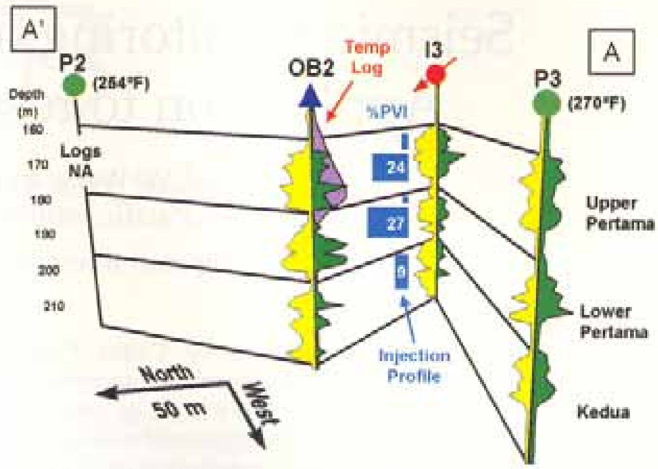


Figure 3. Well log cross-section A-A' (see Figure 2 for orientation). A temperature log in the observation well and an injection profile survey in the injection well give clues to the distribution and movement of steam. The temperature log suggests that steam from the Upper Pertama is a plausible source of heat registered in the two nearby hot producers.

steam break-through results in inefficient utilization of energy by inhibiting the areal expansion of steam into other regions of the reservoir and, if not checked, will lower ultimate oil recovery.

The most common remedies for early break-through include modifying injection profiles to reduce steam flow into layers suspected of break-through, closing off producer break-through intervals, cyclic steam injection at cold producer wells to "draw" steam into a more radial growth pattern, and installing casing pressure choke valves in the break-through producers to generate back pressure to "push" steam into unswept zones. In order to successfully implement one or more of these strategies, the reservoir management team must determine the break-through flow-units, identify the source injectors, and make reasonable assumptions about the steamflood conformance in the surrounding well patterns.

Let's examine what can be learned from conventional monitoring. As discussed previously, the flow-line temperatures from Figure 2 indicate a conformance problem. However, they do not indicate which flow-units are acting as the steam conduits, and from which injector wells the steam is sourced. We must look to other monitoring data to fill in those pieces of the puzzle. Figure 3 is a well-log cross-section from points A to A' (see map in Figure 2) which intersects break-through producer P3, injector I3, observation well OB2, and break-through producer P2. The steamflood zone can be subdivided into three major flow units, based on the presence of continuous and competent shales: the Upper Pertama, Lower Pertama, and Kedua.

An injection profile survey acquired in injector well I3 (Figure 3) shows the relative volume of steam injected into each flow-unit, in units of percent flow-unit pore volume. The profile indicates that an unbalanced allocation of steam is occurring in favor of both the Upper and Lower Pertama flow-units, at the expense of the lower-most Kedua flow unit.

A temperature log, acquired in the observation well after seven months of injection, indicates steam-related heat (peak temperature of 250° F) in the Upper Pertama and an absence of heat in the other flow units. In addition, well-log data in the surrounding area show that the highest average permeability occurs in the Upper Pertama.

Analysis of these data is inconclusive. The observation well, located within 100 m of both break-through producers, yields the most persuasive clue as to which flow-unit is delivering steam to P2 and P3. It indicates that outward steam expansion from I3 towards the northwest has progressed farthest in the upper most flow unit, and therefore it is plausible that this is the conduit for steam to P2 and P3. This inference is consistent with the average permeability data in the area, and is not contradicted by the injection profile survey which indicates injection rates for both Upper and Lower Pertama are higher than design levels. However, this analysis conveniently assumes that I3 is sourcing the break-through producers – an assumption not supported by available data. If steam reaching the break-through producers is actually sourced from the I2 and I4 injectors, then the observation well data is less relevant to our analysis. Nevertheless, if this information is all that is available, the lowest risk strategy might be to shut off the Upper Pertama in these two break-through producers. If our interpretation is correct, isolation of Upper Pertama steam in these wells will force steam from I3 to expand toward the east and south, thus improving the Upper Pertama conformance in the I3 pattern.

The missing piece

Favorable conditions exist in Duri for imaging steam distribution with seismic data. The acoustic response of the reservoir is very sensitive to changes in fluid saturation because of the porous unconsolidated rock frame, and the large compressibility differences in pore fluid types during steamflooding. Large reflection amplitude and time distortions result from the displacement of liquid pore fluids by lower velocity steam vapor. To help manage conformance, a 3-D seismic survey was recorded at the same time as the conventional

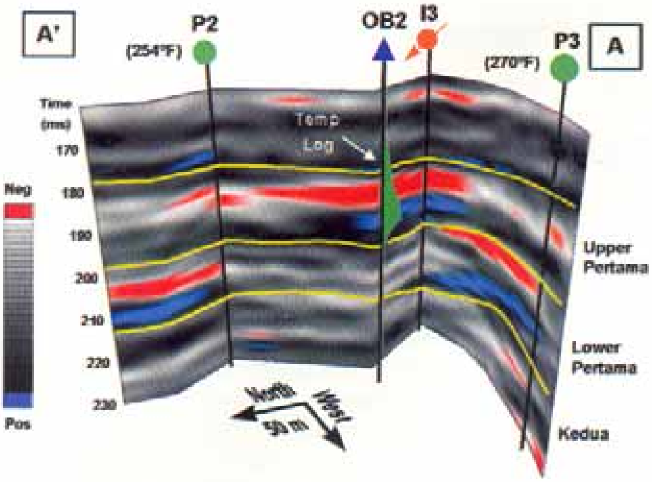


Figure 4. A seismic traverse along the same path (A-A') as the well log cross-section in Figure 3. Three distinct high amplitude steam indicators (red over blue signature) reveal steam pathways between wells. Despite being consistent with the well-based data, the seismic data indicate that the Lower Pertama – not the Upper Pertama – is the steam source for break-through producers P2 and P3. No steam indicators are present in Kedua.

monitoring data discussed previously. The survey was shot to help in designing a conformance improvement program for 31 well patterns in the area. The seismic data were wavelet processed to zero-phase by match filtering to VSP data acquired simultaneously with the surface seismic. Figure 4 is a traverse through the seismic volume along the same path (A-A') as the well-log cross-section in Figure 3. Interpreted boundaries for the Upper Pertama, Lower Pertama, and Kedua are delineated in yellow. Flow-unit boundaries were established using vertical seismic profile information, sonic log data, and seismic stratigraphic interpretation.

Three distinct steam indicators are evident on A-A'. Similar to classic gas "bright spots", the top and base of a low velocity steam zone is identified seismically by a high amplitude trough (red), followed by a high amplitude peak (blue). One steam indicator can be seen in the Upper Pertama extending from the injector to the observation well. Note that this Upper Pertama steam indicator is the only one present at the observation well, which is consistent with the temperature survey. However, despite this agreement, neither break-through producer appears sourced in the Upper Pertama, as was previously inferred from the conventional well-based data alone! A second steam indicator in the Lower Pertama extends from I3 to P3. Steam in producer P2 appears to be delivered by the Lower Pertama also, but sourced from the adjacent pattern to the north. Note that Kedua steam indicators are absent in the seismic data.

The completed puzzle

A generalized procedure was devised for quickly building a picture of steamflood conformance for each layer using all available information – including seismic. Figure 5 is the resulting visualization of steam distribution at the Upper Pertama and Lower Pertama levels. The area of coverage is defined by the grey rectangle in Figure 2. The two conformance maps in the figure are products of a Boolean classification of steam from multiple seismic attributes extracted within each layer. These attributes include various aspects of seismic reflection response such as RMS, mean, minimum, and maximum amplitudes, as well as several Hilbert-based attributes. A technique called discriminant analysis determined a linear combination of these seismic features which best discriminates between the presence or absence of steam. A discriminator function for each layer was derived by comparing, on a regional scale, the seismic attributes that spatially coincide with well locations to the known reservoir conditions sampled by these wells. The discriminator functions were then used to classify seismic feature sets between wells. After classification, the parameterized seismic data are reduced to a map of 1s and 0s denoting steam presence or absence, respectively. The Kedua level is not shown because of the lack of coherent steam indicators in the seismic.

A more complex picture of steam distribution emerges from the integration of seismic information and well-based monitoring data. The areal conformance images of Figure 5 reveal highly channeled nonuniform fluid flow, especially in the Lower Pertama. The north-south trending Upper Pertama steam chest in the I3 pattern, detected by the observation well, does not yet appear to have reached any of the producer wells. At the Lower Pertama level, steam growth is confined to the west of I3, channeling directly to the P3 producer and evading detection by the observation well. A similar steam channel has formed between I2 and P2, indicating poor Lower Pertama conformance for the I2 pattern. The absence of classifiable Kedua steam indicators suggests, as did the injection profile survey acquired in the I3 injector, that Kedua is receiving very little steam.

Our newly enlightened picture of steamflood conformance requires a different improvement strategy from that previously formulated using conventional monitoring alone. Considering this new information, the

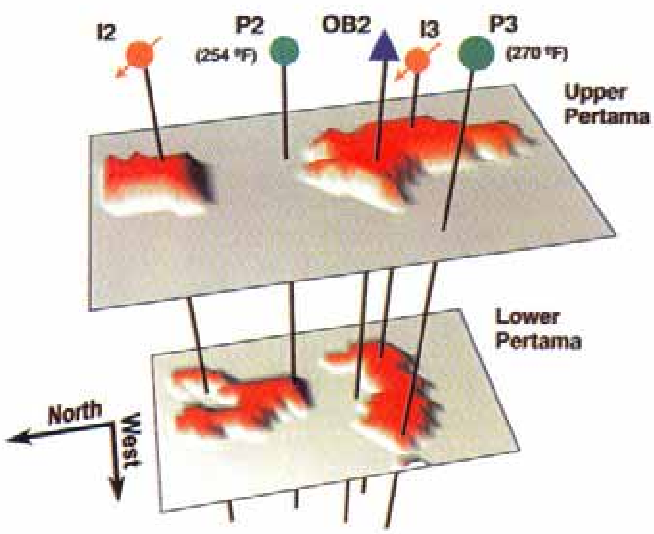
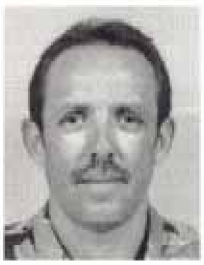


Figure 5. A seismically-influenced visualization of steamflood conformance for Upper and Lower Pertama shows highly channeled nonuniform conformance in the area, especially in Lower Pertama. Red areas are saturated with steam. The maps are the result of a Boolean classification of steam from multiple seismic attributes extracted within each of the layers. The information was used to design a conformance improvement program for the area.

most prudent strategy to improve conformance is to close the Lower Pertama intervals in the P2 and P3 producers. This will interrupt the flow of steam channeling to the break-through producers, and promote steam expansion in the unswept regions of the reservoir. In addition, the corroboration of evidence for poor steam growth in Kedua calls for steps to increase injection into this interval, such as altering the perforation profiles in the nearby injectors. These remedial actions are part of an actual conformance management program for the area covered by the seismic survey. The integration of conventional steamflood monitoring data with seismic data critically influenced many decisions similar to this example. Future time-lapse seismic surveys in the area will monitor the progress of this program and will undoubtably lead to new and surprising revelations.

Acknowledgments

The authors acknowledge Caltex Pacific Indonesia (CPI), Chevron, and Texaco for sponsoring this work.



Mike W. Waite is a senior geophysicist with Saudi Arabia Texaco Inc. in Kuwait. He has recently been selected as a Distinguished Lecturer for the Society of Petroleum Engineers in recognition of his work in managing the Duri steamflood seismic monitoring program from 1995 to 1997. Since 1982, he has been employed by Texaco and has held a number of positions involving seismic acquisition and processing, development and application of geophysical modeling and subsurface imaging techniques, prospect evaluation, and reservoir characterization using 3-D/4-D seismic data. He holds a bachelor's degree in physics from the University of New Orleans (1981). He is a member of SEG and SPE.

Rusdinadar Sigit received a bachelor's degree (1990) in geology from the Institute Technology of Bandung, Indonesia. He worked as an exploration geophysicist for Amoseas Indonesia (1990-1995) in prospect evaluation, 2-D seismic and potential field data acquisition, and analysis in various oil and gas fields in Indonesia. He has been employed by P.T. Caltex Pacific Indonesia since 1995, and is currently working in the Duri seismic monitoring project. He is involved in the 4-D seismic acquisition, processing, and analysis. He is a member of IPA, HAGI and IAGI.

Corresponding author: M. Waite, fax 965-381-1697.

Carbon and Conductivity

"The Rock Doctor"

D.W. Emerson, Systems Exploration (NSW) Pty Ltd
Y.P. Yang

Introduction

In this article we look at the nature and occurrence of carbon in rocks and consider the influence of carbon on rock conductivity as this is of considerable significance in geophysical exploration. Carbon content is frequently discussed and often invoked as an explanation of conductive horizons delineated in hard rock exploration programs, but there is little documented research that sheds light on carbon's influence on low frequency electrical properties of sediments, metamorphics and other lithologies. Carbon comes from the Latin *carbo*, coal or charcoal.

In Australia, carbonaceous material, regarded as graphitic, has been reported in many of the Precambrian schists and slates of the Cloncurry, Mt Isa, Etheridge districts of North Queensland, in the Proterozoic of the Katherine-Darwin region of the Northern Territory and in many localities in the Precambrian of Western Australia. Deposits of graphite have been recognised in metamorphosed coal from the Permian in the Sydney and Bowen Basins. Ore deposits are few, usually they are occurrences of up to about 30 weight percent free-carbon as coarse or fine flake graphite in schist. Perhaps the best known is the Uley Mine in the Proterozoic Middleback Subgroup on the Eyre Peninsula in South Australia. Here, a bed of graphitic schist up to 10m thick contains around 10 to 20% of coarse flake carbon. It is a deeply weathered environment in garnetiferous quartz feldspar gneiss terrain and has been investigated by electromagnetics to trace extensions of the deposit (Milton & McMutrie, 1960).

Carbon bearing sediments, e.g. black shales, seem to be ubiquitous in exploration environments. Some theories of hydrothermal submarine metallic accumulations hypothesise that the pooling of hot fluids in depressions under anoxic conditions favours ore preservation and that these depressions also have accumulations of black carboniferous materials. Hydrothermal fluids are reduced when they come into contact with carboniferous materials and the carbon is oxidised to carbonate. In this way gold and base/metal solution complexes are destabilised and precipitated. Davis (1977) discussed geophysical volcanogenic targets in eastern Australia and noted likely geophysical responses from carbonaceous sediments in a cyclic volcanic sequence. White (1966) documented the results of an airborne electromagnetic survey in Quebec where drilling of a delineated conductor revealed massive sulphides at one end and graphitic sediments at the other.

Carboniferous horizons associated with mineralised terrain have been called "formational" conductors by Frischknecht et al (1991). Palacky & West (1991) commented on the difficulty of discriminating them from sulphidic targets and also remarked on their usefulness in stratigraphic and structural mapping by airborne electromagnetics.

Carbon content can be regarded in some instances as a target itself or as a direct indicator of ground favourable for mineralisation and in other instances as providing the means for facies mapping, but often it is perceived as a nuisance that generates false leads. Whatever the attitude to carbon, positive or negative, it is important in the art of exploration interpretation.

Carbon Minerals

There are three forms of free-carbon in rocks: hard translucent or transparent diamond, amorphous mineraloid carbon (e.g. charcoal) and crystalline scaly graphite. Some physical features of these minerals are summarised in Table 1.

Doped diamonds have semiconducting properties, but geophysically diamond can be regarded as a rare dielectric with a resistivity comparable to that of the best insulators. Its presence makes little difference to a rock's bulk resistivity when it occurs in commercial concentrations of around 1g of diamond to 25t or ultrabasic or alluvial rock. A good summary of diamonds and their physical properties may be found in Reckling et al (1994). Macnae (1995) has outlined the use of indirect geophysical techniques in diamond search. Diamond will not be discussed further in this article.

Mineraloid-carbon is amorphous charcoaly material sourced from organic matter. It occurs in coals e.g. anthracite, and can also occur as an extremely fine grained dust in low grade metamorphics such as carbonaceous siltstones.

Charcoal, a form of mineraloid-carbon, is the carbon residue resulting when wood or other organic matter is burned in the absence of air. It is an impure, black, porous and absorbent material. Commercially, charcoal is available from burned organics and as activated charcoal for chemical and medicinal purposes where residual hydrocarbons are removed to increase absorption performance. Fusain or "mother of coal" is carbonised wood resembling charcoal and high in ash. In this article mineraloid-carbon is regarded as an amorphous material sourced from organic matter. It may occur in sediments of low metamorphic grade, such as some carbonaceous siltstones, and also in coals, including anthracites below a graphitization threshold. In sediments mineraloid-carbon grains may be below the resolution (5 microns) of many optical microscopes. It is deceptive because it can occur as clouds and in a thin section it is difficult to estimate volume percentages. The carbon grains or granular aggregates can stack in the thickness direction and be seen not just as a surface occurrence but through the whole section which is about 30 microns thick. Generally amorphous very fine grained carbon and/or graphite abundances tend to be overestimated by optical techniques. A thin section may focus on a limited part of a rock, a carbonaceous lamina, but the chemical assay may be averaged over a larger portion.

Table 1
Carbon Minerals - Some Properties

Mineral Property	Mineraloid - Carbon	Graphite	Diamond
composition	C (generally impure, charcoal)	C (rarely pure)	C (usually minor N_2 content)
crystallinity	non crystalline amorphous (no long range order)	hexagonal (occurs as scales, flakes, laminae)	cubic (octahedral crystals)
colour, lustre	black, sooty	steel grey, metallic (black & earthy if microcrystalline)	white or other, transparent or translucent, adamantine
hardness (Mohs')	1 to 2	1 to 2	10
density g/cm^3	1.3 to 1.8 (apparent bulk density)	2.27 (SGG: grain density varies with purity)	3.51 (SGG)
magnetic susceptibility SIx10^{-5} (diamag.)	low	-2	-1
DC galvanic elec conductivity (approx.) S/m	10^3 (varies)	10^5 (polycrystalline aggregate)	10^{-16} (crystal)

Graphite is formed in rocks from the recrystallization of carbonaceous matter following the action of pressure and temperature during metamorphism. It is often present as disseminated flakes along the rock foliation or as laminae. It can also be encountered as fracture fills often with a transverse fibrous structure. Such veins and pods are thought to involve the deoxidation of carbon oxides. Magmatic graphite also occurs, it has been noted in meteorites and igneous rocks. The amount of graphite in suitable host rocks can vary widely and it is usually impure, containing volatiles and silicates. Commercially, natural graphites are classified as crystalline (flake, vein) or amorphous. The latter label is an unfortunate misnomer as it refers to finely crystalline graphite that is not really amorphous. Taylor (1994) has provided a review of industrial graphites. Synthetic graphites are produced from calcined petroleum coke. These artificial graphites are purer than the best natural product, but their porosity is higher, density lower, grainsize finer and resistivity higher. So natural graphite is still a sought-after commodity.

With the application of temperature and stress, carbonization of organic matter in rocks occurs as the first stage of graphitization. Volatiles are released and mineraloid-carbon of high microporosity results with semi random arrangements of micelles comprising aromatic clusters of linked benzene rings. Increasing metamorphism coalesces the micropores to mesopores. When the pore wall material is thick enough to accommodate crystalline reorganization, semi-graphite and finally graphite forms usually at around 500°C and 500MPa. Minerals such as silica and pyrite may act as catalysts for the generation of graphite.

Electrical Properties

Hexagonal graphite is a semi metal with strongly bonded carbon atoms in layers that are held together by weak van der Waals forces. The layers contain multiple benzene rings with delocalized electrons that readily traverse the 2D structure (van Vlack, 1989). Accordingly the planar macromolecular layers impart a strong electrical anisotropy to a graphite crystal. For current flow in the layers and normal to the hexagonal axis, the basal (crystal) conductivity (σ) is extraordinarily high 2.5 x 10^6 S/m, but the anisotropy, $\sigma_{\parallel}/\sigma_{\perp}$, can vary from 100 up to 10,000 (Shuey, 1975). The laboratory bulk conductivity of natural graphite is nominally about 10^5 S/m and would be dependent on crystallinity, aggregation, grainsize, grain contacts and impurity levels. Reported values in the range 0.5 to 2x10^5 S/m (Duba & Shankland, 1982). Such conductivities exceed those of most sulphides.

Artificial solid graphites are porous polycrystalline aggregates that may be isotropic or moderately anisotropic (up to 1.7:1) if the crystallinity is somewhat oriented in the manufacturing process. A typical nominal conductivity value is 10^5 S/m which is considerably less than the single crystal $\sigma_{\parallel}$ owing to grain boundary scattering (Shuey, 1975).

Mineraloid-carbon would be expected to have a conductivity less than graphite. Duba & Shankland (1982) cite a value of 10^4 S/m for low density amorphous carbon. Duba (1977) measured DC conductivities of more than 10^2 S/m for coal char. A value of between 10^2 and 10^3 S/m is suggested when Parkhomenko's (1967) high carbon anthracite conductivities are extrapolated to zero ash content. A nominal conductivity value of around 10^3 S/m or more seems to be indicated for *good* quality mineraloid-carbon.

Carbonaceous Rocks

A consideration of mineral conductivities leads naturally to the conductivities of rock containing these carbon minerals, but, unfortunately, there appears to be little detailed information on conductivity and less still of petrology. This is surprising in view of carbon's importance in exploration regions. Telford et al (1990) and Parasnis (1986) give a considerable range of 10^{-2} to 10^3 S/m for graphitic shales, schists and slates. Brant et al (1966) interpreted conductivities of a few S/m over New Brunswick graphite zones that were several tens of metres wide. Brass et al (1981) modelled a graphite lens in gneiss near Pfaffenrenth with a conductivity of 4x10^{-2}S/m. Asten et al (1987) interpreted a downhole TEM conductivity of 12.5 S/m for a 4m band of cindered Bulli coal in the southern Sydney Basin. Palacky (1987), in an overview of the conductivities of geologic targets, ascribed a conductivity range of 0.1 to 10 S/m for graphite.

Nelson et al (1982) presented an excellent study of Nevada carbonaceous siltstones saturated with 7 ohm m solution. For the Gabbs-Sunrise Formation laboratory conductivities of between 10^{-1} and 5×10^{-3} S/m were measured for samples containing 0.8 and 0.2 weight percent free-carbon, chemically determined, but petrographic estimates were in the 2 to 7% range for similar rocks. It was thought that the petrographic volume estimates were too high (see comments above) and that amorphous carbon could occur as a coating on other mineral grains thus boosting conductivities and leading to visual overestimates of carbon abundances.

Precambrian Carbonaceous Sediments

Carbonaceous siltstones and black shales are common lithologies in the Australian Precambrian and are often identified as conductors. The results for inductive and 1 kHz galvanic conductivity (σ) tests on 33 cores from such sediments are summarised in Figure 1. These low porosity sediments from Queensland, South Australia and Western Australia were of low metamorphic grade, of low to moderate anisotropy ($\sigma_{max}/\sigma_{min}$), and were sulphide-free. The samples are a typical but by no means definitive selection. The minimum apparent conductivities plotted against grain density (SGG) in Figure 1 might be interpreted as showing a broad increase in conductivity as grain density decreases. Such a decrease might be regarded as due to carbon content in the absence of other low density minerals. On Figure 1 carbon content could change from minor on the RHS of the x axis to about half on the LHS. Conductivities are mainly fair to moderate with a spread of values clustered in the 2.67 to 2.71 g/cm^3 band. The average conductivity of 8 isotropic samples was 1092 mS/m which is close to the average of all samples, 1090 mS/m. The median or geometric mean value for all samples was 494 µS/m; perhaps a better statistical indicator for this non-normal distribution.

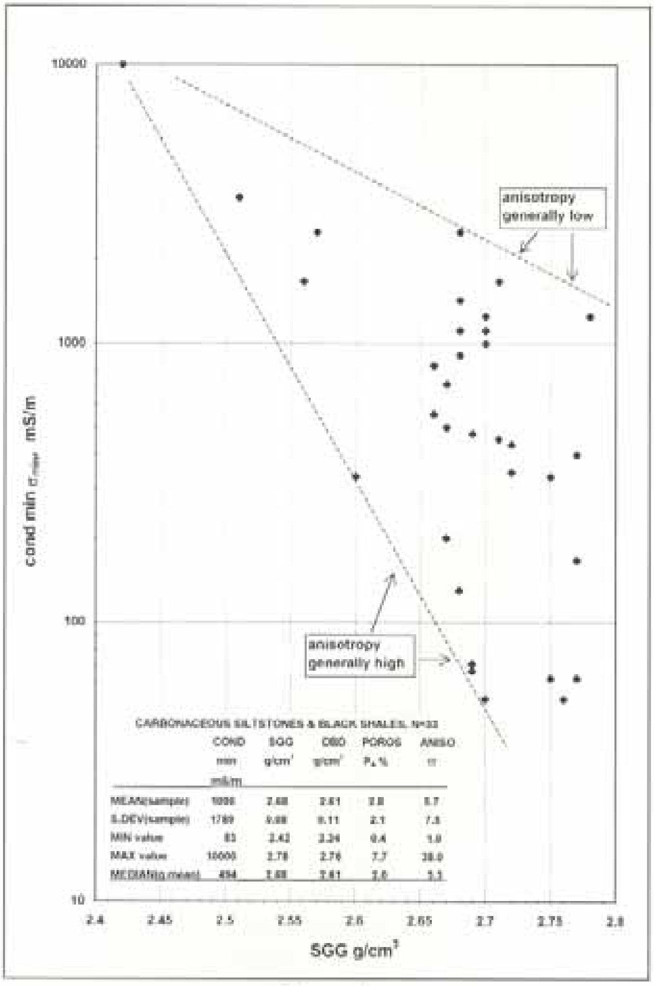


Figure 1.

Laboratory Measurements

Some carbon materials were tested in the laboratory to assess their properties. The results are summarised in Table 2 for natural crystalline graphite, commercial slab graphite, redgum charcoal and medicinal charcoal. The graphites exhibited diamagnetic susceptibilities while the charcoals showed very small positive susceptibilities. The graphites displayed various but high conductivities, ~10^5 S/m, and some anisotropy. The medicinal charcoal had a low conductivity, but the redgum charcoals varied from extremely low to only moderate conductivity. The more conductive charcoal pieces were grey and fine grained; the resistive pieces were black and foliated and were presumed resistive on account of texture (incl. microporosity) and low carbon content. It would seem that variations in a sediment's carbon particle conductivity might be expected and would depend on the nature of the source material and the rock's metamorphic history.

Table 2
Laboratory Tests - Carbons, Dry State

Material	Apparent Density g/cm^3	Galvanic Electrical Conductivity DC, S/m	1kHz, S/m
natural graphite (solid, fibrous, platy, crystalline)	2.25	1.22×10^5 (max) 7.35×10^4 (min)	
commercial graphite solid slab	1.70	1.24×10^5 (max) 9.72×10^4 (min)	
redgum charcoal solid, porous, hetero.			
conductive	1.17		7.7×10^1
resistive	0.56		1.8×10^{-4} (parallel
foliation)			
medicinal charcoal (activated carbon)	0.93		2.6×10^0
granulated commercial packed graphite		1.00×10^3 (extrapolated)	
granulated conductive redgum charcoal (rammed)			2.3×10^1

Granulated commercial graphite (used because there was not enough natural graphite) and crushed conductive redgum charcoal were used in further experiments for which the results are given in Figure 2. Very fine grained flake graphite (few micron length) was mixed in varying proportions with plaster of paris and conductivities determined galvanically at 0.1 Hz (refer Yang & Emerson, 1997). Angular charcoal grains (0.1 to 0.5 mm) were mixed with dried subangular quartz sand (0.1 to 0.5 mm) and in the mixing some charcoal grains disintegrated further and were observed under the microscope to have smeared part (about 30%) of each quartz grain surface with finer charcoal fragments (10 to 20 microns) and this finer charcoal also formed interstitial clusters, especially as charcoal content increased. Charcoal-sand mix conductivities were measured at 1 kHz. The conductivities are regarded as accurate to 1% and 5% for the graphite and charcoal mixes respectively. The higher galvanic conductivities were corroborated by inductive EM measurements.

The plotted data in Figure 2 show similar behaviour for the mixes. Both show dramatic increases in conductivity at the percolation thresholds for transition from insulating to conducting composites. The graphite mix is significantly more conductive and has a lower carbon content threshold (10%, weight) than the charcoal mix (18%, weight). Hsu et al (1988), in conductivity experiments on dry blended then melted polymer-carbon mixes, noted percolation threshold variations of between 5 to 25% (volume) depending on the physical features of the components. The data in Figure 2 show that for minor carbonaceous material contents in the conductive domains, say around 20 to 40%, the conductivities range from 3 to 31 S/m for the graphite mixes and 0.1 to 3 S/m for the charcoal. These are typical of the conductivities encountered in many carbonaceous sediments.

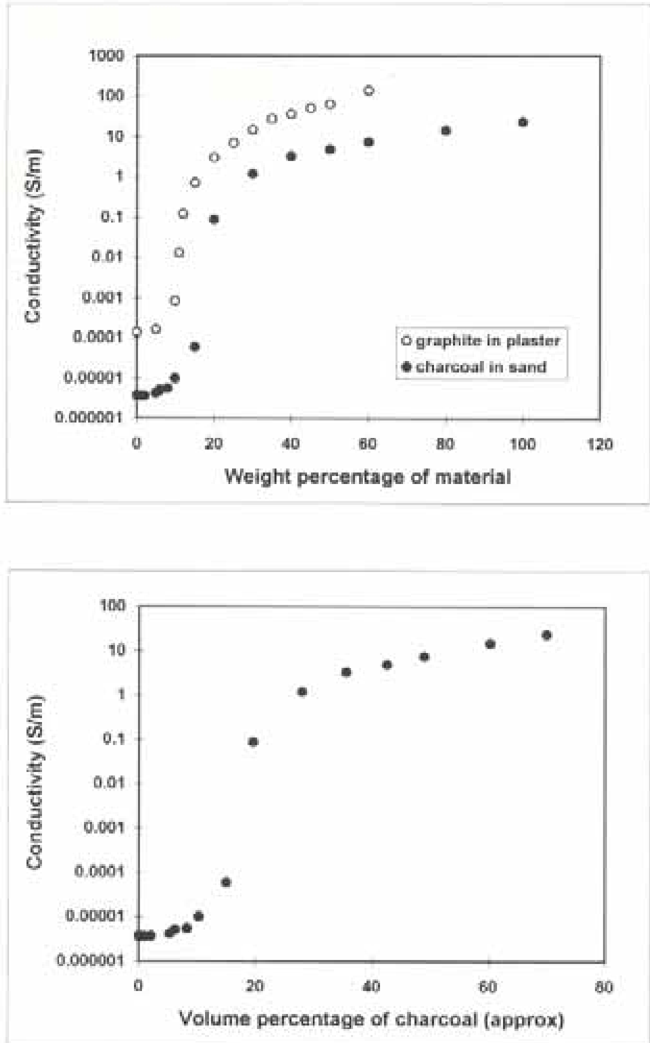


Figure 2.

Anisotropy

Many carbonaceous sediments are not massive but well bedded and often the carbonaceous material occurs concentrated in laminae. Consider a piece of sedimentary core, drilled out normal to bedding and comprising 20% carbonaceous laminae whose individual conductivities were 10 S/m, then the apparent inductive EM conductivity for the whole core would be 2 S/m (σ_{max}), if the rest of the core had negligible conductivity. The galvanic axial conductivity would be low. If the core was drilled out parallel to bedding then the galvanic axial conductivity would be enhanced and the inductive conductivity diminished. Anisotropy and the conductivity tensor should be borne in mind in assessing carbonaceous sediment conductivities.

Concluding Remarks

The nature of carbon in rocks and its possible disposition in low grade metamorphic sediments have been addressed. Many of these sediments contain pyrite beds, bands and laminae adding another variable in assessing electrical characteristics (not covered here). High metamorphic grade rocks with flake graphite have not been studied yet. The tests on the natural coarsely crystalline graphite suggest that high carbon content vein graphite would have a very high conductivity in situ, given continuity of the material.

Mathematical models of the behaviour of conductive platyminerals dispersed in a matrix have not been discussed here. Schön (1996) provides some formulae. The induced polarisation effects of graphite are of major importance in exploration. The reader is referred to Nelson et al (1982) and Olhoeft (1985).

The carbon content of slightly metamorphosed sediments may be expected frequently to impart a low to moderate conductivity to a rock if the carbon content is above a certain threshold. In a single measurement such conductivity is often "apparent" owing to carbon concentrations in beds or laminae leading to electrical anisotropy. A variation in the conductivity of the carbon component itself may be expected depending on whether it is crystalline graphite or low grade mineraloid-carbon or some intermediate structural level material. Texture will further influence the conductivity of carbon aggregates whether dispersed of laminated.

Acknowledgements

The petrography of carbon in sediments and coals was discussed with I Pontifex of Pontifex & Associates Pty Ltd. His advice was much appreciated. Mrs S Franks prepared the manuscript. Don Emerson is an Honorary Research Associate in the Department of Geology and Geophysics, University of Sydney.

References

Asten, MW, King, A & Peacock, J (1987), *Sign Changes in DHEM Surveys for Cindered Coal in the Sydney Basin*, Exploration Geophysics, 18, 319-323.

Brant, AA, Dolan, WM & Elliot, CL (1966), *Coplanar and Coaxial EM Tests in Bathurst Area, New Brunswick, Canada, 1956*, Mining Geophysics, v1, 130-141.

Brass, G, Flathe, H & Schulz, R (1981), *Resistivity Profiling with Different Electrode Arrays over a Graphite Deposit*, Geophysical Prospecting, 29, 589-600.

Davis, LW (1977), *The Geophysical Volcanogenic Target in Eastern Australia*, Bull. Aust. Soc. Explor. Geophys., 8(3), 50-59.

Duba, AG (1977), *Electrical conductivity of coal and coal char*, Fuel, 56, 441-443.

Duba, AG & Shankland, TJ (1982), *Free Carbon & Electrical Conductivity in the Earth's Mantle*, Geophysical Research Letters, 9, 1271-1274.

Frischknecht, FC, Labson, VF, Spies, BR & Anderson, WL (1991), *Profiling Methods using Small Sources*, in: Electromagnetic Methods in Applied Geophysics (ed. MN Nabighian, SEG), 24, 105-254.

Hsu, WY, Holtje, WG & Barkley, JR (1988), *Precolation phenomena in polymer/carbon composites*, Jnl Materials Science Letters, 7, 459-462.

Macnae, J (1995), *Esoteric and mundane geophysics for diamondiferous pipe exploration*, Exploration Geophysics, 26, 131-137.

Milton, BE & McMutrie, IH (1960), *Electromagnetic prospecting for graphite-Uley mine area*, Min. Rev. Adelaide, 109, 67-77.

Nelson, PH, Hansen, WH & Sweeney, MJ (1982), *Induced-polarization response of zeolitic conglomerate and carbonaceous siltstone*, Geophysics, 47, 71-88.

Olhoeft, GR (1985), *Low-frequency electrical properties*, Geophysics, 50, 2492-2503.

Palacky, GJ (1987), *Resistivity Characteristics of Geologic Targets*, in: Electromagnetic Methods in Applied Geophysics (ed. MN Nabighian), 1, 53-129.

Palacky, GJ & West, GF (1991), *Airborne Electromagnetic Methods*, in: Electromagnetic Methods in Applied Geophysics (ed. MN Nabighian, SEG), 2B, 811-879.

Parasnis, DS (1986), *Principles of Applied Geophysics*, 4th edition, Chapman and Hall.

Parkhomenko, EI (1967), *Electrical Properties of Rocks*, (ed. GV Keller) Plenum Press.

Reckling, K, Hoy, RB, Lefond, SJ, Fullerton, DG & Rowell, UH (1994), *Diamonds, Industrial*, in: Industrial Minerals and Rocks, AIME (ed. DD Carr), 371-395.

Schön, JH (1996), *Physical Properties of Rocks: Fundamentals and Principles of Petrophysics*, Pergamon.

Shuey, RT (1975), *Semiconducting Ore Minerals*, Elsevier.

Taylor, HA (1994), *Graphite*, in: Industrial Minerals and Rock (ed. DD Carr, AIME), 561-570.

Telford, WM, Geldart, LP & Sheriff, RE (1990), *Applied Geophysics (Second Edition)*, Cambridge University Press.

Van Vlack, BH (1989), *Elements of Materials Science and Engineering*, Addison-Wesley Pub.

White, PS (1966), *Airborne Electromagnetic Survey and Ground Follow-up in Northwestern Quebec*, Mining Geophysics, v.1, 252-261.

Yang, YP & Emerson DW (1997), *Electromagnetic conductivities of rock cores: Theory and analog results*, Geophysics, 62, 1779-1793.

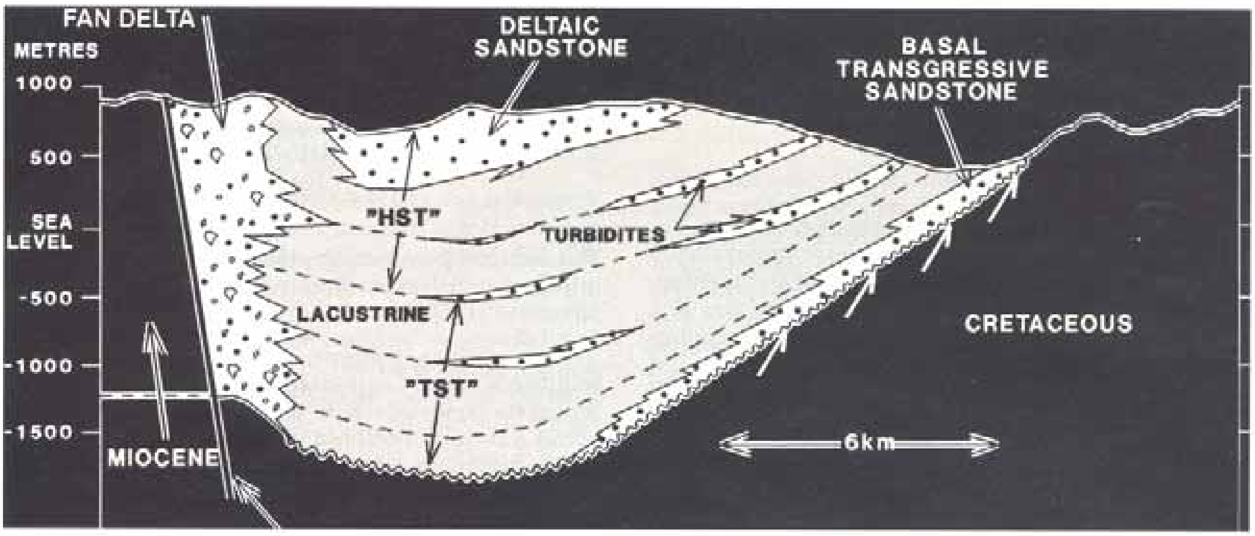
Seismic Window

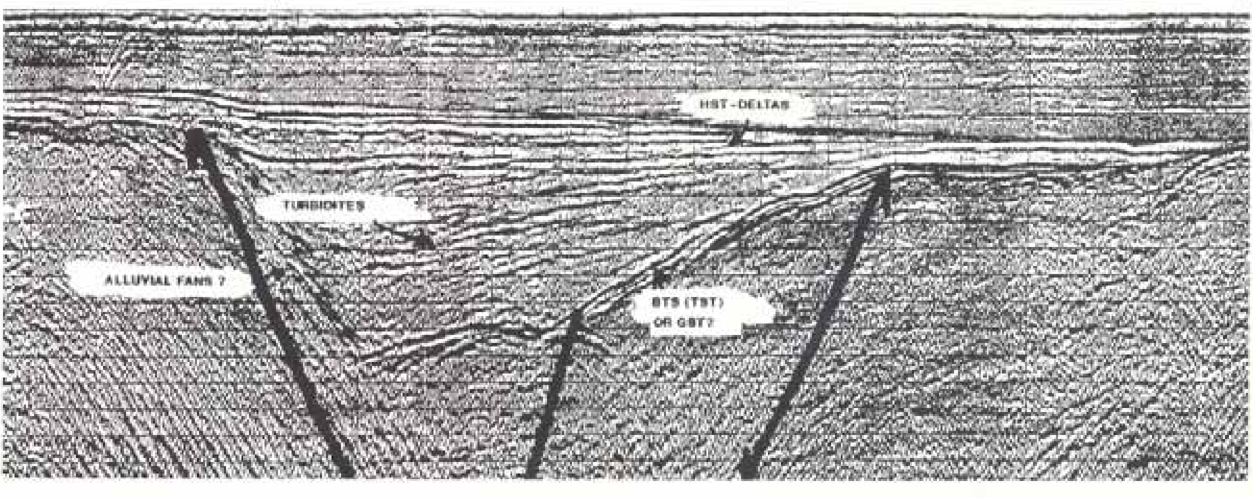
with

Rob Kirk
BHP Petroleum

Bottom Figure – "Seismic line from South East Asia". Top Figure – "Outcrop schematic section from the Ridge Basin, California".

Analogies! Build up your analogy database so you can use it to sell your ideas.





Student Abstracts – Index

UNIVERSITY OF QUEENSLAND

The Use Of Vertical Electric Soundings To Determine The Electrical Properties Of The Weathered Layer In The Boonah Area, South-East Queensland
Anastasia Boylson

Seismic Applications Of Multi-Component Wavefield Separation Techniques
Luo Mu

Evaluation Of An Inverse Method Using The Phase Spectrum Of A Magnetic Anomaly
Monica Wurfel

UNIVERSITY OF ADELAIDE

Applications of three component aeromagnetic data to iron ore exploration in the Hamersley Basin, Western Australia
Lynelle Beinke

A Regional Compilation of the Radiometric Coverage of the Gawler Craton, SA
Igor Chourouev

The use of interval velocities for determining uplift and depth conversion in the Northern Carnarvon Basin
Matt Densley

An investigation of reconnaissance induced polarisation using forward three-dimensional numerical modelling
Nicholas Mumford

A gravity and aeromagnetic investigation of sub-surface granitoids in the Pine Creek Geosyncline
Scott Reynolds

Modelling gravity data in the Eastern Tantanoola Trough, Otway Basin, Victoria
Phillip Skladzien

UNIVERSITY OF WOLLONGONG

The Geophysics of the Aaron's Pass Granite
Matthew B. J. Purss

UNIVERSITY OF NEW SOUTH WALES

Geological Mapping And Mineral Exploration In An Area Of Poor Exposure, Southern New South Wales.
Damien Ewington

CURTIN UNIVERSITY

The Expression Of Low-Throw Complex Faults In Surface Seismic Data
Simon Davis

The Effects Of A Complex Anisotropy On Seismic P-Waves : 2.5D Physical Modelling Experiment.
Micheal Isherwood

CRC AMET

Curtin and Macquarie Universities, see introduction by Paul Wilkes.

HONORS PROJECTS

Investigations Over An Aem Test Site, Bencubbin, WA.
Cliff Allen

Evaluation of an EM model as a possible correction for gravity
M.F. Braine

Separation Of Magnetic And Conductive Sources In Hem Data - The Feasibility Of Magnetic Permeability Mapping In Iron Ore Exploration
Alistair McMillan

Geophysical Signatures Of An Internal Granitoid Contact, Yandal Greenstone Belt, Yandal, Wa.
Paul McMillen

Application Of Three-Component Downhole Pem To Nickel Exploration In The Eastern Ultramafic Belt, W.A.
Russell Mortimer

Exploration Geophysics In The North Kimberley Kimberlite Province Of Western Australia
Jon Sumner

Geophysics In Salininty Studies, Manjimup Area, WA.
Ben Whitfield

PHD PROJECTS

Analysis And Interpretation Of The AEM Response Of The Australian Regolith.
David Annetts

Electromagnetic Response Optimization By Three Dimensional Modelling.
Brett Harris

Multi-Dimensional Inversions And Approximate Interpretation Of Airborne Electromagnetic Data.
Jiuping Chen

Efficient Induced Polarisation And Resistivity Measurements.
Kanglin Lu

Mathematical Modelling Of The Electrical Potential In 3-D Inhomogeneous Anisotropic Media.
Ping Li

Current Gathering In AEM Data.
James Reid

Some Processing Techniques For The Enhancement Of Electromagnetic Signals. In Geophysical Exploration.
Michael Sykes

Student Abstracts

UNIVERSITY OF QUEENSLAND

Evaluation of an inverse method using the phase spectrum of a magnetic anomaly

By Monica Wurfel
(Bachelor of Applied Science (Geophysics) Degree)
Supervisor: Dr. Peter Furness, Department of Earthsciences, University of Queensland

An inverse method proposed by Thomas Moriarty (1988) to determine the direction of remanent magnetisation associated with magnetic anomalies is evaluated. Moriarty's method utilises the properties of the phase spectrum of the observed magnetic field, and its relationship to the Green's function for magnetic sources. His technique was developed assuming any observed magnetic anomaly was purely due to remnant magnetism. Moriarty claimed that this assumption was appropriate for the seamounts he was studying. However, in general the magnetisation vector of an anomalous region has a significant component due to induced magnetisation.

Fortran code is developed and used together with PEST software to trial Moriarty's inversion technique for the more general case where the magnetisation vector of the source has a significant component due to the induced field. Two essential assumptions must be met for the inversion process to work. Firstly, the centre of symmetry of the body must be at the origin of the coordinate system. Secondly, the anomaly must be unaffected by surrounding sources.

The technique is accurate for synthetic data when the interpreted centre of symmetry is close to the true centre of symmetry. For real data the technique is less robust. Moriarty's technique requires that the anomaly be the result of one body with uniform susceptibility and remanence, and that the anomaly be unaffected by surrounding sources. Geologically this is highly unlikely, making Moriarty's technique impractical for exploration work.

Moriarty, T.D (1988) Estimation of the Direction of Remanent Magnetisation: An Inverse Method Using the Phase Spectrum of a Magnetic Anomaly; Master's Thesis, Texas A&M University.

The use of vertical electric soundings to determine the electrical properties of the weathered layer in the Boonah Area, South-East Queensland

By Anastasia Boylson
(Bachelor of Applied Science (Geophysics) Degree)
Supervisor: Dr. Peter Furness, Department of Earthsciences, University of Queensland

The Schlumberger array is used to determine near surface resistivities of various lithologies within the Boonah area, southeast Queensland. The project aims to distinguish factors having significant effect on weathering layer parameters. Previous investigations around the world show that any underlying rock has a unique effect on the resistivity of the overlying soil profile and weathered layer. However, little work has been done in areas with a subhumid-subtemperate climate.

Results from the Boonah area support findings from previous investigations. The resistivity of the weathered layer is found to increase with the increase in silica content of the parent rock, increase of resistance to weathering of the parent rock, and increased depth to the water table. In addition, electrical properties of the weathered layer are found to be intrinsically related to the weathering regime, which in turn is dependent on topography and climate.

In terrains with little or no fresh rock outcrop resistivity techniques could prove very useful in mapping the underlying geology and investigating groundwater accumulations.

Seismic applications of multi-component wavefield separation techniques

By Luo Mu (Master of Science Degree)
Supervisor: Dr. Steve Hearn, Department of Earthsciences, University of Queensland

Two relatively novel wavefield separation techniques are examined. Spectral matrix filtering (SMF) has received minimal coverage in the geophysical literature. Polarisation filtering (PF) has been more widely used, although application in exploration seismology has been limited by the general lack of multi-component recording.

SMF wavefield separation requires smoothing of the cross-spectral matrix constructed from a 2D seismic image, followed by decomposition into a number of eigenimages. This concept is introduced in the context of single-component seismic wavefield separation. Testing on synthetic vertical seismic profile (VSP) images demonstrates practical issues relating to various options of frequency and/or distance smoothing. Combined frequency/distance smoothing has potential application for single-pass separation of upgoing and downgoing VSP wavefields. This is demonstrated using real VSP data. SMF provides a useful alternative to more common VSP wavefield separation methods, although it is computationally expensive.

Application of SMF as a true multi-component wavefield separation tool is also demonstrated. In this context the desired wavefield is estimated within a time window where it is best represented. The wavefield of interest is then extracted from any other window, or component, by projection. This process

is applied to the problem of separation of P and SV wavefields in VSP data, with example applications to noisy synthetics, as well as real, multi-component VSP data.

Two PF algorithms are outlined - the Principal Component method, and the Generalised Least Squares approach. Results from these two algorithms are shown to be similar. Two broad categories of polarisation filter are considered. The 'pass plane' or rotation filter is regarded as more flexible than the 'classic' or projection filter.

The first real-data application of PF concentrates on shear wave splitting (SWS) analysis of multi-component VSP data. The polarisation method proves competitive with other efficient SWS algorithms. The second application of the PF method is to the problem of phase identification in teleseismic and region earthquake recordings. PF assists in the identification of crustal conversion and reverberations from Fijian and Japanese compressional wave arrivals at the Charters Towers seismograph station, providing constraints on gross crustal thickness and velocities. In addition, PF is used to assist in the identification of crustal refraction phases from regional earthquakes recorded on microearthquake systems in North Queensland.

UNIVERSITY OF ADELAIDE

Applications of three component aeromagnetic data to iron ore exploration in the Hamersley Basin, Western Australia

Lynelle Beinke
with Hamersely Iron

The potential applications of three component aeromagnetic data in iron ore exploration have been investigated through a forward model study and the interpretation of real data from the Hamersley Basin. The use of three component aeromagnetic data for iron ore exploration in the future has been recommended.

Modelling has shown that the true intensity and topology of the anomalous magnetic field calculated from three component data can be used to accurately map magnetic bodies. Modelling has also shown that the magnetisation direction of magnetic bodies can be calculated from the declination, inclination, and topology of the anomalous magnetic field. The magnetisation direction can be related to the magnetic properties of underlying bodies, and so help

identify prospective iron ore environments. The application of these results is complicated by topographic and demagnetisation effects, although these may be accounted for with good geological knowledge.

The interpretation of three component aeromagnetic data from the Hamersley Basin indicates that the results obtained from the model study are applicable to real data. Locations that possibly have high remanence, potentially due to hematite enrichment, have been identified from the three component aeromagnetic data.

The generation of three component data from modelled total magnetic intensity (TMI) and three component data is successful. Importantly, it should be possible to generate three component aeromagnetic data from existing TMI data. This means that locations where coverage by TMI data is extensive, such as the Hamersley Basin, can be reinterpreted without the expense of acquiring three component aeromagnetic data.

A Regional Compilation of the Radiometric Coverage of the Gawler Craton, SA

Igor Chourouev
with Pitt Research

Airborne Gamma Ray Spectrometry is an effective tool for mineral exploration, geological mapping and solving environmental problems. Although this method provides valuable geological information its application in mineral exploration is quite limited in comparison to the other geophysical methods. To encourage mineral explorers to make better use of an under-utilised data source an attempt was made to establish a consistent radiometric coverage of the North Gawler Craton.

The radiometric coverage of the North Gawler Craton comprises about twenty surveys which have been conducted by different companies during the last twenty-five years. Some of the old airborne surveys carried out before 1991 did not meet the requirements of the standard spectral windows and calibration ranges recommended by the International Atomic Energy Agency in 1991. The quality of the data was also different between surveys and depended very much on the time observations were made. Because of that an individual, time-intensive approach was adopted in reprocessing the old and low-quality radiometric data. The process of compilation of the radiometric coverage of the North Gawler Craton included: analysis of raw radiometric data and elimination of the noise, merging individual survey grids for each channel; production of colour images K, Th, U and total-count and RGB composites. The images have been incorporated into regional mapping at the 1:1 000 000 scale.

The data processing and merging was conducted using the SCENARIO software package which has been created and developed by Pitt Research Pty Ltd. The interpretation of the Gawler Craton radiometric images has been started with defining the clearest and simplest areas. The false colour K-U-Th image with K = red, U = blue and Th = green is displayed for areas of similar high (white colour) and low (black colour) response. Then the interpretation map has been refined using the individual K, U & Th images and images of the ratios (e.g. K/Th, U/Th, K*K/Th). The defined units have been compared with existing geological maps and other available information. Results of examinations of the individual channel images and images of the ratios with the geological map show that the most of igneous and some sedimentary rocks in the Gawler Craton produce a good contrast with the surrounding rocks and can be mapped with radiometrics.

The use of interval velocities for determining uplift and depth conversion in the Northern Carnarvon Basin

Matt Densley
with Santos

Interval velocities were determined from drift corrected sonic logs and vertical seismic profiles for the following intervals in 169 wells in the northern Carnarvon Basin:

- seafloor-top Toolonga Calcilutite;
- top Toolonga Calcilutite-top Gearle Siltstone;
- top Gearle Siltstone-top Muderong Shale, and;
- top Muderong Shale-base Muderong Shale.

Interval velocity-depth plots for each of the intervals show relative overcompaction (ie. anomalously high interval velocities) in many wells. Such overcompaction may be due to post-depositional uplift, lateral facies variation, or diagenetic effects.

Apparent uplift (the amount of overcompaction measured along the depth axis) was determined for each interval. The apparent uplift values from the three intervals containing predominantly Toolonga Calcilutite, Gearle Siltstone and Muderong Shale respectively, are statistically similar. The consistency of results in these three intervals suggests that, at a regional scale, overcompaction reflects previously greater burial depth, rather than lateral facies variation and/or diagenetic processes.

The greatest amount of apparent uplift is observed along several main trends. These uplifted trends correspond with some of the main tectonic elements of the northern Carnarvon Basin. Apparent uplift of approximately 800 m was detected along the Legendre Trend, while a similar amount of apparent uplift was observed along the Barrow Arch. In excess of 900 m of apparent uplift was seen on the Bambra Anticline. Significant apparent uplift of about 600 m was also detected along an anticlinal trend between West Barrow and Rosily. The uplift was interpreted to be caused by structural inversion in Middle Miocene times.

Interval velocities were also used to calculate velocity anomalies for the selected intervals. This was achieved by fitting regional velocity-depth functions to the input layer velocities. Anomalies with respect to these regional functions were mapped and used in conjunction with the regional functions in order to undertake depth conversion. Depth conversion using velocity anomalies was compared with using ÒrawÓ interval velocities. The interval velocity method used constant layer interval velocities as predicted by interval velocity maps. The depths determined using the two methods were compared with the actual depths at five carefully chosen test wells.

The difference in the depths predicted by velocity anomaly and interval velocity methods was not statistically significant. Thus, in the northern Carnarvon Basin, maps of velocity anomaly do not characterise the lateral velocity variation significantly better than maps of interval velocity. As the velocity anomaly method is not significantly more accurate, the interval velocity method should suffice as a regional depth conversion technique in this region.

An investigation of reconnaissance induced polarisation using forward three-dimensional numerical modelling

Nicholas Mumford
with Zonge Engineering and Rio Tinto

Reconnaissance Induced Polarisation (RIP) is used as an initial geophysical survey method to locate a chargeable orebody. The two major techniques used for this process, Vector RIP and Tensor RIP, both have their benefits and shortcomings. Important information may be found in the results from both techniques. Therefore, neither should be used exclusively in preference to the other.

Tensor RIP adopts the use of two transmitter (Tx) bipoles, usually set at right-angles to one another. Results from multiple data sets allows the derivation and calculation of mathematical matrix *averages* of the electric fields. The properties of these tensor calculations are largely independent of Tx direction and may be derived from either complex resistivities or in-phase and out-of-phase components of the electric field vector. Consequently, the results of four different tensor calculations may be interpreted from one Tensor RIP survey. It is indeed a necessity to use all four tensor calculations as an aid in the debugging of field acquired data sets.

Vector RIP has the advantage of substantially less data reading time and less set-up time with the use of only one Tx bipole. It is often through the use of the single Tx however that misleading features are produced in the data. This is because the direction of the electric field vector produced by any single Tx varies with the relative distance and position from it. Thus, the location of where readings are taken relative to the Tx is important for this technique.

Using forward three-dimensional (3-D) numerical modelling of a homogeneous half-space, an understanding of the basic concepts which explain the behaviour of the electric field vector can be established. These concepts can be used to explain the differences observed in the results of the Vector and Tensor RIP techniques. Furthermore, these concepts can then be applied in understanding the results of more complex 3-D modelling scenarios.

A gravity and aeromagnetic investigation of sub-surface granitoids in the Pine Creek Geosyncline

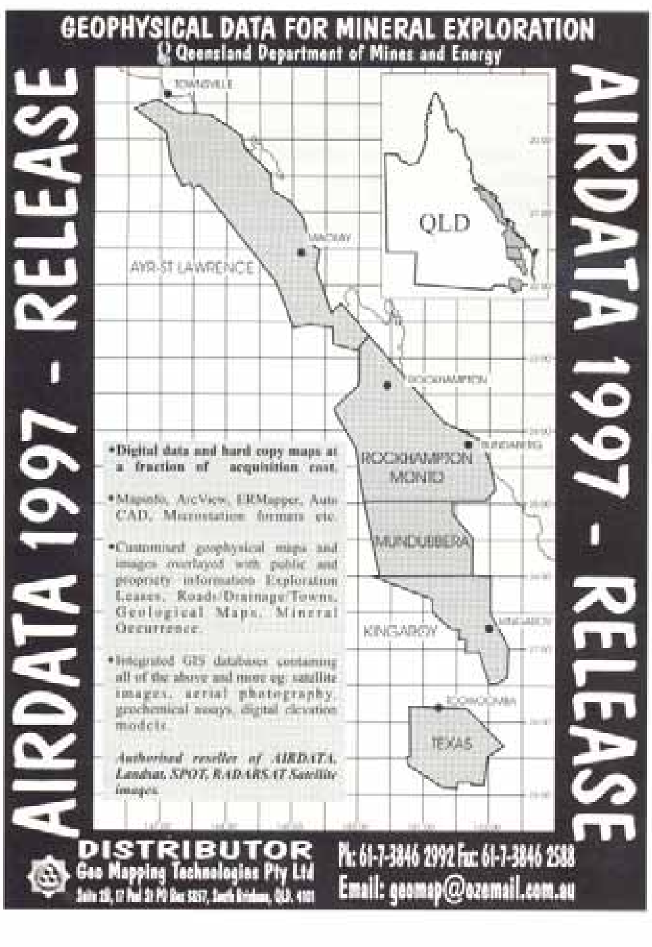
Scott Reynolds
with Northern Gold

The existence and extent of a sub-surface granitoid in the Pine Creek Geosyncline has been investigated by the use of newly acquired gravity, and existing aeromagnetic data. A nearby outcropping granite exhibits a density contrast of -0.1 gcm^{-3} with respect to surrounding metasediments. A large gravity low in the gravity data is interpreted to be due to a sub-surface granitoid. Modelling of this data indicates a body approximately 12 km long and 4 km wide at a depth of less than 1000 metres. This interpretation suggests a larger granite body than was previously considered to underlie the area.

The magnetic susceptibility of the metasediment samples ranged over three orders of magnitude whereas the granite exhibits a zero susceptibility. The extension of the interpreted granitoid from the gravity data is consistent with the aeromagnetic data, however it is partially obscured by higher frequency magnetic sources interpreted to overlie the granitoid. Magnetic modelling has provided no additional information on the location of the granitoid.

Spectral analysis and Euler deconvolution indicate depth to the overlying magnetic sources to be approximately 400 m. Results from spectral analysis suggest the granitoid extends to a depth of 2 000 m. A number of disruptions in the magnetic anomaly pattern have been revealed by spectral analysis, possibly indicating faults.

The deposits along the Howley Anticline are now located within one to two kilometres of a granitoid body. The potential for gold mineralisation has been increased in the vicinity of the granitoid and especially along the nearby Howley Anticline. Results support the use of gravity to define granitoids in future exploration work.



Modelling gravity data in the Eastern Tantanoola Trough, Otway Basin, Victoria

Phillip Skladzien
with Santos

Gravity data acquired in the western Otway Basin, concurrently with a seismic survey, has been merged with the most up to date public domain gravity database available for the study area. A common Bouguer reduction density of 2.0 g/cm^3 has been used in the merging process, resulting in the production of an improved gravity dataset for the study area.

Modelling of gravity data has been carried out. Initial gravity models were based on interpreted seismic sections. Densities derived from the analysis of density logs have been used to further constrain gravity models. Average density values for sediments range from 2.28 g/cm^3 to 2.49 g/cm^3. A basement density of 2.6 g/cm^3 has been used.

A regional gravity gradient increasing towards the continental margin has been removed to enable modelling work. The magnitude of this regional increases from approximately 30 mGal in the north of the study area to 60 mGal in the south.

Gravity models have confirmed the existence of the NW-SE trending Tantanoola Trough, thus substantially increasing the overall hydrocarbon prospectivity of the Otway Basin.

UNIVERSITY OF WOLLONGONG

The Geophysics of the Aarons Pass Granite

Matthew B. J. Purss
Honors Project University of Wollongong
Supervisors Dr Leonie E Jones and Dr John pemberton

ABSTRACT

The Aarons Pass Granite is a Carboniferous I-type granite of the northeastern Lachlan Fold Belt speculated as possessing a faulted western margin. It is a paramagnetic to moderately ferromagnetic magnetite-series granite containing highly variable internal magnetic susceptibilities and exhibiting a mean susceptibility considerably lower than most Lachlan Fold Belt I-type granites. The bimodal nature of the magnetic susceptibility contrast, between less magnetic and more magnetic sub-populations, is interpreted as being a function of magnetite degradation within the less magnetic sub-population.

The total magnetic intensity over the granite displays a 'horse-shoe' shaped anomaly of relatively high magnetic intensity open to the northwest and enclosing a region of relatively low magnetic intensity. The anomaly reflecting the granite at depth extends ~10 km further west from the granite outcrop. The western margin of the granite has been interpreted as a possible faulted contact but owing to the lack of geological evidence it is impossible to arrive at any solid conclusions. With the aid of detailed image analysis (investigating aeromagnetic and airborne radiometric data from the Mudgee 1:100 000 Sheet, and gravity data from the Australian National Gravity Database) and petrophysical studies a preliminary attempt at three dimensional gravity and magnetic modelling of the granite has been made with the purpose of verifying the existence of such a boundary. A nominal 1 km spaced gravity traverse was conducted in order to gain a finer control on the existing gravity data for the gravity modelling.

The radiometric response from the Aarons Pass Granite exhibits two zones of distinct radiometric character, separated by a roughly east-west trending linear demarcation. The northern side of this feature displays relatively high counts of potassium, thorium, and uranium. The southern side, however, shows predominantly a high potassium-low thorium response. A study of soil and rock geochemistry from samples obtained on either side of the dividing feature was used to determine the likely cause of this feature. The results show a decrease in thorium and uranium concentrations in the granite soils from north to south across the demarcation, possibly due to leaching, differential weathering, or the transportation of soils from adjacent rock units.

UNIVERSITY OF NEW SOUTH WALES

Geological mapping and mineral exploration in an area of poor exposure, southern New South Wales

Damien Ewington,
Honours Applied Geology, UNSW

ABSTRACT

A project area of approximately 825 km² has been delineated over a region dominated by alluvial and colluvial cover. The study area is centres upon the township of Pleasant Hills, approximately 50 km southwest of Wagga Wagga. Geophysical interpretation, outcrop mapping, and minor petrochemical assessment have been used to aid geological interpretation and mineral exploration over the study area. This project has provided an understanding of the detailed geology and mineral potential of the area by integrating all project data into a geographic information system (GIS). Geophysical techniques employed in this project include aeromagnetic, radiometric, and DTM imagery, supplemented by Landsat TM imagery.

The mineral potential of the area was determined from observations in the field, petrochemical assessment, and the geophysical imagery. The Pleasant Hills study area contains a small number of mineral occurrences, including abandoned gold workings, tourmaline pegmatites, and possible Sn-W greisens. A rhyolitic tuff unit with the project area is pervasively propylitically altered and contains minor sulphide mineralisation. Three possible mineralisation styles are interpreted for the Pleasant Hills area. Sn-W greisen mineralisation within ?Lower Devonian S-type granites; quartz vein-hosted gold controlled by regional northeast and north-northwest trending faults, and, volcanic-hosted polymetallic deposits associated with propylitic alteration.

The use of the geophysical and remotely sensed imagery, coupled with data manipulation in a GIS, has shown to be highly useful in areas under cover. The ability of the GIS to readily display simultaneously spatially registered, individual datasets for visual analysis enable the user to more accurately and effectively create interpretations. Map production with grids, legend and geological symbols is also easily achieved, and the map can be quickly edited. The application of a GIS in areas of poor exposure is recommended.

CURTIN UNIVERSITY

The Expression of Low-Throw Complex Faults in Surface Seismic Data

by Simon Davis
B.Sc. (Geophysics)

This report is presented as part of the requirement for the unit Geophysics Dissertation 495, a unit of 50 credit points towards the Honours degree in Geophysics from the Curtin University of Technology. It is the result of supervised research; however, the report has been prepared by the student who is solely responsible for its contents.

ABSTRACT

The assumption of an isotropic earth for reflection seismology is incorrect; the earth is anisotropic. Anistropy is defined as the difference in physical properties of a medium with respect to the measurement direction. The most common form of anisotropy is transverse isotropy, which signifies a medium with a single symmetry axis. The seismic velocity varies only with respect to the angle from this symmetry axis but not in the plane of symmetry. Anisotropy has been observed in both the field and through physical modelling by numerous researchers. Three common forms of transverse isotropy are; that caused by the preferential grain alignment such as in clays; that caused when the thickness of the layers (of various velocities) in sedimentary rocks is less than approximately eight times the seismic wavelength (layer induced); and that produced by aligned fractures (fracture induced). The detection of the latter is important as good hydrocarbon reservoir rock is often encountered when both porosity and permeability are increased through fracturing.

Physical modelling experiments were undertaken using the Solid Modelling facility available at the Department of Exploration Geophysics, Curtin University of Technology, Western Australia. A scaled physical model was constructed to simulate a fractured zone with a prevailing hexagonal symmetry (horizontal axis of transverse isotropy) within a layer induced transversely isotropic medium. The model was constructed so that the effects on the seismic data acquired over the model are due purely to the changes in the orientation of the symmetry axis.

The Phenolite used as a modelling material was shown to have an anisotropy of twenty five percent and to possess hexagonal symmetry. A reduction in the reflection time from the bottom of the model was observed for data acquired over the fracture zone. The effect of changing offset and azimuth on the seismic response from the fracture zone was investigated (with source-receiver offset variations showing unique features). The amplitude and instantaneous frequency for each azimuth showed changes as a result of the fracture zone. Moveout differences were observed between data acquired along the fracture zone and data acquired in the layered regions of the model. A very interesting result was the change of the rate of amplitude loss with offset, between the different regions of the model, in the 2.5-D data set. The result from stacking a variable offset common midpoint point (CMP) seismic line was surprisingly good. This indicated that the effect of fractures can easily be overlooked in practice, or mistaken with some other geological features. It has been shown that the numerous anomalous features observed, resulted from purely symmetry changes.

The effects of a complex anisotropy on seismic P-waves 2.5D physical modelling experiment

by Michael Isherwood
B.Sc Geophysics

This resport is presented as part of the unit of Geophysics Honours Dissertation 495, a unit of 50 credit points in the Honours Degree in Geophysics at Curtin University of Technology. It is the result of supervised research; however the report has been prepared by the student who is solely responsible for its contents.

ABSTRACT

Despite many small geological features of interest to the geophysicist occurring beyond all limits of resolution, they still possess a seismic expression, that is, are not beyond the limits of detection. Specifically, the expression of low-throw complex faults in surface seismic data was examined. These are defined as possessing multiple stages of structural displacement that occur within a spatial extent so that the resolution of separate segments is not readily achieved. Such faults pose a potential problem to the longwall extraction of coal. If undetected they can result in the costly termination of mining and worse still roof instability.

Physical modelling techniques were used to study the effect of complex faulting on seismic P-wave propagation. Both constant and variable offset 2-D surface seismic data was recorded over a model containing complex faulting at various azimuths to the fault's strike. Interpretive processing techniques were then performed on the data, the emphasis being on complex trace analysis and pseudo 3-D pre-stack analysis.

The study showed that a number of characteristic amplitude anomalies represent the seismic expression of complex low-throw faults as seen in 2-D surface seismic data. Specifically detected were multiples regions of constructive interference between diffracted and primary reflected energy, dominant diffraction patterns and a characteristic internal amplitude anomaly. All indicated the presence of fault complexity. However, the actual degree of fault complexity, that is the number of individually displaced segments, could not be detected using surface seismic techniques.

The results of multi-azimuth recording over the complex fault showed that the visible effect of the complex faulting on seismic P-wave propagation did not alter with azimuth. With significant implications to the coal industry it was also found that an impulsive source signal, as opposed to a swept signal, is crucial when imaging unresolvable structures. Likewise the significance of recording near offset data, ensuring near vertical travel paths over the complex fault, was also demonstrated.

THE ROLE OF THE COOPERATIVE RESEARCH CENTRE FOR AUSTRALIAN MINERAL EXPLORATION TECHNOLOGIES (CRC AMET) IN EDUCATION AND TRAINING

By Mr Paul Wilkes,
CRC AMET Education Leader and
Senior Lecturer in Exploration Geophysics, Curtin University

When CRC AMET began its life, in 1992, one of its goals was to work to improve the quality of Geophysical Education and Training in Australia. The program goal for Education and Training was to develop a coordinated education program in mineral exploration techniques by fostering undergraduate courses and establishing postgraduate and in-service courses compatible with the needs of the exploration industry. To achieve these aims CRC AMET has:

Increased the numbers of Geophysicists on the staff at both Curtin and Macquarie Universities - the two partner universities in CRC AMET - and increased the participation of other Geophysicists and Geologists from other organisations Eg AGSO, CSIRO, Geological Surveys, Mining Companies, Consultancies, Contractors and other Universities.

Established scholarships for the most talented honours geophysics students at both Curtin and Macquarie Universities. This has significantly increased the number of and quality of honours students at these universities. In 1997 there were nine honours Geophysics students at Curtin and four at Macquarie. The students are encouraged to work closely with exploration companies and increasingly are working on company initiated projects and with company staff as joint supervisors.

1. **Established a new Masters course in Mineral Exploration Technologies (MMET)**

Specifically designed for Geoscientists working in Mineral Exploration companies. From the start of the MMET program, in February 1993, to end 1997, CRC AMET has run 27 units as modules of the M.Sc course and also as individual short courses. The program is now in its third cycle. The Masters program requires completion of 12 units made up of 11 courses plus a semester long project. The first students are completing their Masters degrees in 1998. Courses have been run in Broken Hill, Kalgoorlie, Parkes and Perth. All the courses which run in locations other than Perth have included fieldwork.

The units which have been run are as follows :
Borehole methods
Electromagnetic methods (2 units
Exploration Geochemistry
GIS, Data processing and Image processing
Geographic Information Systems - applications in Mineral
Potential mapping
Magnetics and Gravity
Mathematical Methods
Orebody models
Radiometrics and Remote Sensing
Regolith Geology
Resistivity and Induced Polarisation
Structural Geology

The number of mining company students undertaking the full Masters program has built up to eleven and many other students have attended individual units as short courses. It is gratifying to note the increasing support from mining companies and the increased participation of overseas students. By the end of 1997, 105 individual Geoscientists had attended MMET units.

The leaders for all the courses are carefully selected as experts in their fields and have come from CSIRO, Consultancies, Contractors, Geological Surveys, Mining Companies and Universities.

MMET Courses and Instructors: 1996 and 1997

Course	Dates	Venue	Instructors	Affiliation
Radiometrics and Remote Sensing	March 1996	Perth	Tim Munday Ian Tapley Tom Cudahy Bob Gozzard Paul Wilkes	CRC AMET / CSIRO CRC LEME / CSIRO CSIRO CRC AMET / GSWA CRC AMET / Curtin
Numerical Methods and Inversion	March 1996	Perth	Umesh Das Paul Wilkes	CRC AMET / Curtin CRC AMET / Curtin
Magnetics and Gravity	August 1996	Perth	Duncan Cowan David Isles Paul Wilkes	Cowan Geoscience Consultant CRC AMET / Curtin
Electromagnetics	August 1996	Parkes	Jim Macnae Mike Asten	CRC AMET / Macquarie Monash / Consultant
Resistivity & IP	August 1996	Parkes	Ted Tyne John Bishop	Encom Mitre Geophysics
Structural Geology	March 1997	Kalgoorlie	John Baxter	Continental Resource Management Julian Vearncombe Vearncombe & Assoc
GIS and Image Processing	March 1997	Perth	Bert Veenendahl Paul Wilkes	Curtin GIS Dept. CRC AMET / Curtin
Advanced EM	June 1997	Perth	Jim Macnae	CRC AMET / Macquarie
Borehole Geophysics	June 1997	Kalgoorlie	Ted Tyne John Bishop	Encom Mitre Geophysics
Regolith Geology	July 1997	Perth	Ravi Anand Ray Smith Charles Butt Ian Tapley Tim Munday Paul Wilkes	CRC LEME / CSIRO CRC LEME / CSIRO CRC LEME / CSIRO CRC LEME / CSIRO CRC AMET / CSIRO CRC AMET / Curtin
Seismic Methods	July 1997	Perth	John McDonald Peter Hatherly Milovan Urosevic	APCRC / Curtin CRC MTE / CSIRO APCRC / Curtin

Increased opportunities for PhD studies, at both Curtin and Macquarie Universities, by providing scholarships and participation in CRC AMET projects. This has created an environment where postgraduate students work alongside experienced Research Scientists to the benefit of all involved. At the end of 1997 nine doctoral students were receiving CRC AMET scholarships. Additional students receive scholarships from other sources. A list of PhD projects is included at the end of this paper together with some short summary profiles of current projects.

In summary CRC AMET has achieved many of the original goals in Education and Training and has helped to improve Education for Exploration within Australia and overseas. CRC AMET looks forward very positively to increasing the focus on education and technology transfer and to continue the good work into a new or renewed CRC beyond mid 1999.

HONORS PROJECTS

Investigations Over An AEM Test Site, Bencubbin, WA

By Cliff Allen
Curtin University/Exploration Geophysics
Supervisors: Paul Wilkes (CRC AMET) and
Dr Tim Munday (CRC AMET)

ABSTRACT

There is a requirement to refine the acquisition and interpretation of airborne electromagnetic (AEM) methods. The AEM technique is becoming increasingly popular as it covers large areas quickly and at relatively low cost. Test sites over known conductors are required to help the refinement of AEM methods.

The Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET) is working on improving AEM methods and has proposed that an area near Bencubbin, in Western Australia, be established as a test area. Four surveys using QUESTEM and SALTMAP have been flown over the area and data from these have been inverted using Sattel's layered earth inversion method and Macnae's conductivity depth imaging (CDI) method.

This project has included the researching and compilation of relevant, existing information for the area, to create a comprehensive set of comparable geological and geophysical information. The project has also included the acquisition and interpretation of SIROTEM data to help investigate the effectiveness of the AEM data inversions and to confirm the suitability of the area as a test site.

From the existing information, it was found that the mineralisation contained within the test site is a non-economic pyrite zone. This has been drilled, and surveyed using Crone Pulse EM prior to 1978. Interpretation of the project's SIROTEM data indicated a strong IP effect which exists within anomalies due to shallow and deep conductive weathering.

The area appears to be very resistive with most decays following a power law. The known pyrite zone is not responsive to the AEM systems used. The two inversion methods did not seem accurate for shallow investigations. The conductivity depth images of the QUESTEM 25 Hz data proved best to identify deep conductors.

The area may serve well as a test site for researching the effects of weathering in EM surveying but not in testing systems to look for commercial deep conductors. The accessibility of the area is generally excellent with no problems in getting entry permission from the land owners or tenement holders. Some of the land is used to grow wheat and the growing season restricts access. The land surface is very convenient for vehicle access and ground em surveying.

Evaluation of an EM model as a possible correction for gravity

by M.F. Braine
School Earth Sciences, Macquarie University, Nth Ryde, NSW 2109.

ABSTRACT

On the Australian continent, inhomogenous regolith acts as a shallow source of gravity anomalies, and hence provides a significant interpretational problem for mineral explorationists. Published results from Western Australia, identify the geometry of the basement topography as being reflected in the gravity profiles. Exploration beneath this inhomogeneous regolith, using gravity without the effect of the regolith cover itself, would provide a distinct improvement of gravity's diagnostic capability.

Initial analysis determined that EM was a feasible method to define basement topography, from which a gravity correction could be attempted. The primary question needed to assess the feasibility was: 'Does a mappable conductivity boundary correspond to each major boundary of density contrast?' Testing of this hypothesis was completed at Elura, NSW by constructing an EM model and a gravity model for the purpose of interpretation. In surprising contrast to petrophysical evidence, gravity profiles at Elura reflected lithology as being more important than the depth of the basement. An attempt to apply the geometry of the modelled EM basement/regolith contact as a means of creating a model for gravity correction, saw no improvement in the residual gravity profile. The regolith structure at Elura was geophysically delineated as having a progressively increasing resistivity with depth, and where gravity highs are not reflected in basement highs.

The original hypothesis for this work, 'Does a mappable conductivity boundary correspond to each major boundary of density contrast?' was therefore answered in the negative at Elura. What is hypothesised, is that the local gravity response is largely due to lithological relationships, whether related to bedrock or palaeodrainage. EM data on inversion provide a quite different image of the regolith/basement interface than that estimated from gravity. Further work on these differences are essential for a deeper understanding of the geophysical signature.

Investigation of a New Technique for the Correction of Static Shift Distortion in Magnetotelluric Soundings

By Leharne Lay
Macquarie University/School of Earth Sciences
Supervisor: Prof. James MacNae

ABSTRACT

Despite the many potential applications of the magnetotelluric (MT) method, it has accounted for only a small percentage of exploration effort. The factor most responsible for the limited use of magnetotellurics is the distortion of the electric field component that arises from the accumulation of charge on the boundaries of near surface inhomogeneities. Although this so-called "static shift" has remained a primary focus of geoelectric research since the discovery of its effects, no definitive solution has been developed to date.

This thesis documents the earliest stages in the development of a static shift correction technique, which differs from all previously developed methods. Unlike its predecessors, this approach specifically addresses the physical basis of the boundary charge distortion of the electric field, which gives rise to the effect. The measurement of the estimated static shift or "MESS" correction method utilises an artificial inductive source to emulate the local behaviour of the natural magnetotelluric field. Direct measurement of the distortion of the inductive source telluric field (ISTF) then provides an estimate of the distortion of the natural telluric field.

Numerical modelling was carried out to support the theoretical justification of the technique in its scalar form. This involved the application of normalised ISTF responses as corrections for static shift distortion observed in synthetic MT soundings. A further aim of modelling, was to determine in what way the exact details of the inductive source geometry used, in particular the polarisation and curvature of the ISTF, bear on the effectiveness of the MESS correction.

For all models tested, application of the MESS correction provided a substantial reduction in static shift. The best corrections were obtained with a uniform induced field, an identical polarisation of MT and ISTF. Application of mixed polarisation's and varying degrees of ISTF curvature provided corrections with variable success. The uniformity of the induced field was deemed to be more important than polarisation for the models tested.

Separation of Magnetic and Conductive Sources in HEM Data – The Feasibility of Magnetic Permeability Mapping in Iron Ore Exploration

By Alistair McMillan
Macquarie University/School of Earth Sciences
Supervisor: Prof. James MacNae

ABSTRACT

In general the information content of data from HEM transmitter-receiver coil pairs, consists primarily of the sum of two different phenomena, ie conductive eddy current response and magnetic polarisation response. The secondary field at the receiver coil, resulting from conductive eddy currents, induces in-phase and quadrature components in the coil which are customarily signed positive. The amplitudes of the components are frequently-dependent. In contrast, the secondary field at the receiver coil, resulting from magnetic polarisation, usually only induces an in-phase component of negative sign in the coil. The amplitude of this component is commonly frequency-independent.

A technique has been developed to produce to produce magnetic permeability maps from the low frequency coplanar coil pair used in the DIGHEM helicopter FEM system, by taking the difference between the recorded and predicted in-phase responses, which is roughly similar to inverting the electromagnetic data to an n layered earth plus an extra shift factor. The apparent magnetic permeability can then be calculated from this shift factor by modelling the data with a non-conductive permeable half-space. The method is complementary to both conventional magnetic mapping and conductivity / resistivity mapping. The method, though less sensitive than magnetic mapping to sources at depth, is better able to separate the responses of shallow magnetite / haematite zones. The method is also independent of remanent magnetism and magnetic latitude.

Geophysical Signatures of an Internal Granitoid Contact, Yandal Greenstone Belt, Yandal, WA

By Paul McMillen
Curtin University/Exploration Geophysics
Supervisor: Vernon Wilson (Curtin University)

ABSTRACT

In recent years, the emphasis in gold exploration within, and surrounding internal granitoids has increased. These intrusive events act as heat sources for the hydrothermal fluids which mobilise and focus gold mineralisation, with the contact zone an area of particular importance. The presence of surface gold mineralisation in quartz veins and a significant weathering profile provided the incentive to delineate the contact zone in the Hamster prospect by integrating geological and geophysical data.

Ground-based total magnetic intensity (TMI) and time domain electromagnetic (TDEM) responses were obtained at varying resolutions within a rectangular grid straddling the contact zone. Depth to basement profiles and laboratory volume magnetic susceptibility measurements were determined by acquiring rotary air blast drillhole samples. Additional processing and transformations of the TMI data provided information concerning the geological structure and orientation of magnetic sources which were not observable in the unprocessed data. The negative transients recorded in the TDEM response are attributed to polarisation currents associated with the clay products of the weathering profile. The relative magnetic susceptibility measurements and the TMI profile exhibit correlations, as do the basement and TMI profiles along portions of the drillhole sampled lines. The lithological boundary between the microdiorite porphyry and granodiorite, determined from drillhole rock chip samples, compares exceptionally well with the TMI response. The forward modelling results, employing both geological and geophysical constraints, provide supporting evidence of the existence of the contact zone.

The ground-based TMI response suggests an extension of the surface mineralisation at 35 m depth sub-parallel to the contact, with significant length as to warrant a follow-up drilling program. The integration of geological and geophysical data is required to completely delineate the structural and lithological features of this exploration area.

Application of Three-Component Downhole PEM to Nickel Exploration in the Eastern Ultramafic Belt, WA

by Russell Mortimer
Curtin University/Exploration Geophysics
Supervisors: Vernon Wilson and Bill Amann
(Outokumpu Mining Australia)

ABSTRACT

This dissertation examines the interpretation techniques which can be implemented for three-component drillhole electromagnetics (DHEM), and includes the development of a rapid manual interpretation scheme. The effectiveness of these techniques in delineating nickel sulphide mineralization in the Eastern Ultramafic Belt of W.A. is also evaluated. The thick conductive overburden, complex host rock geology, and depth of mineralization in the Seagull study area combined to produce a difficult environment for EM prospecting. However this is an environment which commonly exists in many parts of Australia, and one which could test the limits of the interpretation techniques examined.

Numerous Crone three-component downhole PEM surveys were carried out at the Seagull prospect prior to 1997 after the failure of other geophysical methods in identifying and delineating nickel sulphide mineralisation. Extensive theoretical forward modelling and data manipulation has enabled the development of a rapid manual interpretation technique. The technique greatly reduces interpretation time when compared to conventional methods, as well as maximizing the information contained within DHEM records. The Seagull downhole PEM data was then interpreted using the manual method and the results were compared to those obtained using both forward modelling and inversion routines. From the comparisons made, the rapid manual interpretation technique was found to work very effectively.

Subsurface geology within the Seagull prospect is well known from extensive deep drilling. This made it possible to determine the effectiveness of the interpretation techniques examined. Taking into account the troublesome EM environment present at the Seagull prospect, the findings of all three comparative geophysical interpretations correlated well with the known mineralization trends. The amplitude of the secondary field and the decay rate are dependent on the quality and size of the conductor. The receiver, which is synchronized to the off-time of the transmitter, measures this transient magnetic field where it cuts the surface coil or borehole probe. These readings are across fixed time windows or "channels".

Time base is an important consideration when planning EM surveys, and is the length of time that the transmitter current is off (it includes the ramp time). This also equals the on time of the current. A number of time bases are available with the Crone PEM system to allow for powerline noise reduction, and particular situations. A time base of 150msec has recently become available for situations where the overburden is thick and conductive, which is a common occurrence in Australia.

Exploration Geophysics in the North Kimberley Kimberlite Province of Western Australia

By Jon Sumner
Curtin University/Exploration Geophysics
Supervisors: Paul Wilkes (CRC AMET) and
Dr Robert Ramsay (Striker Resources N.L)

ABSTRACT

This report examines the use of geophysics in kimberlite exploration, especially as an aid to gravel sampling and soil loaming. The success of the project was highlighted by the discovery of two kimberlite pipes during orientation surveys over geochemical soil anomalies. Studies were focussed on the North Kimberley Kimberlite province in the far north of Western Australia.

Geophysical orientation surveys were conducted over a kimberlite pipe cluster and a kimberlitic fissure system. The Ashmore pipe cluster is located in Warton Sandstone and was investigated using magnetic, electromagnetic and gravity surveys. Each of the techniques produced anomalous responses over the kimberlite pipes.

The magnetics showed that the area was more complex than initially suspected and appears to have been subject to many intrusive events of smaller scale than the kimberlite pipe intrusions. The Lower Bulgurri Fissure System was investigated using magnetic and electromagnetic methods at the Brolga prospect, approximately 1.5 km northeast of Ashmore. The magnetic results show a suspected reversely magnetised dyke within the Carson Volcanics host. The electromagnetic response was coincident with that of the magnetic survey. The Brolga results were not as convincing as the Ashmore results due to the more difficult host rocks.

It is concluded that geophysics is an essential tool in kimberlite exploration and can be used to define kimberlite targets more quickly than using geochemical techniques alone.

Geophysics in Salininity Studies, Manjimup Area, WA

By Ben Whitfield
Curtin University/Exploration Geophysics
Supervisor: Vernon Wilson

ABSTRACT

Secondary salinization of agricultural land in the south west of Western Australia has resulted in great economic loss for the state due to the decrease in production from once highly productive land. The major salinity concern is in the wheatbelt, where the problem has been studied extensively for the past two decades.

The commonly acknowledged cause of secondary salinity is the removal of deep-rooted, perennial, native vegetation, to be replaced by shallow-rooted crops. The resulting change in the water balance is an increase in the amount of runoff and infiltration to deep groundwater systems. This causes watertables to rise, remobilizing salt that is stored at depth in the profile, to discharge at the surface at susceptible locations.

The project area studied during 1997 is a complete subcatchment to the Perup River, in the high rainfall zone (800 mm) of the lower south west of Western Australia. Surface salinization and waterlogging prompted the author, and previously (1995) the local Land Care District Committee, to investigate the cause of the salinity and possible management practices that could be employed. The research undertaken as part of this project, involved magnetic, frequency domain electromagnetic (EM 31 and EM 38), early-time, ground-based time domain electromagnetic (EM 47) and shallow drilling methods to determine the hydrogeological conditions present.

It was found that in the subcatchment, the movement of salt is largely controlled by topography. Dykes in the central part of the catchment are intimately associated with the formation of the valley seep, as are areas of elevated basement rock.

The EM 47 proved an effective tool for mapping stratified salt accumulation in most areas. However, the presence of conductive clays associated with some linear magnetic anomalies proved to influence the in situ measurement of conductivity using the transient electromagnetic method.

PhD PROJECTS

SHORT SUMMARIES OF PhD PROJECT

RESEARCH STUDENT : David Annetts

UNIVERSITY / DEPARTMENT : Macquarie University / School of Earth Sciences

CONTACTS : email dannetts@laurel.ocs.mq.edu.au
phone 61 2 9850 9280
fax 61 2 9850 8366

SUPERVISOR/S : Prof. James C. Macnae

PROJECT TITLE : Analysis and interpretation of the AEM response of the Australian regolith

OBJECTIVES : Understand the nature of the EM response of various classes of conductance heterogeneities. These heterogeneities occur routinely in the field, and their responses can have major deleterious effects on layered-earth inversion programmes, and on CDI-based interpretation schemes.

EXPECTED OUTCOMES : Fundamental understanding of responses of conductance heterogeneities, leading, either directly or otherwise, to improvements in automatic interpretation programmes.

START DATE : February, 1995

EXPECTED DATE OF THESIS SUBMISSION : December, 1998

PUBLICATIONS / PRESENTATIONS : None.

SOFTWARE WRITTEN : Mostly data reformatting / translation programs. Either in Mathematica, or F77/F90.

Major mods to various numerical-modelling programs (LEROI_AIR/ARJUNA_AIR). Modifications have been to enhance useability.

DATE OF THIS SUMMARY : December 1997

RESEARCH STUDENT : Brett Harris

UNIVERSITY / DEPARTMENT : Curtin University / Exploration Geophysics

CONTACTS : email harris@geophy.curtin.edu.au
fax 61 8 9266 3407

SUPERVISOR/S : Assoc. Prof. Umesh Das.

PROJECT TITLE : Electromagnetic response optimization by three dimensional modelling

OBJECTIVES :

- To identify the practical advantages and disadvantages of an airborne system in a range of geoelectrical settings.
- To assist with understanding and evaluation of alternative survey hardware configurations.
- To develop interpretational aids for fixed-wing airborne EM systems.

EXPECTED OUTCOMES : 3D modelling software for response optimization for airborne and ground EM systems.

START DATE : June 1995

EXPECTED DATE OF THESIS SUBMISSION : June 1998

PUBLICATIONS / PRESENTATIONS : Harris, B and Das, U.C. Primary waveform effects on AEM response to be presented at AEM conference, Sydney 1998

SOFTWARE WRITTEN :

- Fortran program to calculate apparent resistivity from multiple csem systems.
- Fortran program to convolve system waveform with impulse Response.
- Maple program - calculates layered earth response in frequency domain for arbitrarily located dipole source and receiver.

DATE OF THIS SUMMARY : December 1997

RESEARCH STUDENT : Jiuping Chen

UNIVERSITY/DEPARTMENT : Macquarie University / School of Earth Sciences

CONTACTS : email jchen@laurel.ocs.mq.edu.au
phone 61 2 9850 9280 fax 61 2 9850 8366

SUPERVISOR/S : Prof. James C. Macnae and Dr. Art Raiche

PROJECT TITLE : Multi-dimensional inversions and approximate interpretation of airborne electromagnetic data

OBJECTIVES : To provide iteration-based and approximate algorithms to interpret AEM data

EXPECTED OUTCOMES :
- 1D Maximum entropy inversion program;
- 2.5D AEM inversion program based on ARJUNA_AIR;
- 3D thin plate inversion program based on LEROI_AIR;
- Complex exponential decomposition;
- Deconvolution of arbitrary system waveform

START DATE : Feb., 1996 EXPECTED DATE OF

THESIS SUBMISSION : July, 1999

PUBLICATIONS / PRESENTATIONS :

Chen, J., and Macnae, J. C., 1997, Terrain corrections are critical for airborne gravity gradiometer data: Expl. Geophysics, 28, 21-25

Chen, J., and Macnae, J. C., 1998, Automatic estimation of parameters in Tau-domain: To be presented at AEM conference, Sydney.

Chen, J., and Raiche, A., 1998, A damped eigenparameter approach to multi-dimensional AEM data: To be presented at AEM conference, Sydney.

SOFTWARE WRITTEN :
- 1D Maximum entropy inversion;
- 2.5D AEM inversion;
- complex exponential decomposition

DATE OF THIS SUMMARY : November 1997

RESEARCH STUDENT : Ping Li

UNIVERSITY / DEPARTMENT : Curtin University / Exploration Geophysics

CONTACTS : email pingli@geophy.curtin.edu.au
fax 61 8 9266 3407

SUPERVISOR/S : Assoc. Prof. Norm Uren

PROJECT TITLE : Mathematical modelling of the electrical potential in 3-D Inhomogeneous anisotropic media.

OBJECTIVES : To develop new methods which can be used to solve the problems of electrical response of 3-D bodies in the following environments :
1. Arbitrarily oriented anisotropic 3-D half space
2. Horizontal layered anisotropic half-space
3. Anisotropic half-space with two vertical boundary planes

EXPECTED OUTCOMES : New concepts

START DATE : 2/95

EXPECTED DATE OF THESIS SUBMISSION : June 1998

PUBLICATIONS / PRESENTATIONS :

Das, U.C. and Li, P.,1996, A!nalytical solution for direct current electrical potential in an arbitrarily anisotropic half-space. Applied Geophysics, 53, 63-76

Li, P. and Uren, N.F., 1997, !The modelling of direct current electric potential in an arbitrarily anisotropic half-space containing a conductive 3-D body. Journal of Applied Geophysics (in press).

Li, P. and Uren, N.F., 1997, !The electrical potential arising from a point source in an arbitrarily anisotropic half-space with regolith cover. Exploration Geophysics (in press)

DATE OF THIS SUMMARY : December 1997

RESEARCH STUDENT :Kanglin Lu

UNIVERSITY/DEPARTMENT: Macquarie University / Earth Sciences

CONTACTS : email klu@laurel.ocs.mq.edu.au
phone 61 2 9850 9282 fax 61 2 9850 8366

SUPERVISOR/S : Prof. James C. Macnae

PROJECT TITLE : Efficient Induced Polarisation and Resistivity Measurements

OBJECTIVES :
- To develop capacitive electrodes which potentially increase IP and resistivity
- survey speed dramatically and makes the two methods useable in dry, sandy or hard surface areas.
- To develop multi-channel IP and resistivity data acquisition system to increase survey speed and improve data quality.
- To define efficient survey arrays for detect a 3D target.

EXPECTED OUTCOMES :
- Theory and experimental results for capacitive electrodes
- Multi-channel IP and resistivity data acquisition system
- Efficient Arrays to detect a 3D target
- A 3D integral equation E-field modelling program.

START DATE : March 1994

EXPECTED DATE OF THESIS SUBMISSION : January 1998

PUBLICATIONS / PRESENTATIONS :

Lu, K. and Macnae, J., 1997, The High-frequency Experiments, a chapter of "Manual on Electrode Design and the Year-long Experiment at Garchy" edited by Clerc et al, published by CNRS, France

Lu, K. and Macnae, J., 1996, Integral Equation 3-D E-field Modeling and Effect of Overburden, 13th EM Induction Workshop, Hokkaido, Japan.

Lu, K. and Macnae, J., 1996, Design and Test of Capacitive Electrode, 30th International Geological Congress, Beijing, China.

Macnae, J. and Lu, K., 1996, The experiment design and acquisition of high-frequency data to supplement the low-frequency electrode comparison: Second workshop of the campaign of intercomparison between several different kinds of electrodes for geoelectrical measurements, Garchy, France.

Macnae, J.C. and Lu, K., 1994, The Feasibility of Airborne IP measurements; Expanded abstracts of the John S. Sumner Memorial International Workshop on Induced Polarisation and the Environment; University of Arizona, Tucson, USA.

SOFTWARE WRITTEN : 3D E-field modelling program for IP, DC resistivity and inductive source resistivity modelling

DATE OF THIS SUMMARY : November 1997

RESEARCH STUDENT : Michael Sykes

UNIVERSITY / DEPARTMENT : Curtin University / Exploration Geophysics

CONTACTS : email sykes@geophy.curtin.edu.au
phone 61 8 9266 3521
fax 61 8 9266 3407

SUPERVISOR/S : Assoc. Prof. Umesh Das

PROJECT TITLE : Some processing techniques for the enhancement of electromagnetic signals in geophysical exploration.

OBJECTIVES : To use 3-D mathematical modelling to assist in the development of a new processing techniques to aid interpretation of EM data.

EXPECTED OUTCOMES :
- A procedure to reduce the layered earth component in frequency-domain EM data.
- A procedure to remove 'herringbones' from time-domain AEM data maps using the Radon transform.

START DATE : Feb. 1996

EXPECTED DATE OF THESIS SUBMISSION : Oct. 1998

PUBLICATIONS / PRESENTATIONS :

Sykes, M.P., and Das, U.C., 1997 Enhancement of electromagnetic signals of conductive mineral deposits. 59th EAGE conference and technical exhibition, Geneva.

Sykes, M.P., and Das, U.C., 1998 Removal of herringbone effects from AEM data maps using the Radon transform: AEM conference, Sydney, 1998

DATE OF THIS SUMMARY : November 1997

RESEARCH STUDENT : James Reid

UNIVERSITY / DEPARTMENT : Macquarie University / School of Earth Sciences

CONTACTS : email jreid@laurel.ocs.mq.edu.au
phone 61 2 9850 9282
fax 61 2 9850 8366

SUPERVISOR/S : Prof. James C. Macnae

PROJECT TITLE : Current gathering in AEM data

OBJECTIVES : Approximate models for current gathering responses for plate in homogeneous halfspace, plate in either layer of 2-layer earth, plate touching overburden.

EXPECTED OUTCOMES :
- Fast modelling software
- Better understanding of importance of current gathering in AEM data

START DATE : 2/95

EXPECTED DATE OF THESIS SUBMISSION : late '98

PUBLICATIONS / PRESENTATIONS :

"Comments on the electromagnetic smoke ring concept" Reid J.E. and Macnae, J.C. Geophysics (submitted)

"Doubling the effective skin depth with a local source" Reid, J.E. and Macnae, J.C Geophysics (submitted)

SOFTWARE WRITTEN :
- Fortran 90 routines for FEM and TEM (pure impulse response) electric and magnetic fields in and above homogeneous halfspace and two-layer earth models, and above and below an infinite thin sheet in free space. Vertical magnetic dipole source assumed.
- Fortran 90 program for conductivity depth imaging of frequency-domain EM data (unpublished algorithm). Horizontal coplanar and perpendicular Tx-Rx configurations only.
- Fortran 90 integral equation program for the galvanic B and dB/dt response of a rectangular plate in a homogeneous halfspace, based on Nabighian et al (1984) "Crosshole MMR", Geophysics 49, 1313-1326. The assumed source in this program is an airborne vertical magnetic dipole, but the program can be easily modified to calculate the response due to a different source (eg classical MMR, electric dipole etc) by changing the source electric field calculation.

DATE OF THIS SUMMARY : December 1997

Letters to the Editor

Cause for Optimism

Dear Sir,

There seems to be a feeling of pessimism about the future of geophysics, so I might be on the wrong tram but I don't think so. Although now retired from the scene and not having the practical concerns expressed by Derecke Palmer, Norm Uren, Nicholas Direen and others, I nevertheless believe there is cause for a lot of optimism. Apart from the high proportion of students at our last conference (and indeed the increased total number of attendees) referred to by Roger Henderson; I continue to be impressed with the number and calibre of student presentations around the country each year.

Universities have fashions like the rag trade or car market. When I graduated (in 1947) engineering and science were top of the pile. Subsequently the "Humanities" took over.Then it was fashionable to do Arts/Law and then the softer environmental courses. Universities adapt to what the market wants (ie fashion, job opportunities) and it is probable , as Derecke sees it, that our profession is not back in favour for those reasons. I too have a feeling that, at present, our population is skewed towards senior geophysicists.

The problem as I see it is that we have never sold ourselves. We have spent a lot of effort preaching to the converted (ourselves) so that in spite of disasters like Thredbo and the occasional volcanic eruption the "people in the street" don't learn what a geophysicist is or does. (I have trouble with my own friends!) However there is a little light as the term "earth scientist" seems to be used increasingly and that at least gives the public a fighting chance.

I think of some of the large, exciting, well advertised projects around us; the Olympic Games Complex, The Very Fast Train, The Fitzroy Dam, salt encroachment on sugar growing regions in Queensland, seismic monitoring for safety in coal mines, dam sites and many other huge undertakings by corporations, authorities, even councils in which geophysics in one form or another is involved. What we have to do is to get a wedge of geophysics into the popular reporting of these projects and so educate the public.

For example, the proposed Darwin - Alice Springs railway line has captured the imagination of Australians for over 100 years. Some very innovative geophysics was carried out some years ago by the late John Haigh. Yet as far as I know the public are unaware of the major technical problems of locating the track (eg in the limestone area around Katherine). Innovative Australians have solved such major problems to provide a safe and permanent route. This is only one such story which should be told

My congratulations to Derecke for his part in the Science Outreach Programme. I trust that the ASEG will take a more resolute step towards "popularising" geophysics in the media.

W J (Bill) Langron
Kiama, NSW

A Call to Nurture Innovation, Enterprise and Endeavour

I was recently in Norway (a country with a population of only 4.5 million) for five days giving a workshop with Peter Gunn from AGSO. One of the most striking observations to be made about the quality of Norwegian scientific practice was the backing, commitment and long-sighted approach to nurturing their scientists and engineers in projects that strive to break new ground. There is a commitment to traveling the world, looking for advancement in thinking and technology and to then combine this with their own research and development.

How can we, as Australians, nurture, reward and value enterprise as the Norwegians do?

I have recently been aghast to see what sums of Australian development money are being spent offshore, in England, Canada and the USA, by some of our mining houses, in (supposedly hush-hush?) commercialisation of technology. Why has this situation developed? Certainly in the past, the involvement of Australian groups has been sought, but they have supposedly either under-quoted, over-spent or not delivered. There is a surprising lack of internationally competitive geophysical instrumentation developed, made and delivered in Australia. For all Australia's innovation and development, what outcomes and products can be named? SIROTEM, SALTMAP and the superior gold detector recently developed by Bruce Candy of MineLabs come to mind, but this is a poor showing in such an active industry.

As a nation of scientists and engineers, we Australians are not doing enough to develop our indigenous capability. The geoscience small business sector is exceedingly fragile and often too science-dominated to allow more stable and viable business to flourish. There is no lack of excellence or of Federal research money (although this may be hotly disputed). The process seems to fall down in the commercialisation phase.

It is difficult to blame young graduates from universities for the death of new products. Perhaps some of the senior company people have not been sufficiently vocal in demanding tangible outcomes as well as a high level of management (from past AMIRA projects). It does no good to apportion blame. Rather, the question should be "What can be done now to provide leadership, enthusiasm and capital?"

Outsourcing is an approach to solving the problem of encouraging growth whilst creating support. Currently the call to outsource is very popular. In outsourcing lies an opportunity to build innovative small businesses. Instant providers who are viable will not suddenly emerge but an incubation period of two years is a reasonable time to see if a business will survive without undue support. Rather than just seeing outsourcing as a way of supporting established providers, it should also support smaller businesses during a start-up period. Consulting and interpretation are easy to outsource. So are software developments, as long as they are linked to existing systems. It is difficult for companies and organisations to justify the cost of hardware and instrumentation development because the risk of failure for any one group appears to be large. Surely the creation of a consortium that spreads the risk is the obvious answer.

I propose the creation of an award to also foster innovation and growth in technology. One of my companies would sponsor this award and I call for further contributions of sponsorship. Perhaps the Australian Society for Exploration Geophysics (ASEG) would be an appropriate peer review arena for this new award, as the existing award policy is not working in a way that fosters commercial or technical achievement (I am not aware of any award having been granted in the last three or four years). The Federal Government DIST or the Innovations Award programs are closer to the essence of what constitutes reward for technological achievement that I would like to see adopted in the geophysics world.

I strongly believe that technological innovation and incremental improvement by better engineering should be encouraged in any way possible. Nurturing rather than knocking, sharing ideas rather than being secretive, reward and acknowledgment rather than the cold shoulder – these are some of the qualities that are missing in our professional life.

Dr Desmond J. FitzGerald

Whistling Bravely?

Geophysics could possibly be the miner's canary, as Australian Science goes down the pit. We've been small, bright and cheerful so far but the question is - will anyone notice the lack of chirp in time? Especially, if we (the miners) don't, who will?

This sounds pretty negative, and I admit it's written to attract attention, especially of those among us who frown on pessimism. We must, however, look squarely at what has been happening in recent times in this country and realise that Geophysics (and Earth Science in general) is really out on the end of a number of limbs in the education system. Geophysics and Geology are a small section of Science and Engineering enrolments. If interest in Science declines, throughput into Geophysics will also decline.

Writing just over a year ago in Science (v27/9, Oct 1996) John de Laeter and John Dekkers surveyed Science enrolment trends over the last decade or so in Australian Schools. The major cause for concern seen there is the decrease in enrolments in the major discipline-oriented subjects at year 12 (Physics, Chemistry, and Biology) across the nation, falling by about 20% between 1992 and 1995, together with the observation that many year 12 students take no science subjects at all.

Now, many of us would rather point to the fact that the number of Year 12 Science enrolments went up by 70% between 1976 and 1992 - but before complacency sets in, look at the Geology figures in year 12. In 1977 there were 4561 enrolments; in 1995 there were 1263. That's across the nation, out of something like 175000 enrolments altogether. At these small scales, quantum effects start to take precedence - either you have Geology or you don't - rather than continued contraction.

There are other studies giving different perspective. The Seale Report to the Victorian Government, completed in July 1997, disclosed another ominous trend within Science: although total Science enrolments in Victorian Universities increased by 15% between 1991 and 1996, enrolments in Physical Science fell by 40% in that period. Few geophysicists have been drawn from the ranks of geneticists or plant physiologists.

Both the Seale and de Laeter & Dekkers reports give a high priority in their conclusions to the need for professional organisations to take a positive role in 'growing' Science in the Schools. This is a tough challenge, not least because many professionals are comfortable in their niches, but especially because students at the end of the 20th century have been taught that economic advantage is the primary reason for education. Science offers only vague career paths and virtually no role models for economic success. A number of students interviewed during my University's Review of the Science Faculty referred to the common view that they had 'wasted' a good entrance score by choosing Science, and that their peers could not understand why they wanted to go that way. They asked for reinforcement of their decision.

Finally a note on the effect of this on University Science. The basic funding model used from top to bottom of the system is enrolments. If Science is out of favour, its share of the (declining) budget falls. Fewer students might well mean less costs, but we are an expensive business, and again quantum effects start to be observed. Within Science, the same rules place Earth Sciences at risk. In my University, the first-year enrolments in Physics, Chemistry, Mathematics and Biology are each five

times the first-year enrolment (about 300+) in Earth Sciences. That our Honours class is larger than Physics and Maths combined is of little relevance, because these are an order of magnitude smaller than first-year enrolments.

We have to be concerned about the progress in Science in this country. Even though most of our geophysical equipment and support software is imported, we need the best minds we can get to use that technology in this context. Very, very few students write down 'geophysicist' as a career goal instead of 'lawyer', 'doctor', 'leg-spinner', or 'personality'. Worryingly, fewer and fewer are even writing down 'scientist'.

Lindsay Thomas
University of Melbourne

Hot Links

Koya Suto

The Internet is with us. You may be using e-mail every day but when did you last browse for geophysical information? From this issue, I will be writing a small column about geophysical web sites which may be of interest to you as well as what is happening to our own home page.

Yes, the ASEG has had it's own home page for several years. It currently resides at the University of Melbourne site: **http/buster.met.unimelb.edu.au/~aseg**.

Opening our home page, you can see all about the ASEG, publications, Research Foundation, State Branches, Federal Executive Committee members, membership requirements, Corporate Members and education including a list of institutions which have geophysics courses and an outline "About Geophysics". They provide links to home pages of various organisations and institutions.

An important link has been established to the ASEG Hobart Conference Home Page. This page includes the deadlines for submission of papers, and will be kept up-to-date as the conference approaches.

The Corporate Membership sub-page has hot links to home pages of our corporate members, where you can find their services and price list in some cases. Try this when you look for a contractor for your next project. We are planning to enhance this site by making it an extensive geophysical directory.

Another plan for the ASEG site is to make an educational page. The material used for the Student Sessions in the past ASEG Conferences will be included into this page, so that the general public, particularly high school students, can access to the information. This will be implemented in the very near future.

Your input to the ASEG site and this column are welcome. Please send your comments to Koya.Suto@oca.boral.com.au.

Membership

New Members

South Australia

Grant ANCHER
Pitt Research Pty Ltd
PO Box 279
DAW PARK SA 5041
Phone: 014 094 541

International

Charles DARDEN
PO Box 460209
Houston, Texas
USA 77056-0209
Tel: + 1 713 580 7981
Fax: + 1 713 850 7984
Email: iagc@wt.net

Change of Address

Western Australia

Barry BOURNE
PO Box 175
BELMONT WA 6104
AUSTRALIA
Phone: 08 9270 9235
Fax: 08 9270 9223
Email:
barry.bourne@expl.riotinto.com.au

Chew Kian CHUA
11 Lefroy Road
BULL CREEK WA 6149
AUSTRALIA
Phone: 08 9224 5077
Fax: 08 9310 1350
Email:
kian.chua@woodside.com.au

Elizabet CLYDSDALE
PO Box 175
BELMONT WA 6984
AUSTRALIA

Mathew COOPER
Unit 11 / 20 Overton Garden
COTTESLOE WA 6011
AUSTRALIA
Phone: 08 9327 8278
Email: mathewc@awi.com.au

James DIRSTEIN
21 Churchill Avenue
SUBIACO WA 6008
AUSTRALIA
Phone: 08 9382 4307
Fax: 08 9382 4308
Email: dirstein@iinet.net.au

Sue DOWNIE
PO Box 6383
EAST PERTH WA 6892
AUSTRALIA
Phone: 08 9268 2605
Fax: 08 9268 2600
Email:
sue.downie@perth.waii.com

Will FEATHERSTONE
School Of Spatial Sciences
GPO Box U1987
PERTH WA 6845
AUSTRALIA
Phone: 08 9266 2734
Fax: 08 9266 2703
Email:
Featherstone_WE@cc.curtin.edu.au

Richard HAREN
PO Box 239
SCARBOROUGH WA 6922
AUSTRALIA
Phone: 08 9341 6680
Email:
rands.haren@onaustralia.com.au

Susantha KUMARAPELI
4 / 115 Peninsula Road
MAYLANDS WA 6051
AUSTRALIA
Phone: 08 9272 9207
Email: s.sk@eduserv.its.unimelb.edu.au

Stephen MUDGE
PO Box 322
VICTORIA PARK WA 6979
AUSTRALIA
Phone: (09) 442 8100
Fax: (09) 442 8181
Email: smudge@rgc.com.au

Louisa McCALL
Leinster Nickel Ops
PO Box 22
LEINSTER WA 6437
AUSTRALIA
Phone: 08 9026 5674
Fax: 08 9037 9090
Email:
louisa.ccall@wmc.telememo.au

Christopher MACHUNTER
1st Floor, 94 Rokely Road
SUBIACO WA 6008
AUSTRALIA
Phone: 08 9382 4922
Fax: 08 9381 3264
Email: cmachun@tpgi.com.au

Gregory NYEIN
28 Merrivale Way
GREENWOOD WA 6024
AUSTRALIA
Email:
splsales@scintrex.aust.com

Graham STAKER
26 Glouchester Road
KALAMUNDA WA 6076
AUSTRALIA
Phone: 08 9479 8400
Fax: 08 979 8444
Email: grstaker@iinet.net.au

Stephen TOBIN
23 Felspar Street
WELSHPOOL WA 6106
AUSTRALIA
Phone: 08 9458 6700
Fax: 08 9458 6755
Email: geosys@eis.net.au

Gregory TURNER
Group Technology
PO Box 7001
Cloisters Square
PERTH WA 6850
AUSTRALIA
Phone: 08 9442 2037
Fax: 08 9442 2084
Email:
Greg.Turner@WMC.com.au

Michael WEBB
PO Box 152
FLOREAT WA 6014
AUSTRALIA
Phone: 08 9479 8400
Fax: 08 9479 8451
Email:
mike.webb@wmc.com.au

Brett WESTON
41 Kishorn Road
APPLECROSS WA 6153
AUSTRALIA
Phone: 08 9364 8444
Fax: 08 9364 6575

David WILSON
13A View Road
MT PLEASANT WA 6153
AUSTRALIA
Phone: 08 9316 9152
Email: DRW@bigpond.com

Julie Anne WITHERS
PO Box 218
LEINSTER WA 6437
AUSTRALIA
Phone: 08 9037 9442

ACT

Richard ALMOND
PO Box 167
KIPPAX ACT 2615
AUSTRALIA
Phone: 02 6241 2407
Fax: 02 6241 2420

Jacques SAYERS
PO Box 378
CANBERRA ACT 2601
AUSTRALIA
Phone: 02 6249 9609
Fax: 02 6249 9983
Email: jsayers@agso.gov.au

Victoria

Paul BASFORD
PO Box 1231k
MELBOURNE VIC 3001
AUSTRALIA
Phone: (03) 9288 0497
Fax: (03) 9288 0211
Email:
BasfordP@Pasminco.com.au

Robert ELIOTT-LOCKHART
4 / 2 Anderson Street
CLIFTON HILL VIC 3068
AUSTRALIA
Phone: 03 9666 5154
Fax: 03 9667 2099
Email: robert.eliott-Lockhart@shell.com.au

Kim FORWARD
2 Milford Street
BENTLEIGH EAST VIC 3165
AUSTRALIA
Phone: (03) 9802 4700

Alan HOGAN
61 Streeton Cres
IVANHOE EAST VIC 3079
AUSTRALIA
Phone: 03 9499 8839
Email:
Hogans@bigpond.com.au

Robert KIRK
16 Waters Edge
WILLIAMSTOWN VIC 3016
AUSTRALIA
Phone: (03) 9652 6750
Fax: (03) 9652 7130
Email: kirk.rob.rb@bhp.com.au

LIBRARIAN
Minerals & Petroleum
Reference Centre
8 / 240 Victoria Parade
EAST MELBOURNE VIC 3002
AUSTRALIA
Phone: (03) 9873 4411
Fax: (03) 9873 5679

Phillip LOCK
Production Department
GPO Box 400C
MELBOURNE VIC 3001
AUSTRALIA
Phone: 03 9270 3517
Fax: 03 9270 3592
Email:
PHILLIP.W.LOCK@EXXON.SPRINT.COM

Sundar SARMA
21 Duke Street
KEW VIC 3101
AUSTRALIA
Phone: 03 9852 7232
Fax: 03 9853 4299
Email: sarma@melbpe.org.au

Queensland

Peter BROWN
PO Box 401
PARADISE POINT QLD 4216
AUSTRALIA
Phone: 07 5564 1355
Email:
pbrowns@ozemail.com.au

Paul PHYTHIAN
30 Ballinger Crescent
ALBANY CREEK QLD 4035
AUSTRALIA
Phone: (07) 3878 9900
Fax: (07) 3878 9977
Email: paulp@digicon-brs.com.au

Northern Territory

Greg BERESFORD
9 / 75 Aralia Street
NIGHTCLIFF NT 0810
AUSTRALIA
Phone: 08 8948 2900
Fax: 08 8948 2900
Email: gberes@ibm.net

Anthony HOSKING
PO Box 42454
CASURINA NT 0811
AUSTRALIA
Phone: 08 8927 4930
Fax: 08 8927 9307

South Australia

Craig BARNES
91 King William Street
ADELAIDE SA 5000
AUSTRALIA
Phone: 08 8224 7741
Fax: 08 8224 7765
Email:
craig.barnes@santos.com.au

Stephen BIGGINS
7 McKenna Street
KENSINGTON PARK SA
5068
AUSTRALIA
Phone: 08 8431 6902
Fax: 08 8338 4255
Email: sbiggins@senet.com.au

Shunhua CAO
Level 4, 150 Albert Road
MELBOURNE SOUTH SA
3205
AUSTRALIA
Phone: 03 9697 1247
Email: hcao@melbourne.
wireline.slb.com

Dave COCKSHELL
GPO Box 2355
ADELAIDE SA 5001
AUSTRALIA
Phone: 08 8274 7671
Fax: 08 8373 3269

Ian EDWARDS
91 King William Street
ADELAIDE SA 5000
AUSTRALIA
Phone: 08 8224 7954
Fax: 08 8224 7328
Email:
ian.edwards@santos.com.au

William FAWCETT
GPO Box 2576
ADELAIDE SA 5001
AUSTRALIA
Phone: 08 8235 3803
Fax: 08 8223 1851
Email: wrf@sagres.com.au

Peter McSKIMMING
21 Greer Street
HYDE PARK SA 5061
AUSTRALIA
Phone: 08 8278 5759
Fax: 08 8278 5275

Chris PORTER
Santos House
91 King William Street
ADELAIDE SA 5000
AUSTRALIA
Phone: 08 8224 7715
Fax: 08 8224 7113
Email:
chris.porter@santos.com.au

Richard SMITH
GPO Box 2319
ADELAIDE SA 5001
AUSTRALIA
Phone: 1-613 731 9571
Fax: 1-613 731 0453
Email: smith@geoterrex.ca

New South Wales

Ian BROWNE
PO Box 571
MOSMAN NSW 2088
AUSTRALIA
Phone: 02 9960 3187
Fax: 02 9960 3187

Peter CLARK
University Of New England
PO Box U9
ARMIDALE NSW 2351
AUSTRALIA
Phone: 02 6773 3508
Fax: 02 6773 3307
Email peterc@gri.une.edu.au

Kim STANTON-COOK
4 Bedford Crescent
COLLAROY NSW 2097
AUSTRALIA
Phone: 02 9984 7142
Fax: 02 9984 8057
Email: scook@planet.net.au

John CRAMSIE
21 Brierley Street
MOSSMAN NSW 2088
AUSTRALIA
Phone: 02 9901 8300
Fax: 02 9901 8256

Len DIEKMAN
PO Box 1432
NORTH SYDNEY NSW 2060
AUSTRALIA
Phone: 02 9460 0829
Fax: 02 9460 0831
Email: 106453.2257@
compuserve.com.au

Donald EMERSON
PO Box 6001
DURAL DELIVERY CENTRE
NSW 2158
AUSTRALIA
Phone: 02 4579 1183
Fax: 02 4579 1290

John HOLLIDAY
'Homeleigh'
Phoenix Mine Road
LUCKNOW NSW 2800
AUSTRALIA
Phone: 02 6392 2500
Fax: 02 6392 2550

Helen LINHA
39 Billarga Road
WESTLEIGH NSW 2120
AUSTRALIA
Phone: 02 9484 3414
Fax: 02 9484 0289
Email: helenl@zip.com.au

James MACNAE
PO Box 516
MOSMAN NSW 2088
AUSTRALIA
Phone: (02) 9850 9291
Fax: (02) 9850 8366
Email:
james.macnae@mq.edu.au

James MCINTYRE
PO Box 536
ST LEONARDS NSW 2065
AUSTRALIA
Phone: (02) 9901 8356
Fax: (02) 9901 8256

Antony OSMAN
24 Stanhope Rd
KILLARA NSW 2071
AUSTRALIA
Phone: (02) 9498 3615
Fax: (02) 9418 2132

Doug PRICE
Flat 5, 5 Pavilion Street
QUEENSCLIFF NSW 2096
AUSTRALIA
Phone: 07 3307 9665
Fax: 07 3307 9500
Email:
price.doug.dg@bhp.com.au

Peter RUSZKOWSKI
2/16A Thrupp Street
NEUTRAL BAY NSW 2089
AUSTRALIA
Phone: (02) 9901 8355
Fax: (02) 9901 8256
Email:
peterr@nswgs.nsw.gov.au

Mike SMITH
48 Hilma St
COLLAROY PLATEAU
NSW 2097
AUSTRALIA
Phone: (02) 9529 2355
Fax: (02) 9529 9726

International

Frank ARNOTT
4 The Broadway
Newbury
BERKSHIRE RG14 IBA
UNITED KINGDOM
Phone: 01635-48511
Fax: 01635-35542
Email:
frankarnott@compuserve.com

John BANCROFT
Dept Geology & Geophysics
2400 University Drive
CALGARY ALBERTA
CANADA
Phone: 403-220 5026
Fax: 403-284 0074
Email:bancroft@geo.ucalgary.c
a

Craig BEASLEY
10001 Richmond Avenue
HOUSTON TX 77042
USA
Phone: (1)713-963 575
Fax: 713-963 5757
Email:
CRAIG.BEASLEY@WAII.COM

Richard IRVINE
29Fl, Bank Of China Tower
1 Garden Road
MID-LEVELS
HONG KONG
Phone: 852-2840 2432
Fax: 852-2501 5774

Marilyn MAWDSLEY
2415 Udell Road NW
Calgary
ALBERTA T2N 4H4
CANADA
Phone: 403-268 7834
Fax: 403-268 7780
Email:
marilyn_mawdsley@pcp.ca

Edward MOZLEY
PO Box 749
OCEANSIDE CA 92049-0749
USA
Phone: 601-688 4855
Fax: 601-688 4476
Email:
mozline@worldnet.att.net

John MILSOM
Geology Department
Gower Street
LONDON WCIE 6B7
UK
Phone: 71-504 2392
Fax: 71-387 1612
Email: j.milsom@ucl.ac.uk

Rado REBEK
Cruz Del Sur 133
Piso 4
Las Condes
SANTIAGO
CHILE
Phone: 56 2208 3969
Fax: 56 2207 6892

Colin REEVES
Kanaalweg 3
ED DELFT 2628
THE NETHERLANDS
Phone: 31-15 2748 847
Fax: 31-15 2623 961
Email: reeves@itc.nl

George REYNOLDS
87 Ryevale Lawns
LEIXLIP CO. KILDARE
IRELAND
Phone: +353 87 584 212
Fax: +353 1 624 2339

David SPRING
1360 Post Oak Blvd
Suite 500
HOUSTON TX 77056
USA

Michael SNYDER
5716 E Hinedale Place
Englewood
COLORADO 80112
USA
Phone: 303 529 9250
Fax: 303 595 0667
Email: mike.snyder@waii.com

Diwi SNYDER
5716 E Hinsdale Place
Englewood
COLORADO 80112
USA
Phone: 303 221 2179

Peter STICKLAND
Suite 205, 10810 Old Katy Road
HOUSTON TX 77043
USA
Phone: 713 465 3628
Fax: 713 465 2938

Christop WALLACE
#201 4905
48th Street
YELLOW KNIFE NT XLA 2P8
CANADA
Phone: 867 873 4530
Fax: 867 873 4532
Email:
CWallace@internorth.com

Richard WEST
1597 Cole Blvd, Suite 250
GOLDEN CO 80401
USA
Phone: 303-232 7779
Fax: 303-235 4429
Email:
west.dick.rc@bhp.com.au

Peter WHITING
37 Jalan Pemimpin
#06 01 Union Building
577177
SINGAPORE
Phone: (65) 258 1221
Fax: (65) 258 0989
Email: peterw@digicon-spr.com.sg

Derek WOODWARD
PO Box 30-368
LOWER HUTT
NEW ZEALAND
Phone: 64-4-473 8208
Fax: 64-4-471 0977
Email:
D.woodward@Gns.cri.nz

If you wish to place your event in our Calendar, contact:

Kyla Hughes,
Jenkin Buxton Printers
263 Middleborough Road
Box Hill, VIC. 3128
AUSTRALIA
Tel: +61 3 9890 4711
Fax: +61 3 9898 9677
Email: jbprint@mail.austasia.net

Calendar of Events

1998

Mar 8-11
APPEA Conference, National Convention Centre,Canberra
Attn Lynda Gordon
APPEA Limited, GPO Box 2201 Canberra, ACT, 2601
For further details:
Tel: (02) 6247 0960
Fax: (02) 6247 0548

Mar 23-25
International Conference on Coal Seam Gas and Oil, Sheraton Hotel, Brisbane
Intermedia
For further details:
Tel 07 3369 0477
Fax 07 3369 1512
email csgo98@im.com.au , www.im.com.au/coalseam

April 30
First Call for Papers, Abstract submission, SEGJ 4th Int Symposium. Preferred format for abstracts (400-500 words) is email sent to <segj4th@gsjart.gsj.go.jp>. See details below

Jun 20-26
SEG /SEG Beijing Beijing 98 Conference and Exhibition
For further details:
www.seg.org

July 21-24
AGU, 1998 Western Pacific Geophysics Meeting, Taipei.
For further details:
200 Florida Avenue
Washington DC, 20009, USA
Tel: 1 202 462 6900
Fax: 1 202 328 0566
Email:
meetinginfo@kosmos.agu.org
www.agu.org

Sept 13-18
SEG Conference New Orleans
For further details:
www.seg.org

Oct 28-30
Gas Habitats of SE Asia & Australasia,Jakarta,Indonesia
Indonesian Petroleum Association
For further details:
Tel: 62- 21 5273663
Fax: 62-21 5219063
email ipa@cbn.net.id , www.ipa.or.id

November 8-12
Australian Society of Exploration Geophysicists 13th International Conference and Exhibition, Hobart Tasmania Australia
For further details:
ASEG Conference Secretariat, 93 Victoria Avenue, Albert Park VIC 3206
Tel: +61 3 9690 6744
Fax: +61 3 9690 7155
email: wsm@latrobe.edu.au

Dec 10-12
SEGJ/SEG/ASEG 4th Int Symposium Fracture Imaging Tokyo. The technical sessions will cover "Fracture Detection, Imaging, and Characterization" and "Underground Heterogeneity".
For further details:
The Society of Exploration Geophysicists of Japan
San-es Bldg., 2-2-18
Nakamagome, Ota-ku
Tokyo, 143-0027 Japan
Phone/Fax: +81-3-3774-5858
http://wwwsoc.nacsis.ac.jp/segj/meeting/is4/.
In Australia email
mcdonald@geophy.curtin.edu.au

Advertisers Index