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Society of
Exploration
Geophysicists
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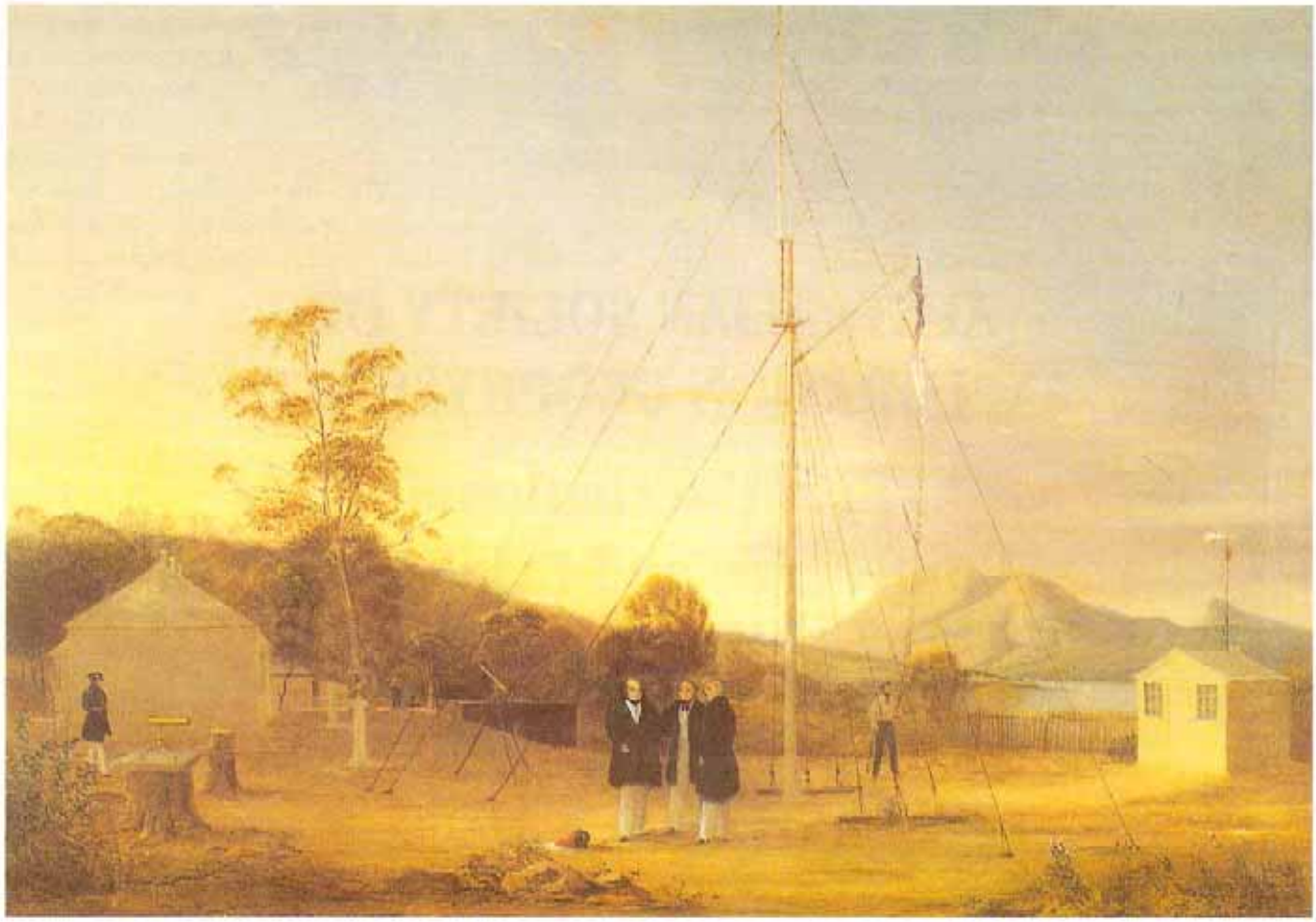
Preview

February – March 1999

Issue No. 78



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Editor's Desk

Welcome to this, belated, first issue of 1999. This edition is given over to the 1998 Hobart Conference roundup including award citations, and our now traditional (?) student and university review. There is also a section on ASEG Research Foundation activities so that Corporate Sponsors can see where their funds are going.

In order to encourage more Letters to the Editor the FE and the Preview Editorial Board has to decided to provide a prize for the best letter of 1999. That prize will be a carton of ASEG wine with the closing date being 15th November 1999. The subject can be about Preview, the Society, it's conferences, it's publications or any other geophysical matter. It should be thought provoking. The judges' (Preview Editorial Board) decision will be final.

Thanks are offered to Bernie Milton, John Webb and Andrew Mutton who answered the call and provided the AMF with a full set of Preview back issues.

FRONT COVER: Hobart, venue for the 1998 ASEG conference, was the site for one of the first geophysical observatories in the Southern Hemisphere, the Rossbank Magnetic Observatory. The front cover shows a reproduction of the painting by Thomas Bock 'The Rossbank Observatory', 1842. It is from the Collection of the Tasmanian Museum and Art Gallery.

1999 Corporate Plus Members Paid as at 11-3-99

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1999 Corporate Members Paid as at 11-3-99

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President's Piece

The ASEG welcomes you to the New Year and trusts it will be a good one, both professionally and personally. Certainly there are challenges ahead...

Many minerals and petroleum members are enduring uncertain times, owing to the low commodity prices. Given that the prices' forecast is not encouraging, it is evident many companies are taking stock of their manpower needs. In times like these, people more likely to succeed are those who demonstrate professional versatility; a broad awareness of how to do things leaner without unnecessarily compromising quality; people who do rather than those say they can do.

What does membership of the ASEG do to assist your professional development, dare I say survival? Much, we trust, including:

- Receive regular journals with topical items.
- Attend largest technical conference and exhibition in the Asia-Pacific region.
- Attend continuing education courses (often heavily subsidised).
- State-based meetings provide a forum for technical exchange and social functions.

Potentially one of the largest benefits of ASEG membership, however, is the opportunity to network and increase your exposure - as time goes on, it's often becomes more important who you know as well as what you know.

So what can you do right now?

The main way is to join one of the informal ASEG subcommittees, covering the spectrum from publications to membership to Internet to conferences to students. Communication is largely via email. Contact your State branch - it is not an onerous commitment, but rather one that gives considerable satisfaction in being an active part of the Society. There are those who do and those who don't... which group do you fall in?

As advised in the last issue of Preview, the ASEG is formulating a Business Plan that controls financial matters, sets goals for membership mix and trends, improves continuing education and publications, has the right focus on supporting research. Draft goals of this Plan are published in this edition.

Some may question why go through the hoops developing this plan? The intention is to increase the value of being a member of the ASEG. If we know where we're going, the time previously spent wondering how to react to all sorts of situations will be replaced with action, driving towards goals that give members value for their membership.

The Plan's success relies on increasing our membership numbers - active, associate, student and corporate. An increase of 10% per year for the next few years is achievable. More members mean more diversity and therefore a benefit to you. It also means additional revenue for the Society that can be channelled into areas such as continuing education. With your renewal was the new member form - please do your bit as a Society's ambassador to sign up people and corporate members.

Let's all work together to increase the relevance of the ASEG. A Business Plan and active subcommittees will ease the Federal Executive transition to Sydney in April, when it will begin its three-year term. The ASEG can and should assist in developing your professional future - make it happen!

Noll Moriarty
President

ASEG Membership Benefits

- **ASEG Meetings and Conferences**
- **Exploration Geophysics (4 issues per year)**
- **Preview (6 issues per year)**

ENCOURAGE YOUR COLLEAGUES TO JOIN

Membership Applications, see this issue or contact:

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Executive Brief

As the term of office for the Brisbane Federal Executive draws to a close, we are putting effort into formulating a Business Plan for the Society. The plan serves to ensure that the Society's funds are maintained and used in ways which provide benefits to all members. The idea of producing a business plan was discussed at the last Council Meeting at the Hobart conference and all the State Branch representatives gave their support to the idea. Noll Moriaty has collated everyone's ideas and put together a draft Plan. You can have a look at it on the newly revamped ASEG home page (www.aseg.org.au <http://www.aseg.org.au>). Please have your say on any of the issues by contacting any member of the State or Federal Executive.

For example, the Publications committee proposes that Exploration Geophysics is published only twice per year, including conference editions. The rationale behind this is the cost of producing Exploration Geophysics (approximately $60,000 to $80,000 shortfall per year) and the lack of material to warrant four issues. Further information is given in the document.

Another proposed initiative is that the ASEG will fund a continuing education course(s), similar in concept to the SEG DISC strategy, during the period between conferences. The ASEG has already been asked of it wishes to be co-sponsor of the 1999 Esso Distinguished Lecturer course. Although the Esso Distinguished Lecturer and course haven't yet been chosen, we have indicated we would like to co-sponsor this event. This will provide our members with the opportunity to attend this well-recognised and professional tour at reduced rates. It is also an excellent opportunity for the Society to raise its profile with petroleum explorationists who are not already members.

Membership dues provide approximately 30% of our income. We hope we can attract more local and international members to the Society and increase membership at the rate of approximately 10% per year. Our membership drive at the Hobart conference certainly showed that there is scope for attracting new members who are already aware of the activities of the society. If you know of any potential new members, please encourage them to join the society. The January 1999 figures for membership are as follows:

All Categories = 1336
Corporate = 7
Corporate Associate = 22
Active = 841
Associates = 348
Honorary = 11
Students = 105
Complimentary = 2
Resignations = 5

The financial status of the Society at January 1999 is as follows:

Cheque Account balance	= $ CLOSED
Premium business account	= $107,778.79
Term Deposit (CBA Commercial Bill)	= $100,000.00
Cash Management (Sands)	= $10,267.61
Term Deposit (Sands)	= $40,000.00
Net Cash:	**~ $ 203,000.00**
Trust Moneys:	~ $ 50,200.00

Robyn Scott
ASEG Hon. Secretary

Calendar Clips

1999

April 18-21 APPEA Conference, Perth

April 21-23 Murray Basin Conference, Mildura

June 7-11 EAGE Annual Meeting, Helsinki

Sept 28 - Oct 1 SAGA/SEG Conference, Cape Town

Oct 27-29 3D EMT Conference, Salt Lake City

Oct 31- Nov 5 SEG Convention, Houston

2000

March 12-16 ASEG 14th Conference, Perth

Preview Deadlines – 1999

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

ERRATA

In the last issue the list of Corporate members was 1998's list because that issue was nominally a 1998 edition. New Corporate members are listed in this issue and their names will be published in the 6 issues of this year

Kevron's name was missing from their advertisement due to a colour separation that was truly separate.

Society Briefs

New Federal Executive 1999

President	Mike Smith
First Vice President	Brian Spies (President Elect)
Second Vice President	Timothy Pippett
Secretary	Dave Robson
Treasurer	Graham Butt
Committee	Derecke Palmer
	Jim Macnae
	Bob White
	Ray Shaw
	Joe Cucuzza
	Koya Suto
Past President	Noll Moriaty

Change of Auditors

At the AGM a resolution will be put to remove Mr Selwyn O. Sedger as auditor of the ASEG and to be replaced by Mr Malcolm V. Leeke & Sons.

AGM

The AGM of the Society will be held in Brisbane will be held at Oxley's Wharf Restaurant, 330 Coronation Drive, Milton, Queensland on Tuesday 13th April, at 5.15pm for drinks, 6.30pm for meeting followed by a talk by Natasha Hendrick.

Changes to Publication of Exploration Geophysics

Members are advised that the Federal Executive has approved a change to the publication schedule for Exploration Geophysics, commencing in 1999. From this year, only two issues of EG will be published each year. The next issue, Vol 30 No 1/2 (June 1999), is well into preparation and will have about 15 papers. This will be followed by Vol 30 No 3/4 (Dec 1999), and the Perth conference volume (Vol 31 No 1 March 2000).

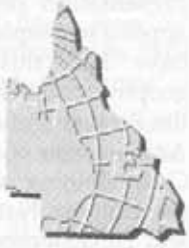
There are several reasons the change was recommended. Primarily it is believed that this new schedule will provide a more realistic timeframe in which the Editor is able to produce an issue which is more substantial and acceptable to members than the slim quarterly issues. The bi-annual format will also fit much better into production of ASEG conference volume, which will remain as one of the two annual issues in a conference year. It is also hoped that the larger format will be more attractive to advertisers.

Call for Papers

Second International Symposium on 3D Electromagnetics University of Utah, Salt Lake City, USA, October 27-29, 1999. Abstract submissions by 31 March and extended abstracts by 1 July. For contact details see Calendar of Events.

ASEG Branch News

Queensland



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The Queensland Branch is maintaining its proactive support for local geophysics students. During 1998 we held a number of special student functions, as well as continuing to encourage them to participate in our regular branch meetings. August saw the presentation of geophysics Honours and PhD research projects at the annual Student Presentation Night.

Congratulations to Simon Coombs, Matt Kay and Mike Winter from the University of Queensland, and Trinetta Herdy from the Queensland University of Technology for their professional presentations. The ASEG was also involved in running a geophysics information stall at the University of Queensland Engineering and Science Careers Expo. During October we held a Student BBQ with the Exploration Geophysics Laboratory at the University of Queensland. Brent Haines and Garry Fallon gave entertaining and insightful stories on 'life as a geophysicist'. Students were able to learn more about exploration geophysics courses and careers. Great food and live music were provided following the formalities of the evening. The Queensland Branch covered cost of registration for two geophysics Honours students to attend the ASEG conference in Hobart. And thanks to the support of local ASEG members all current exploration geophysics students were successful in obtaining vacation employment. The Queensland Branch will continue to support student/industry initiatives and hopes to see many more geophysics students participate in their local professional network.

Fun was had by all at our Branch Christmas party, held at the Bali Grill in Rosalie, during December. We would like to thank our industry sponsors - Veritas, Velseis Group and Oil Company of Australia - for helping make the evening a success.

Finally, the Queensland Branch webpage has recently been launched. Check it out at http://www.aseg.org.au/qld/. In the future all technical meetings, social functions and other relevant Branch news will be published on the webpage. Any ideas and contributions to make our page bigger and better are welcome.

New South Wales

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The NSW Branch finished 1998 with two meetings in December. The meeting on 1st December was on Geophysical Exploration in China. This included a presentation on tectonics and nonlinear techniques applied in geophysical exploration. We were fortunate to have had this delegation of prominent Chinese geophysicists which included Prof. Liu Guanding who is the President of Chinese Society of Geophysics and is an Academician of Chinese Academy of Science, and Prof. Guan Zhining who is the expert committee member of the Chinese National Modern Exploration Engineering and Development Centre and councillor of continental dynamic branch of Chinese Society of Geophysics.

This was followed two weeks later by a Student Evening with an award and 12 month ASEG membership being presented to Michael Seargent from Macquarie University. Michael discussed the structure and composition of the crust beneath the Agulhas Plateau (S.W. Indian Ocean) which was based on a wide-angle seismic experiment conducted during 1997/98.

On the 10th February the new year was "kick-started" with a joint ASEG SMEDG meeting on "The Gympie Gold Discoveries - New Exploration Methods in an Historic Goldfield". It was presented by Ian Levy and Steve Webster and they discussed how modern airborne geophysics, high sensitivity geochemistry and basic geological remapping provided the creative "spark of inspiration" needed for success. This meeting was very well received with over 70 members in attendance.

The State Branch AGM is planned for the 18th March. This will be followed with a guest speaker, Kevin McCue from AGSO who will discuss "The recent Tsunamigenic Earthquake near Sissano Lagoon in PNG". This tsunami averaged 10.5 m over Sissano Lagoon and Kevin who was on-site two weeks after this earthquake will discuss its "local" force and how it ravaged the area. Kevin (in partnership with co-worker Malcolm Somerville), will detail Their recommendations for at least minimising, if not averting the effects of a recurrence of such an event in the future.

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Western Australia

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Treasurer: Bob Groves (08) 9279 6456 / Fax: (08) 9279 6456

At the AGM held on December 16, 1998, the following executive and committee were nominated and duly elected without too much ferocious competition:

President:	Jim Dirstein
Vice President:	John McDonald
Secretary:	Terry Crabb
Treasurer:	Bob Groves
Committee Members:	Mike Benefiel, Cameron Blyth, Kevin Dodds, Graham Elliott, Tony Endres, Nick Fitzgerald, Dave Howard, Mark Russell, Greg Street, John Watt, Bill Witham.

Monthly meetings held in the Celtic Club, West Perth on the third Wednesday of the month have included the following:

September 16	Alan Stein, IKODA, *"4D 'Psychiatric' Seismic"* Anton Kepic, WMC, *"Seismoelectric signals from sulphides"*
October 21 and 28	Curtin University Student nights. Twelve top quality papers were presented. Winners of the ASEG WA awards for best papers were: Damien Leslie, *"Effects of high-velocity layering on seismic wave propogation"* Russell McChesney, *"Geophysics and diamond exploration in the North Kimberly"* Special mention for excellence to Shane Evans, Javier Peyriere, Troy Thompson and Bryn Bender
November 18	Dr John Bancroft, CREWES Project, Dept of Geology & Geophysics, University of Calgary: *"Prestack migration using the equivalent offset method"*

South Australia

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Much to report from the SA branch since we last wrote. 1998 ended up fairly busy, with December 98 and early 99 predictably slow. Things should be picking up nicely once we get our AGM out of the way on the 2nd of March.

The July (1998) talk, was presented by Rolf Klotz, the R&D manager for Western Geophysical in Australia and the far east. His talk was titled "Wave Equation Layer Replacement" and was well presented and innovative.

Our August meeting, was our annual Industry Night, with presentations by Steve Bustil of MIM Exploration, David Cockshell of PIRSA (used to be Mines and Energy SA), Jenny Bauer of Boral Energy, John Hughes of SANTOS, and Dave McInnes of Pasminco Exploration. A very successful set of presentations highlighting the variety of exploration activities going on in and around SA.

Our September meeting was a presentation by Peter Rose of Telegraph Exploration, based out of Austin Texas. His talk was titled "Risk Analysis and Professionalism in Petroleum and Mineral Exploration", and was designed to make us all think about where geophysics fits into exploration.

November was our busy month, making up for the lack of activity in October. In early November we were able to take advantage of the influx of overseas visitors for the upcoming ASEG conference by having Scott McInnes from Zonge Engineering (USA) present his talk titled "Imaging CSAMT and Resistivity/IP Data". Scott's talk made people start to realise that IP and CSAMT data can make "sense". We of course held our annual Melbourne Cup Luncheon (on Melbourne Cup day of course), which was extremely well attended. Activity in November was topped off by the ASEG Conference in Hobart, which was both enjoyable and informative.

The SA Branch hopes that everyone received and is enjoying their ASEG wine selections. If you have not already received your order please let us know. And we are looking forward to doing it again this year.

Victoria

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The Victorian State Branch held a well attended Student Presentation Night in October. Roger Hurren was awarded the Best Speaker prize for his talk titled: The lateral variation in magnetisation in Tertiary near surface basalts, Victoria.

The other speakers were:

Trevor Allen	*"High definition gravity surveys for kimberlite exploration";*
Tom Forrest	*"The application of DC resistivity to the study of Mitre Lake, Murray Basin, Western Victoria";*
Trudi Hoogenboom	*"Total magnetic intensity banding of the Mount Cole Granite";*
Tony Rudge	*"Structural association of the Arunta Block and Amadeus Basin: from re-processing and interpretation of the 1985 AGSO deep seismic reflection survey".*

All participating students were awarded one year's ASEG membership by the Victorian Branch and are to be commended for their efforts.

The 1998 Christmas party was held at the home of Shanti Rajagopalan and her husband Andrew. Thanks to them both for their hospitality, and to Shanti and her helpers for organising another successful event.

Sneak Preview

1999 will be a big year!

- *Membership Handbook*
- *Airborne Radiometric Corrections*
- *A Revision of the SEGY standard*
- *3D Treatment of Inverted IP Data*

As always your contributions are welcome.

Refer, Review, or Resell? Recommending a Geophysics Text

Lindsay Thomas
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One of our colleagues remarked to me a little while ago that he would like to acquire a copy of Heiland's Exploration Geophysics (1940). I was able to tell him that our university library has a copy-because I still refer students to it, annually.

This article started out as a brief review of a new - is publication the word? - CD-ROM on the Applications of Geophysics. In thinking about the product I found some interesting questions for educators and for our professional colleagues are raised. So, instead of simply discussing the good and bad points of the CD-ROM I've widened my aim somewhat, to look at a sample of the range of media materials available for basic instruction in Geophysics. Readers might like to take up discussion in the Letters column.

Resources for Teaching Geophysics

In teaching Geophysics within a University Science degree there will usually need to be a number of compromises made between the desirable and the possible. The time available isn't large, so a broad coverage will necessarily be shallow, or a deep study will be of a narrow part of Geophysics. If the students have a strong geology background, it will often be at the expense of mathematics (and vice versa). What follows will reflect another choice, as I will look at materials for exploration and more particularly shallow or environmental Geophysics, rather than global Geophysics. The context (rather than a choice) is teaching that Geophysics at an introductory level for Science or Engineering students who may not be planning to study any further in Geophysics.

None of these choices are absolute, but I think such choices are made to give some consistency to an introduction to Geophysics in a finite time. Once a general scheme is decided, the next question is very often-what text will be used? Latterly, there is a wider range, as I will discuss below, but often the choice will be between a set textbook and more-or-less extensive course notes. This choice can be affected by a further difficulty which seems to affect Australia (or Australian students) more than other Western societies: the cost of texts. A recent text by Sleep and Fujita (Principles of Geophysics, 1997) does show that a coherent text can be produced which covers most scales and introduces sensible mathematics, progressively-but although they cover migration in seismology and reduction-to-the-pole in magnetics, they don't mention electrical or electromagnetic methods at allÉ So, if only part of the book is to be used for a single- or two-semester subject, is the instructor justified in requiring its purchase? (If the student proceeds into a more-intensive study of some part of Geophysics textbook purchase becomes easier to justify but not necessarily more likely.)

Traditional

Using handout notes with a set text, and possibly a reference text, is a traditional basic resource in much of Science. Many readers will probably have at least had Applied Geophysics by Telford and others (1976, originally) recommended to them, and before that Milton Dobrin (and Heiland) provided the footings. These combined practical instruction with extensive reference material, and so could be recommended and seen as a long-term investment purchase. For a number of years I distributed handouts, recommended Telford, and suggested Sheriff's Encyclopedic Dictionary of Exploration Geophysics for those who would be professionals, as I believed that being able to look things up quickly is a useful survival skill.

An innovative book when first published, Burger's Exploration Geophysics of the Shallow Subsurface provided a valuable extension to the conventional text. Apart from the deliberate focus of the title, Burger included disks containing both simple applications for modelling and inversion in each of the main geophysical fields, and "live tables", copies of the Excel spreadsheets from which many of the book's tables and graphs had been constructed. This provided many students with a first, meaningful introduction to "what-if" modelling with spreadsheets, although at that time computer availability for classroom teaching was a general handicap.

For many students, especially those majoring in geology, Telford was seen as too specialised and too expensive. For some Milsom's neat text Field Geophysics (1989) has turned out to be useful in acquiring, and then using, the necessary amount of respect for geophysical information. Keary and Brooks (An Introduction to Geophysical Exploration), and Parasnis (Principles of Applied Geophysics or Mining Geophysics) fell between Telford and Milsom, rather on the more-quantitative side. These might all be useful as review texts for an undergraduate subject, but less so as a long-term reference volume.

Until recently there was no real alternative these in the basic text field, but a new book, An Introduction to Applied and Environmental Geophysics by Reynolds (1997) offers a wider coverage of current techniques with examples from the environmental problems which are increasingly relevant to the profession. However, despite the currency of some of the coverage and the length (nearly 800 pages), Reynolds eschews detailed mathematical coverage in most cases, giving depth rules in gravity, for instance, rather than the traditional formulae for simple-body responses. In the end this makes the book rather disappointing, in that it is difficult to recommend it as a long-term investment when, for instance, it does not even mention reduction-to-the-pole

processing in magnetics.

Familiar (?)

Several years ago, Learning Curve PL produced a Computer-Assisted-Learning module called "Geophysics for Geologists" with mining-industry assistance through AMIRA. This module, delivered on CD-ROM, has been quite widely used in both university undergraduate settings and in the exploration office settings for which it was developed, so I assume that it will be familiar to numerous readers. The module presents two exploration problems in a "role-playing" setting, supported by an electronic library which can be accessed readily during progress through the problems. Quiz screens allow for some self-test (and moderate progress through the problems).

Patrick James and colleagues from the University of Adelaide reported formally on a trial of this CAL package as part of an undergraduate subject, both replacing and supplementing material which would otherwise be delivered by conventional lecture format. Interestingly, in the initial trial, they reported only marginal changes in the two conventional measures often applied: the instructor effort required, and the exam results produced. However, they also reported a high level of student approval of the CAL method, revolving around the self-pacing which this delivery allowed. Their conclusion was that the CAL was valuable but to increase the traditional lecture coverage in the next delivery.

I subsequently used the same module at a similar level, principally as an adjunct resource to follow conventional lectures to geology students (having read of the Adelaide experience), and to demonstrate the integration of concepts into an exploration process. An important aspect surprisingly not mentioned by James impressed itself on me: the extended, role-playing problem setting is a strong motivator for students to use the electronic library in order to continue with the module, especially where they are uncertain of concepts. After all, a student with Telford and a notebook can work through the problems at his or her own pace!

"Geophysics for Geologists" works well as a resource for initial review and reinforcement of the concepts it covers. In the university classroom setting delivery is problematic, however; assuring access for 50 students in anything other than a structured classroom setting is difficult. If the CD was priced to compete with Myst or Flight Simulator I'd probably put it on the list with the hammer, compass, lens and first-aid kit as a necessary purchase for geology students!

Alternative

A recent e-mail announced the release of "Applications of Geophysics in Environmental Investigations", an instructional CD-ROM released by Matrix Multimedia in Canada, and probably available through amazon.com by the time this is published. I was interested to look at the product as a resource to support a new subject I am running (see below), because the price seemed, possibly, low enough to make it recommendable to uncommitted students.

The authors, John Greenhouse, David Slaine, and Paul Gudjurgis have extensive teaching and industry experience from which they draw. The CD-ROM is organised in a book-like fashion, with chapters on the various geophysical techniques, a glossary, and a sponsors' section at the end. The authors make use of the format by having pop-out definitions, a small number of animations, and colour illustrations. The stated aim is "to provide a quick reference to information required to use geophysics sensibly and efficientlyÉ" and the CD-ROM is variously described as a "field guide", for use in "general training courses" and as a "desktop reference".

I think that "Applications of Geophysics in Environmental Investigations" may be of some use in general training courses for non-geophysicists, but I don't think it will work well in the other proposed uses, nor in my niche. My subject provides students with a quartet of related problems, in gravity, magnetics, resistivity and seismic refraction, and I am keen to see material which broadens the solution range within the same general (environmental) context. The CD-ROM doesn't accomplish its tasks well enough to make it recommendable. There certainly are interesting case histories discussed, but although the CD-ROM is intended for non-geophysicists, the case histories are organised by geophysical method rather than by problem type.

The problems lie in the failure to make significant use of the medium. The animations are very sparse and simplistic, and are not well annotated; nor is there a voice-over which might have helped. Technical terms are not hot-linked to the glossary, nor is there any index or cross-reference links, so use as a reference is limited; it is hard to see a logic to the choice of terms which are given pop-out definitions within the text.

Because these are all facets of a resource which the CD-ROM medium facilitates, they detract from this product as a personal-library investment. As an example: the second resistivity case history refers to the use of the azimuthal array method in a fracture-rock aquifer context. A user familiar-enough with the CD-ROM to know that such an target was discussed would, having located the case history in the appropriate (resistivity) method would then have to read through the "theoretical" material to find out what the azimuthal method was. Realistically, the "azimuthal array" term could be hotlinked to either the technical section or to the glossary.

The authors predict a web-enabled upgrade in a couple of years, although I have not discovered whether this will be a new-purchase or add-on item. For this kind of product, though, I don't think the Web is a necessary extension (yet).

Now is the Future

I have mentioned a new subject just begun. I quickly acknowledge that I am implementing the website that was described by Tom Boyd in Leading Edge (July 1997, 1039), developed with the assistance of the SEG. This structure (GP311 for short) contains extensive written notes; supporting and generally hot-linked into a set of "role-playing" problems in which the student is asked to bid for and carry out geophysical contract services. It is probably best to go to the website to appreciate the structure: my version is at www.met.unimelb.edu.au/ES304/ and contains a link to Boyd's original (and frequently updated) GP311 site at the Colorado School of Mines. (We duplicated the original site to cut down on web traffic and to give some chance for local students' queries to be directed locally.) My subject structure requires students to spend a three-

hour, relatively structured lab-class each week for twelve weeks on this problem, supplemented by a tutorial largely used for computer-technical problem solution, and twelve conventional lectures on basic theory-and a significant amount of personal study, as in any University subject. My students found the pace hard and the goals difficult in this first implementation-but overall approved of this form of teaching. I haven't done a formal evaluation as James did in Adelaide, but my impression is that the drive to meet report deadlines caused students to treat the underlying principles more superficially than I would have hoped. Reducing the deadlined workload might avoid that in future.

What advantages do I see from this mode of teaching? Largely those identified by Boyd. Learning-by-doing is a valued approach in many fields; computer simulation allows students to learn from "observations" which might be difficult or impossible to make in the field. The interaction between system noise level, repeat observations, station spacing, and detectability is seldom one which any geophysical field camp will be able to address, but with Boyd's simulations tradeoffs can-with thought-be evaluated. One of the most useful outcomes can be how to learn by doing: GP311 requires that students produce "if-then" statements to encapsulate the "physics" of each problem. Accurately reporting what happens if a target, or interface, changes in depth in such a format follows naturally from "if I change this then what happens".

The other advantage I see is that non-specialists don't see, and so are not daunted by, the number-crunching required for both design studies and response "inversion" (matching) - but since the simulated data are available, other students can manipulate those data off-line if they wish, with pencil and paper, Excel-or ModelVision. We will continue the experiment next year.

Where will we go?

I think the Tom Boyd approach will be a significant part of the future of resources for this kind of teaching in basic Geophysics. I believe that GP311 is stronger all around as a teaching and learning resource than the "Applications of GeophyicsÉ" CD-ROM, but the latter does have a wider range of case histories and of individual techniques. I don't, however, see that the Web is a necessary part of the delivery, basically for economic reasons, but it is a vital further resource. "Geophysics for Geologists" is a polished product, but lacks the interactivity of GP311 and is much too expensive for private use.

To some extent, costs will decide where we go. One of my students observed that her ISP charges to access the website were much more than the cost of a writable CD. It is a very attractive notion to think of a CD-ROM which combines the three (or four, including Burger) electronic approaches, and it could be done now. However, if the pricing of such a product reflects book-industry levels rather than course-note levels, Web-based delivery will be more attractive to students.

There are some indications that Web-delivery rather than CD-delivery will become more widespread anyway (Microsoft are said to be downgrading products such as Encarta and Bookshelf in favour of Web sources), but that raises the problem of permanence and maintenance of the site and its content.

Perhaps the ASEG could take a step in a direction

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Book Review – "The Hammer of Eden"

It's fiction, but is it popular?

Popular-blockbuster writer Ken Follett's latest release includes three new star characters: a seismic vibrator truck and two geophysicists! Parochially, we should be pleased, as the male geophysicist is "a hunk" and the female "has the figure of a supermodel"; in other words, they will look well in the film-but the book is a clunker.

There's a genre in popular fiction (Dick Francis is an author who comes to mind, and I suspect that Mills'n'Boon are in there too) in which a tried-and-true formula is brightened up by being placed in a new context each time. Here the formula is the psychopath attacking society to get his own way, but the angle this time is not the bomb threat, or the hostage, or the hijack, butÉan earthquake stimulated with a vibrator. The technical explanation isn't too deep, but neither are the characters.

The vibrator is wielded by members of a California commune, trying to stop a power development. Communal living provides stereotypical opportunities for sex scenes (the women are differentiated largely by hair colour) but makes the violent action segments more implausible. The really implausible content revolves around our defenders, the FBI. The superheroine has to contend with the bad guys, with her own ineptness (breaking down a door without even notifying anyone), and with FBI office politics which are unbelievable even by University standards! (Follett gives the psychopath a surprisingly good run, even allowing him to suicide quielty at the end of the book, thanks again to superheroine's ineptness.)

I do wonder where the basic idea for this angle came from. Follett thanks an organisation called "Research for Writers" in his acknowledgements, for their assistance in locating information about the plot. I think they should have written the book, too-they seem to me to have spent more time on the job.

It's a beach or plane-trip book, but use a library copy. Follett's "Pillars of the Earth" was a much better book, and that could be worth the money from your holiday budget.

Ken Follett (1998): *"The Hammer of Eden"* (Crown Publishers, Inc, New York).

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Fellowship for Brian Spies

Brian Spies was elected as a Fellow of the prestigious Australian Academy of Technological Sciences and Engineering at their annual meeting in Fremantle on November 23. His citation reads "... for major contribution to geophysics for resource exploration and non-destructive pipeline testing and to managing collaborative research."

Brian's election to the Academy follows in the footsteps of other notable geophysicist Andy Green and Ken McCracken who were elected last year.

Obituary

VALE WAYNE KERWIN THIELE 1940-1998

Wayne Thiele passed away on the 15th October 1998 in Adelaide, his hometown and where he lived most of his life. Wayne will be remembered by his family, friends and colleagues as a good man, perhaps a simple sentiment but one that is appropriate.

Wayne was born in Adelaide in 1940 and went on to graduate from the University of Adelaide in 1961 with an Honours degree in Geology and Geophysics. He had a brief career with Petty Geophysical before joining Delhi in 1965. These were the days before digital processing had come to Australia. Wayne liked to recall one of his field trips to the Cooper Basin at that time that included interpreting field records, changing the seismic program and siting a well.

At a time when exploration activity was very low in Australia Wayne took his then young family and tried his luck with Phillips in Tehran. This was when the Shah was in charge and American companies were welcome in Iran. This was followed by a three-year period in the Philippines where he worked on a variety of projects including offshore Cebu. He then moved to Indonesia and lived within a small expat community with his growing family.

Life with Phillips was proving to be uncertain and when he was about to be transferred to London for a 1-5 year period Wayne decided to join Occidental in Adelaide as Chief Geophysicist in 1981. However within two years Occidental closed their Adelaide office. Sensing that a move to Perth would also be short-lived, Wayne rejoined Delhi as a Queensland Cooper Basin Team Leader in 1982 where I first met him.

Delhi moved it's Queensland exploration group to Brisbane in 1985 but Wayne decided to stay in Adelaide for the benefit of his sons' education. When Santos took over Cooper Basin operatorship from Delhi in 1987, Wayne joined them in their Timor Sea group and also worked in their SE Asian operations. His most recent position was within the Bonaparte Exploration working on the Bayu -Undan development.

He was diagnosed with a rare form of heart cancer in 1996 and was given a short time to live. He survived some 2 ½ years and continued to work until the end. On the eve of his death he was still talking shop with two of his colleagues who had come to visit him.

Wayne is survived by his wife Julie, whom he had first met in 1958, his sons Stephen, David and Peter and three grandsons. God bless you Wayne. You will be missed.

Henk van Paridon

The ASEG and the AGC

The Australian Society of Exploration Geophysicists is a member of the Australian Geoscience Council. What is the AGC? The AGC is the peak body for geoscientists in Australia representing about 7000 geoscientists and exists to:

* Provide expert apolitical advice to government on matters relating to earth science.
* Promote the development of scientifically sound policies for effective earth science education and research.
* Provide the Australian public with greater appreciation of the economic, environmental and cultural values of the earth sciences.

The other members of the AGC are the Association of Exploration Geochemists, the Australasian Institute of Mining and Metallurgy, the Australian Geoscience Information Association, the Australian Institute of Geoscientists, the Geological Association of Australia, the Institute of Australian Geographers, and the Petroleum Exploration Society of Australia. In addition there are several non-voting Associate Members, (which includes the Australian Geological Survey Organisation).

The AGC is, in turn, a member of the Federation of Australian Science and Technological Societies (FASTS). Just as the AGC is the peak body for geoscientists, FASTS is the peak body for about 50,000 scientists in Australia.

In dollar terms membership of the AGC costs the ASEG $1.80 per member per annum. Much of AGC's income is passed to FASTS.

For further information consult the AGC web page on www.agso.gov.au/agc/. Our representative on the AGC is Graeme Mackee (email: mackee.graeme.gl@bhp.com.au). Graeme intends to update members on relevant issues arising from the AGC through Preview.

Doug Price
(price.doug.dg@bhp.com.au)

CRC AMET Launches TEMPEST

The much-awaited TEMPEST airborne EM system, developed by the Cooperative Research Center for Geophysical Exploration Technolgies (CRC AMET) and licenced to World Geoscience Corp Ltd, is currently flying a large demonstration survey near the south-western NSW town of Temora. The survey addresses both mineral exploration and environmental applications.

Better still, the new system has helped promote geophysics to school children, featuring on the ABC's web site "The Lab" in mid January (see http://www.abc.net.au/science/news/stories/s18382.htm).

More information is given on CRC AMET's web site, at www.crcamet.mq.edu.au.

13th ASEG Geophysical Conference and Exhibition. 8th - 12th November 1998

Seven hundred geophysicists, plus spouses and partners, "crossed the borders" last November, to talk, exhibit, and most of all enjoy the 13th ASEG Conference in Hobart, Tasmania. Defying pessimistic trends in the Industry, 107 oral papers and 36 poster papers presented an upbeat picture of the growth of geophysical technology.

Mawson and Mates

What will be the most enduring memory of the 13th ASEG Conference in Hobart? For most delegates, it will probably be the penguins; they featured in Antarctica audio-visuals screened at the commencement of the Opening Session, again as waiters at the ice-breaker cocktail party, later as part of the Antarctica décor for the Conference Dinner, and finally as a group of "missing persons" after the Dinner. It seems about two dozen penguins "walked" after the dinner, and rumours continue to circulate at Branch Meetings around the country, as to which senior members of the society were seen walking the streets of Hobart in the morning after the dinner, arms around a furry friend or two.

With an impassioned plea by Co-Chairman Craig Dempsey for the return of "Mawson's Mates", a few penguins were found, and became a temporary feature of various desks around the Conference precincts. However, the majority did not make it home, and the venue presented Treasurer Dave Gamble with a bill for $2500. Fortunately, the bulk of this has been covered by the Conference all-risks insurance policy, but we would have preferred to avoid both the loss and the claim.

Hobart Delivers four Milestones for Geophysics

In welcoming Official guests and delegates to the 13th ASEG Conference, Co-Chairman Michael Asten spoke of four features of special significance.

- This was the first ASEG conference to be located outside the circuit of mainland capital cities. The attendance figures, showing 547 registered delegates, including 50 from 22 overseas countries, exceeded all expectations, and broke records for non-Sydney SEG conferences.
- Hobart was the site of one of the first geophysical observatories in the Southern Hemisphere - Thomas Bock painted the Rossbank magnetic Observatory in 1842.

- Hobart was the site of the first undergraduate teaching programme in geophysics in Australia (at the University of Tasmania, under Prof. Sam Carey AO - see his citation for the ASEG Gold Medal, in the previous issue of Preview).
- The year 1998 is the year of the announcement of a major mineral resource (the KWR heavy mineral sand deposit near Ouyen, Vic) where the discovery is attributable to information derived from a geophysical data-set in a State Government Exploration Initiative.

President Draws Short Straw

President, Noll Moriarty, conducted a quick straw poll of the audience during his closing address to the conference. He asked whether delegates preferred a 3 or 4 day conference. The delegates were clearly in favour of a 4-day event. However the result may have been misleading, according to Noll, claiming that those in favour of a 3 day event had already left...

On a more serious note Noll also noted that there was still a perception by the petroleum geophysicists that the ASEG conference was not for them. It was to be hoped that they would be present in force for the Perth Conference in 2000.

A Night to Remember

One of the most interesting sights during the conference was 300 geophysicists being led by a police piper following a cruise on the Derwent. Police assistance had been ordered to help this strange entourage cross the road with traffic held up for some 10 minutes. Dinner speaker, explorer Nick Feteris, enthralled the audience with his tale of an adventurous sky dive from a mountain in Pakistan. Easy as falling off a log apparently.

Barry Long, despite being temporarily upstaged by Veritas CEO, Steve Ludlow, proved he was still the MASTER of ceremonies. His purpose-built white jacket has been extensively remodelled of late and Barry was able to seamlessly blend in with the penguins.

Border Control

Along with the 'crossing the border' theme delegates were issued a passport to collect stamps from all the booths. A full passport, 101 stamps, enabled the holder to participate in a draw for a gold nugget drawn at the end of the conference. Other innovations at the exhibition were the cappuccino and ice cream stands that did a roaring trade. These may add a new dimension to what is normally considered a prime location in the exhibit hall. Congratulations to Landmark Graphics for their award winning booth which featured 3D Visualisation where delegates could wear funny glasses and emerse themselves in a 3D data set.

Epi-Log

The last word in logging. This brand name now available for plagiarising. Final thanks must go to all those involved in putting the conference together. To Mike Asten and Craig Dempsey and their team: and also to the conference sponsors particularly Baker Hughes/Western Geophysical who continue to support our conference. Thanks from all of us the delegates and ASEG members.

SEG Japan International Symposium

The 4th Society of Exploration Geophysicists of Japan International Symposium was held at Nihondaigaku-Kaikan, Ichigaya Tokyo from 10-12 December 1998.

The Symposium was sponsored by SEGJ and the Chairman was Dr Teruki Miyazaki of the Geological Survey of Japan. The meeting was co-sponsored by SEG and the Australian SEG, with the co-chairs being Dr Arthur Cheng of Baker Atlas in Houston and Dr John McDonald of Curtin University.

At 162 the attendance was a little less than had been hoped for but attending were delegates from 16 different countries including Bulgaria, Mongolia, Peru and Switzerland.

A total of 68 papers were presented at the Symposium. Although the theme was 'Fracture Imaging' a wide range of topics was covered ranging from crustal studies to core imaging by electrical tomography. Eleven speakers were invited to give extended talks, including two from Australia; Peter Hatherly of CSIRO Exploration and Mining and Milovan Urosevic of Curtin University of Technology. Other Australian papers were given by Gary Fallon of MIM Exploration and by John McDonald.

The Symposium ran very smoothly and SEG Japan is to be congratulated on a great job of organisation. The meeting was crowned by a superb banquet that provided copious supplies of lobster, shrimp and crab amongst other delicacies.

A lot of interest was displayed in the upcoming ASEG 2000 and many people requested notice of the Call for Abstracts.

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Honorary Membership (For distinguished contributions to the profession of geophysics)

Hugh Rutter

Hugh Rutter has been an active member of the Society since its inception in 1970. In 1971, while at WMC, he provided important advice that that had profound influence on the research program of the CSIRO Division of Mineral Physics when it was established in 1972.

As Chief Geophysicist of BHP Minerals for 5 years to 1981 he took a series of initiatives in the introduction of new technology into mineral exploration. He played a major industry role in the development of the then-novel Sirotem within CSIRO, and introduced a programme of

high-resolution seismic mapping of coal resources in the Bowen and Sydney basins. He took a lead role in founding the Victorian State Branch of the ASEG in 1978.

Hugh later founded a geophysical consulting company which over the years has contributed to both mineral and petroleum exploration throughout Australia, and in Asia and Africa. He is a founding member of the Flagstaff group of consulting geologists and geophysicists. In addition to becoming a leading practitioner of exploration geoscience, Hugh has taught numerous Industry courses in geophysics for the Australian Mineral Foundation, and has held part-time appointments at Monash University and as a program leader within CSIRO.

Hugh has used his wide contacts and high reputation in geosciences for the benefit of the ASEG by serving for three years 1992-94 as Federal President, during which he directed significant changes in the operation of the society and secretariat, which strengthened professionalism of its operations. He furthered links with the Society of Exploration Geophysicists in the USA which led to co-sponsorship by the SEG and an increased international recognition of our conferences in 1995, 1997 and 1998. He continues to assist with conferences, serving on the 1998 Conference Organising Committee as Workshops Chairman, and on the ASEG Conference Advisory Committee.

The Society and the profession have benefited greatly from Hugh's guidance, teaching and representations over 28 years, and it is fitting to recognise this at this conference with the award of Honorary Membership.

Honorary Membership of the ASEG (For distinguished contributions to the profession of geophysics)

Norman Frederick Uren

Norm Uren graduated with a BSc in Physics from the University of Western Australia, and then went on to finish a Diploma in Education; he was a natural teacher. He taught physics at Perth Technical College, and later transferred to the W.A. Institute of Technology (WAIT). There he met Stewart Gunson, who was teaching some geophysics to physicists. WAIT had a large physics school and a small geology staff. Norm, with a background in physics, decided that geophysics was his future and he would help Stewart set up a strong geophysics area within physics.

Norm meanwhile continued his own education with a Postgraduate Diploma in Applied Physics in 1969, with a project on gravity methods. In 1975 he completed an MSc degree in magnetic methods while assisting Stewart expand the geophysics content of the physics program at WAIT.

In 1973 the geophysics program was officially recognised and it was elevated to the Bachelor of Applied Science status. The course had as many as 23 graduates by 1976.

In 1981, Norm assisted in the establishment of the Department of Geology and Geophysics at WAIT, and started a seismic course in response to the then booming petroleum industry's needs. With Brian Evans, he later

set up the Graduate Diploma in Applied Physics, a course designed to train non-geophysicists in all areas of geophysics.

Evans and Uren gained the attention and the financial support of the University of Houston's Allied Geophysical Laboratories to underwrite seismic field developments in WA. By 1985, Norm had attracted 25 students into the Graduate Diploma program. Meanwhile, Norm instilled in the students the necessity for ASEG membership as a way to continue their professional associations.

Norm had the foresight to see that for exploration geophysics to prosper in Australia, an internationally recognised research program had to be established. This would require PhD students and PostDocs; however as no academic staff member in WA had a PhD in geophysics, PhD students could not be supervised. Norm set out to rectify this problem and, without financial support from any source other than himself departed for Houston to complete, in 1988, a PhD in seismic anisotropy. Norm is probably the only person in the world with postgraduate qualifications in three areas of exploration geophysics; gravity, magnetics and seismic.

Due to Norm's efforts on his return to Australia, the newly established Department of Exploration Geophysics at Curtin soon became a node of research through three Co-operative Research Centres, and by 1997, the geophysics student population was the largest in the southern hemisphere with over 140 students, all majoring in exploration geophysics. Norm's vision of an internationally recognised research program had been realised; by 1998 five PhD and 12 MSc degrees had been awarded by the Department, and an average of 39 graduates per year. This productivity is reflected in the exploration geophysics community working in Australia. It is estimated that fully 50% of practising geophysicists have, at some time, been taught by Norm.

Norm is probably as well known in the US as he is in Australia where his research skills are widely recognised. His innovative work in seismic anisotropy and seismic multiple attenuation has been published in the leading journals and his papers are to be found in SEG publications, in the journal Geophysics and in several books. Norm's multiple attenuation work has brought a flood of industry personnel to his doorstep. His substantial contributions to teaching and research were rewarded in late 1998 by his appointment to the first personal Professorial Chair in petroleum geophysics established at Curtin University.

In addition to all these activities Norm has been very active in service to the professional societies. For many years he has been the ASEG representative on the SEG Standing Committee on International Affairs. In 1995-1996 he became the first Australian to serve on the Society of Exploration Geophysicists Executive Committee as Vice President. Norm has been President of the ASEG and twice President of the WA Branch of the ASEG.

B.J. Evans and J.A. McDonald

The ASEG Service Medal (For extraordinary service to the ASEG over many years)

Lindsay Ingall

Lindsay's association with the ASEG has spanned over 25 years, and he has had an active involvement on the Federal Executive or as a member of various sub-committees continuously over that period. To many members, Lindsay could be regarded as the 'father' of the Society, having been instrumental in the foundation of the ASEG in 1970, formalising the original Articles of Association, and incorporating the Society as a public company in August 1971.

Lindsay was a member of the original Executive Committee, and was President of the ASEG in 1971/72 and 1978/79. He is currently Chairman of the Honours and Awards Committee, but has recently advised his desire to hand this over to Bill Peters. Lindsay was made an Honorary Member of the ASEG in 1988.

Lindsay has intertwined his ASEG involvement with an active and varied career as a practising geophysicist. He graduated with a B.Sc degree in Geology and Physics from Sydney University in 1947. Soon after he joined the Zinc Corporation in Broken Hill and spent 18 months carrying out regional magnetic, gravity and electrical surveys around the Broken Hill. In 1949 Lindsay joined the Bureau of Mineral Resources (now AGSO) with the objective of getting down to the Sub-Antarctic. He was first assigned to work on the pendulum gravity survey of Australia, before setting off for a 12 month stay on Heard Island where he looked after the operation of the magnetic and seismological observatories.

Shortly after returning to Australia, Lindsay decided to go to Canada, where he carried out seismic and gravity surveys from Quebec to the Northwest Territories. The most challenging time was spent in the Canadian Arctic, where Lindsay pioneered geophysical exploration for his company.

Lindsay returned to Australia in 1962 and formed the Wongela Geophysical company, which was actively involved in gravity exploration for oil, coal, oil shale and base metals, and was also responsible for a large proportion of the regional helicopter gravity coverage of Australia for the BMR between 1964 and 1974. A little known fact is Lindsay's role in the delineation using gravity surveying of the Stuart oil shale deposits in central Queensland during this time.

Lindsay was always keen on helicopters and he teamed up with a pilot and engineer to set up in 1963 a helicopter company, which was a major component of the helicopter gravity contract work carried out by Wongela. Lindsay also became involved in overseas assistance work in Thailand, South Korea and Sri Lanka between 1977 and 1980.

Lindsay now lives in the Blue Mountains west of Sydney, but maintains his active interest in geophysics through his consulting work, and of course through the ASEG. Lindsay is also well known to hundreds of other geoscientists who are not members of the ASEG through his long standing involvement with the Australian

Institute of Geoscientists (AIG), which was formed in 1981. Lindsay was on the original committee of the AIG, was President in 1989/90, and is currently an AIG Councillor and Chairman of the membership committee.

Nominated by the ASEG Federal Executive.

Geoff Pettifer

Geoff Pettifer has made a significant contribution to the continuing growth and success of both the local branch and of the Society as a whole. Geoff's involvement in the ASEG goes back to the 1980's as Secretary of the Victorian Branch, but his main involvement with the ASEG was as a member of the Federal Executive from 1992 to 1996. He took on the onerous role of Preview Editor, and saw through the production of over 20 issues of Preview during this period.

Of particular note, Geoff was most influential in upgrading the format of Preview to its present high standard, including incorporation of Preview as an ASEG Conference handbook. Largely because of Geoff's efforts, Preview now enjoys a wide acceptance amongst the readers of earth science publications, and this acceptance has enhanced the reputation of the ASEG amongst the geoscientific community within Australia as well as overseas.

Within the local branch, Geoff has, as President and as committee member, worked hard to keep the Victorian Branch alive and kicking. He has worked at making sure branch members have the opportunity to listen to interesting speakers. He has also, in his own thoughtful way, encouraged and supported younger ASEG members and members new to the state in many ways, including getting involved in ASEG activities.

Geoff is an unashamed enthusiast for geophysics (see Preview No 47 December 1993). Geoff holds a B.Sc. in Physics and Geophysics from the University of Melbourne, and a Graduate Diploma in Applied Geophysics from the University of NSW. Joining the Bureau of Mineral Resources in 1970, he worked initially in seismic and gravity, but transferred to engineering and groundwater geophysics. He later spent some rewarding years at the Geological Survey of PNG, followed by several years at the Geological Survey of Victoria involved in establishing geophysics capability in the Victorian Government. Geoff also has a strong interest in the petroleum industry, which saw his involvement in Victorian Government basin studies geophysics and image processing, and establishment of Victorian petroleum information databases and services.

Most recently, Geoff joined Geo-Eng Australia, a consultancy group, returning to his interest in groundwater and engineering geophysics, applied to mining, environmental, hydrogeological and geotechnical projects. Through this interest he maintains, as time allows, a link to Preview as current Associate Editor of the Preview Clean and Green occasional column. He also maintains his interest in petroleum as a PESA State committee member and is interested in forging closer technical links between the ASEG and PESA.

Nominated by Victorian Branch and Federal Executive.

The Grahame Sands Award (For innovation in geophysical technology)

Andrew C Duncan

In 1994 a joint venture between EMIT and Western Mining Corp commenced a project to design and build a new time-domain EM instrument. Existing instruments then provided only rudimentary signal processing capability, which resulted in inferior data in the vicinity of power lines, radio stations and mine communications equipment. With the increasing application of TEM methods on active mine leases, interference from cultural EM sources had become a significant limitation on the technology.

The SmartEM instrument was conceived and built using the full resources of an on-board computer to allow on-line signal processing, graphical display in oscilloscope, spectral analyser, and traditional stacked geophysical data forms, storage on disc of raw and processed data, and immediate recall and re-processing of acquired data. Advanced signal processing algorithms, applied to raw time-series data, have proved the key component of this new instrumentation, but careful interfacing to other commercially-available field equipment and the use of industry-standard display and file formats have contributed to the successful utilization of this system in production surveys.

The result is a new-generation multi-channel EM and IP receiver instrument which demonstrates an order of magnitude improvement in data quality in the vicinity of power-line and other noise sources, and which provides a new generation of data-reduction and display capabilities in the field. It has been interfaced to operate with a range of industry-standard transmitters, and surface and borehole sensors. Early successes are documented in Preview April 1997. The instrument is now in regular use with WMC and another of Australia's major mining companies, and it has been successfully used in trial EM, magnetometric and IP surveys by two further mining companies in Australia and overseas.

A second generation SmartEM instrument of reduced size and power requirements is in an advanced state of development, and is likely to enhance the position of this new instrument as being a generation ahead of both Australian and North American commercial EM instrumentation.

The ASEG Service Certificates (For outstanding service to the ASEG)

Presented at the ASEG Conference, Hobart, November 1998

Lindsay Thomas (Victoria) - Nominated by Victorian Branch

Lindsay Thomas has served as ASEG Treasurer for many years (both on the local and federal committee). His strong background in Mathematics helped him as he struggled hard to reconcile the budget year. Because of the tardiness of the state branches in submitting annual accounts, he nearly went to jail in service to the Society!

Lindsay is an icon to his students many of whom have since joined the ASEG. Lindsay is one our regular members at our branch committee meetings and contributes with his questions and active participation. He is a senior member of the Victorian Branch and the award is well justified for all the work he has put in to the ASEG over many years.

Terry Crabb (WA) - Nominated by WA Branch

Terry Crabb has served on numerous ASEG committees over a period of more than 20 years. Whilst in Perth in the early 1980's, he served on the WA Branch committee, then following his move to Adelaide immediately became involved with the SA Branch, eventually serving as Branch President.

With the first move of the Federal Executive away from NSW and to SA in 1984, Terry became a member of the Federal Executive committee with responsibility for ASEG publications, and also served as Treasurer followed by Secretary over three years. It was during this time that the idea of an ASEG newsletter was conceived by the Executive, and Terry along with Peter Elliott were instrumental in starting Preview in 1986.

After working in Canada for several years, Terry returned to Perth in 1998, and immediately re-joined the WA Branch committee, taking on the position as Secretary.

Doug Roberts (SA) - Nominated by SA Branch

Doug has been working for the last twenty years for Boral Energy Resources (and its predecessors). He joined the ASEG in 1973, when the South Australian Branch was formed, and has been active with the local Committee for five years, starting as Committee Member, and then serving as both Secretary and Treasurer.

In the late 80's he rejoined the South Australian committee, serving as a Committee Member for more than three years. During both stints, he served on the Conference Sub-Committees all four times that Adelaide hosted the national conference. He has also served on the ASEG Research Foundation for the past six years, the last three as Secretary.

Henk van Paridon (Qld) - Nominated by Federal Executive

Henk's involvement with the ASEG goes back to 1984, during which time he served continuously on the SA and Queensland Branch Committees up until 1996 (including two years as Branch President), when the Federal Executive moved from Melbourne to Brisbane. Henk was the chief instigator and organiser of the new Federal committee, so it was no surprise that he was unanimously voted to take over as Federal President in 1996.

He remained on the Federal Executive until June 1998, and took on the onerous role of Preview Editor from Mike Shalley in mid-1997. Henk is still the Preview Editor, and the continued high quality and recognition of Preview throughout the geophysical community is testimony to the huge effort Henk has put into this.

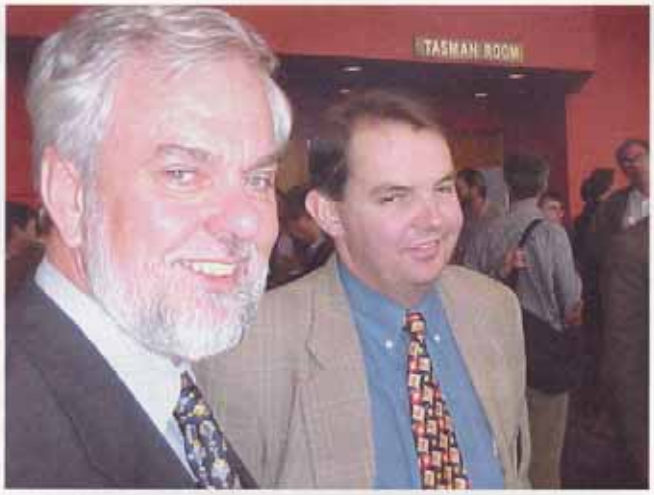
Henk has also been very involved in other ASEG activities over the years. In 1992 he was co-chairman of the ASEG Gold Coast Conference, and has also served on the Continuing Education Sub-Committee.

Steve Webster (NSW) - Nominated by NSW Branch

Steve Webster has been an active member of the ASEG since 1971 and has held positions on ASEG committees right through to the present day. Steve was on the Federal Executive Committee in 1973 to 1975, and 1979, Federal Treasurer in 1980 and 1981. He has been on the committee for the Sydney 1985 and 1997 Conferences as Treasurer.

Steve has also served on the State Branch Committee for an extended period and has had extensive input into the local branch over the years. He has also been an ambassador for geophysics both in Australia and overseas, through his professional involvement with government, industry and most recently as a consultant.

Conference Collage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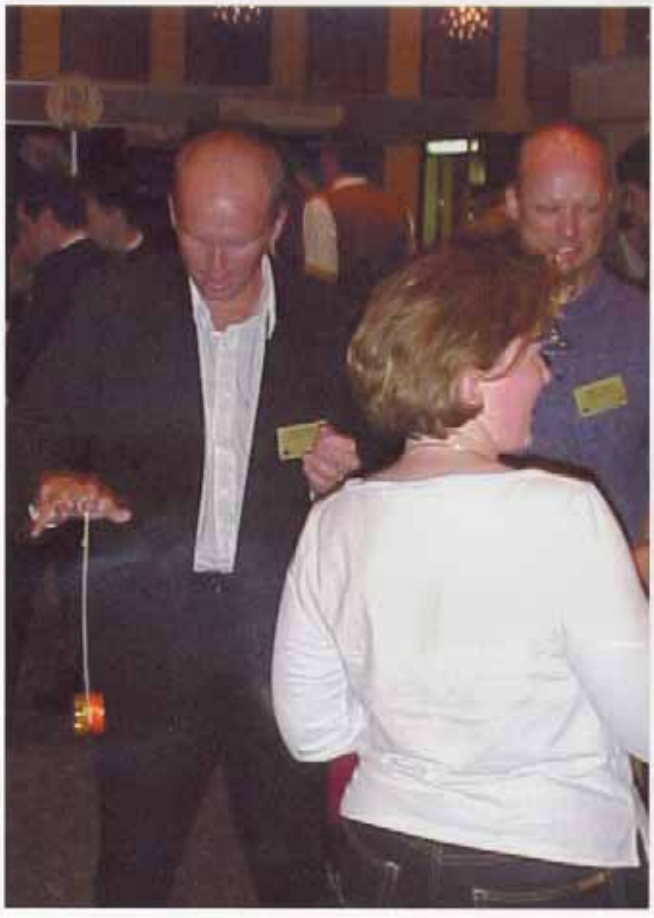

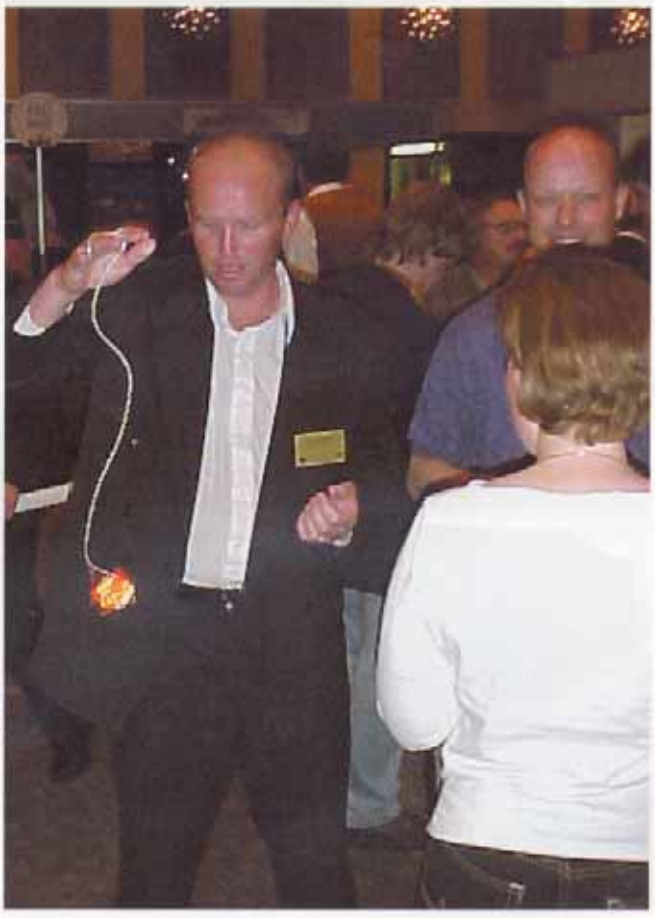

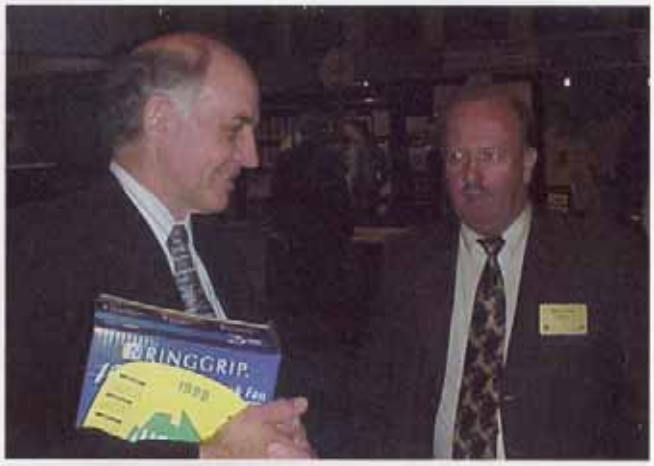
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REGISTRATION


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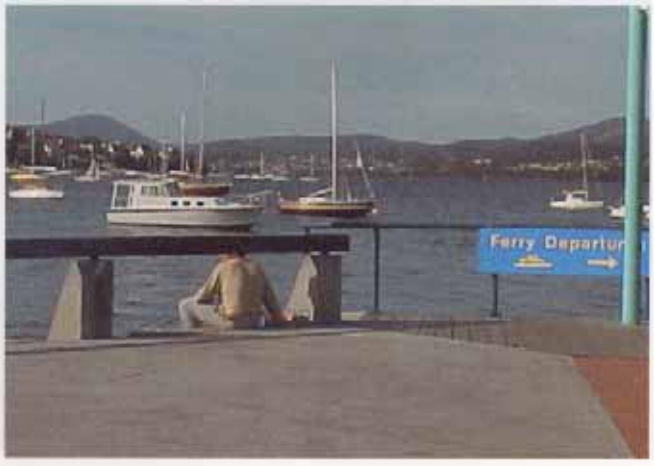
Ferry Departur

University of Adelaide Department of Geology and Geophysics

Staff

Geophysics at the University of Adelaide received a major boost last year with the appointment of Stewart Greenhalgh to the Douglas Mawson Chair, as Professor of Geophysics and Head of the Department of Geology and Geophysics. Stewart was formerly Professor of Geophysics and Head of the School of Earth Sciences at Flinders University, and is well-known to the geophysical community in Australia. Stewart joined two other geophysicists in the Department: Drs Peter Brooker and Richard Hillis. The geophysicists in the Department teach and research collaboratively both with the geologists in the Department, and with staff at the University's National Centre for Petroleum Geology and Geophysics.

Tradition and Future Developments

The University of Adelaide has a proud tradition and reputation in geophysics education, having appointed the first Professor of Exploration Geophysics (David Boyd) in the country in 1969. Prior to that time geophysics was undertaken in the Physics Department by the late Dr David Sutton who set up an earthquake monitoring network within South Australia, beginning in 1959.

A number of Professor Boyd's students have gone on to assume prominent positions in industry and government. Up until the year of his retirement in 1991, 107 Honours, 9 MSc and 8 PhD theses in geophysics had been completed in the Department. With a view to continuing and expanding David Boyd's interest in, and strong links with minerals geophysics, the Department hopes next year to complete the arrangements for another a new Professor of Geophysics, focusing in, and largely funded by, the minerals industry.

Research

Research is well supported in the Department with significantly in excess of $1M worth of externally funded projects currently being undertaken. The Department's success in raising external funding has continued in the most recent round of ARC awards for projects commencing in 1999. The Department has 7 PhD students in geophysics either completed or studying in 1998 and 4 MSc students.

Teaching

The Department offers a BSc major in geophysics. Components of the undergraduate geophysics syllabus are taught at all levels. Solid earth geophysics is combined with plate tectonics in First Year Geology. Geology and geophysics students undertake second and third years courses in exploration geophysics, and geophysics majors also undertake a specialised third year geophysics course which covers theoretical aspects of the subject. These courses are complemented by courses in geology, maths and physics. More geologically-oriented geophysics students can undertake a double major in geophysics and geology, and those more physics-oriented can undertake a double major in geophysics and physics.

The Department is proud of the employment record of its Honours graduates. From 1989-1997 inclusive, 31 of our 34 Honours Geophysics graduates have been employed in the geophysics area. The other three are undertaking PhDs in geophysics. Employers of our Honours graduates include: Santos, BHP, MIM, Pasminco, CRA/RTZ, North Flinders, Normandy, Hamersely Iron, WMC, Esso, Western, Halliburton, Schlumberger and the Geological Surveys of NSW and Victoria.

The Honours Geophysics course is divided half-and-half between coursework and project (thesis) work. The coursework includes the following components in either one or two week blocks:

- Interpretation of Airborne Magnetic Data;
- Electrical/EM Methods;
- Geophysical Fieldwork;
- Integrated Minerals Geophysics;
- Signal Analysis;
- Seismic Processing;
- Seismic Interpretation;
- Geostatistics, and;
- Geodynamics.

Additional information on the Department, its staff, research projects, Honours, and a variety of other topics can be found on the Department's web page (geology.adelaide.edu.au). This brief review of geophysics at the University of Adelaide's Department of Geology and Geophysics, closes with the Honours theses abstracts of the 'Class of 1998'.

Three-Dimensional Physical Modelling using Cross-Hole Applied Potential Resistivity Methods

Peter Clifford (Supervisor: Stewart Greenhalgh)

The cross-hole applied potential relationships were studied for a resistive cylindrical body with changing dip and strike. Apparent resistivity curves showed an elongation of the anomaly maxima as dip was increased. The amplitude of this maximum remained constant as strike was increased, but a bulk shift occurred in the apparent resistivity values. This bulk shift increased with increasing strike. These results form the foundation of a computer artificial intelligence program under development.

Two-dimensional numerical models utilising the finite-element method were compared with two-dimensional analogue models producing consistent apparent resistivity curves when using a resistive rectangular anomaly. The validity of the numerical program was confirmed. A field experiment at Kambalda, Western Australia showed that a significant drop in the apparent resistivity is obtained as electrodes cross a conductor. Resistivity measurements are shown to be within 1 metre of accuracy in relation to the known position of mineralisation.

The Geostatistical study of Soil Parameters for properties near Loxton, Riverland, South Australia

Shanti Jayaswal (Supervisor: Dr. Peter Brooker)

Two properties of different sizes near Loxton were surveyed on a 75m by 75m grid to study the changes in the soil characteristics. The study of soil characteristics is used to implement and improve irrigation systems for environmental and economic benefits. The spatial variability of the soil characteristics was described by semi-variograms which indicated both properties to be isotropic. The sampling grid size of 75m by 75m was adequate for the range of irrigation valve areas used in the Loxton region, except for 1 hectare where a 50m by 50m sampling grid gives a better representation of the variation in the soil characteristics. The 75m by 75m sampling grid can be used for anisotropic or isotropic conditions. The 4 hectare irrigation valve area had the minimum error in the estimation of the average value for the soil variables.

Square irrigation valve areas of size 1, 2, 3 and 4 hectares were Krige estimated using centred square sampling grids ranging in size (50m, 75m, 100m, 150m and 200m) and for a centred 75m by 50m sampling grid. The difference in the Krige variances for the two Loxton properties was due to the difference in the sill level model parameter and number of samples. The results of this study were compared with two other studies conducted in 1993 and 1996 near Waikerie in the Riverland. The studies showed similar magnitude of variability overall even though the topsoil at Loxton was not as well developed and there was a large anisotropy in the 1993 study, which was a reflection of the underlying dune system. The difference in the Krige estimations between the studies is a reflection of the soil regimes (highland, first slope and riverflat).

Heat Flow in the Cooper-Eromanga Basin

Jennifer Scott (Supervisor: Richard Hillis; Company Supporting: Santos)

Heat flow was calculated in the Cooper-Eromanga Basins using geothermal gradients and average thermal conductivities from 72 wells. Equilibrium bottom hole temperatures were estimated from temperature-time data obtained on well logging runs, and extrapolated using the Horner plot method. Geothermal gradients were calculated using these extrapolated bottom hole temperatures and the total depth of the well. These geothermal gradients ranged from 34°C/km to 61°C/km, with a mean gradient of 47°C/km. Lithologies and porosity-depth relationships for 32 wells were estimated from well logs. Lithologies were divided into sandstones, coals, carbonaceous shales and shales, with matrix thermal conductivities of 6.0 W/m/K, 0.5 W/m/K, 1.5 W/m/K and 2.5 W/m/K respectively. Average thermal conductivity was then calculated using the above matrix thermal conductivities and the porosity-depth relationships. Thermal conductivities varied between 1.8 W/m/K and 2.3 W/m/K, with a mean of 2.1 W/m/K. Resultant heat flow values varied between 71 mW/m^2 and 125 mW/m^2, with a mean value of 98 mW/m^2.

Most heat flow variations within the basin appear to be due to basement topography, with high heat flow over basement highs and vice versa. However, higher heat flow over the Nappamerri Trough area is interpreted to be due to the granites which are known to exist in the area. These granites have heat production values almost four times as high as the nearby Ordovician basement rocks. Heat flow variations caused by these granites are much greater than those due solely to basement depth. The high heat flow anomaly caused by the granites in the Nappamerri Trough area is large enough that it partially obscures the variations associated with the basement low in the trough.

Forward Modelling Mise-à-la-Masse: Effects of Current Sink Location and Potential Response from Simple Bodies

Benjamin Till (Supervisor: Dr. Peter Brooker; Company Supporting: Zonge)

The Mise-a-la-Masse surveying technique involves directly injecting a conductive ore body with a current source. By analysing the resulting electrical potential measurements made on the earth's surface, inference can be made about the orientation, shape, dip and continuity of the ore body.

The definition of infinity for a current sink distance in homogeneous earth for a source at depth is the distance at which the resulting potential field is similar to that produced by the source alone. The distorting effects of the current sink are quantified by creating finite difference computer models and analysing the output. Definitions of infinity are made for various source depths. They are for 100m, 300m , 500m source depths, 1000m, 2000m and 2500m respectively. Simple bodies are modelled in homogeneous earth using the corresponding definition of infinity. The effects of dip, location of current source in the body, body conductivity and body depth are presented. Using these results an attempt is made at modelling a real data set.

Conductivity Structure of the Weathered Zone at Number Four Tank, Cobar, NSW

Mark Tingay (Supervisor: Dr. Peter Brooker; Company Supporting: Pasminco)

The Number Four Tank region, near Cobar in central New South Wales, is covered by a deep, conductive weathered zone. Schlumberger vertical electric soundings, in-loop SIROTEM soundings and dipole-dipole resistivity show an approximately layered earth conductivity structure over most of the region. The conductive weathered zone can be simplified as one layer of approximately 70 m thickness and a resistivity of 25 Ohm-m. The Schlumberger soundings also reveal a 3.3 m thick layer of resistive alluvium overlying the weathered zone.

A weathering trough is located at the base of the conductive weathered zone. Dipole-dipole resistivity was inverted to reveal a 100 metre wide weathering trough with an underlying 150 metre wide conductive zone. In-loop SIROTEM soundings detected the deep conductor, which strikes approximately north-south. Stripping and decay curve analysis reveal a less than 200 metre wide conductor with a 0.45 millisecond decay constant.

Overpressure in the Nappamerri Trough, Cooper Basin, South Australia

Peter van Ruth (Supervisor: Dr. Richard Hillis; Company Supporting: Santos)

The detection of abnormal pressure is an important aspect of oil exploration in drilling, production and in source rock evaluation. This study looked at 31 wells from in and around the Nappamerri Trough, Cooper Basin, South Australia. This is an area of known overpressure, where mud weights as heavy as 17.4 MPa/km (0.77 psi/ft) have been used in drilling to balance formation pressure. The study aimed to enhance pre-existing data on the nature and distribution of abnormal pressures in the basin. Additionally, the study aimed to investigate the likely origin of overpressure in the Cooper Basin.

In the study, mud weight profiles and drill stem test data were used as direct pressure measurements in sandstones. Shale interval velocity data, in the form of the sonic log, were used to identify associated porosity anomalies in shales. Additionally, the d-exponent was used to identify changes in drilling rates that are associated with abnormally pressured zones. These techniques have indicated that occurrences of overpressure within the Cooper Basin are concentrated in the Nappamerri Trough. Overpressure of a lesser magnitude was also encountered in the Moomba area. The results of this study suggest that the Nappamerri Trough is characterised by abnormally pressured compartments below the Roseneath Shale and Murteree Shale at depths greater than 2800 m. The cause of the overpressure appears to be the results of a fluid volume change since overpressured and normally pressured shales from the study area have velocity effective stress values which do not lie on a loading curve (R^2=0.45). The results of this study suggest that hydrocarbon cracking is the most likely mechanism of overpressure generation in the Cooper Basin. Aquathermal pressuring may also play a minor role. Since hydrocarbon cracking is the dominant mechanism of overpressure generation, the use of quantitative techniques based on disequilibrium compaction generated overpressure, would lead to incorrect formation pressure estimates.

University of Queensland and QUT

Predictive Deconvolution for Non-Random Reflectivity Sequences

Simon Coombs
Bachelor of Applied Science (Geophysics)
Department of Earth Sciences, University of Queensland
Supervisor: S. Hearn

A fundamental assumption in seismic reflection processing, made about sedimentary basins, is that the Earth's reflectivity series is composed of randomly distributed spikes in time, space and amplitude. This produces a flat, or white, power spectrum and an autocorrelation which is a spike at lag zero. The random reflectivity assumption forms the basis for the predictive deconvolution algorithm.

In practice real reflectivity spectra show deficiency in power at low frequencies and, as a consequence, a line fitted to the power spectrum will exhibit a positive spectral slope. Previous investigations into the spectral properties of reflectivity sequences suggest this non-random response is related to local geology. In general, steep slopes appear to be related to thin, repetitive, or 'cyclic', geological sequences, whilst shallow slopes are associated with thick, non-repetitive sedimentary deposits. It is possible to modify the predictive deconvolution algorithm to account for a spectral slope observed in the environment of interest. This is done by incorporating autocorrelation side-lobes, corresponding to the assumed spectral slope, in the development of the Prediction Error Filter.

This thesis uses the parameter of spectral slope to examine the effectiveness of a generalised or 'spectral slope' predictive deconvolution algorithm that can account for all geologically feasible spectral slopes.

Tests using purely synthetic reflectivities suggest that significant reductions in error are able to be made using the modified algorithm. In general, it was possible to reduce the error energy to less than one tenth of the error energy associated with standard predictive deconvolution. Real reflectivities analysed from the Amadeus Basin of the Northern Territory, and the Bowen and Surat Basins of Queensland returned similar reductions in error energies to the synthetic reflectivities.

In testing the algorithm on both synthetic and real reflectivities, an important procedure was to track the deconvolution error as a function of assumed spectral slope. This mechanism also provides a practical means of determining the optimum spectral slope to be used when the algorithm is applied to real surface reflection data.

This project was supported by an ASEG Research Foundation grant.

Late Quaternary Sedimentology and Seismic Stratigraphy of the Brisbane River Delta, Fisherman Islands, Moreton Bay

Trinetta Herdy
Bachelor of Applied Science (Honours)
School of Natural Resource Sciences
Queensland University of Technology
Supervisor: Simon Lang

The Brisbane River delta lies at the mouth of south-west Moreton Bay, and is a good example of an incised river valley that has filled a funnel-shaped estuary and built a 300km^2 fluvially-dominated delta during the Late Quaternary. An extensive offshore delta front and prodelta has developed with a slight elongate surficial distribution reflecting tide and lesser wave influence. This study aims to study the facies of this incised valley fill and coastal evolution in a mixed fluvial and tide setting, with a view to aiding development of hydrocarbon exploration models, and assisting with geotechnical and environmental management of the Fisherman Islands area.

An extensive surficial sampling grid of intertidal and subtidal sediments over the study area allowed the recognition of eight different sediment lithofacies. These lithofacies were determined on the amounts of sand, mud, and biogenic carbonate present within each sample. Five different sedimentary environments were identified, including the distributary mouth bar delta front, prodelta, distributary channels, fringing reefs, and a zone of minimal deposition.

Vibrocoring, high resolution seismic reflection profiling, and seismic refraction profiling have identified three systems tracts representing four phases of fill within the study area, and represent a complete type 1 depositional sequence. These systems tracts include the late lowstand (Phase 1), early and late transgressive (Phase 2 & 3), and highstand/stillstand (Phase 4) systems tracts. An incised surface developed on older Pleistocene alluvial deposits during the falling stage in relative sea-level culminating 18000yrs BP. Alluvial sediments (sands and gravels) filled this topography during the late lowstand but were transgressed by estuarine muds during the rapid transgression that reached its peak 6500yrs BP. A maximum flooding surface traceable throughout the area was then overlain with mud-prone estuarine and prodelta deposits of the early highstand, but rapid progradation especially since 3000yrs BP has produced a series of delta lobes comprising mouth bar and distributary channel deposits that make up the Fisherman Islands.

The Brisbane River incised valley fill could be useful as a template for exploration models in comparable ancient settings with fluvial and tidal influence, and where glacio-eustacy and moderate sediment supply in a variable discharge drainage basin were involved. Finally, mapping of the complex palaeotopography beneath the Brisbane River delta at Fisherman Islands may assist Port development strategies by recognising palaeovalleys, palaeohighs, and identifying sand-prone alluvial lowstand and mouth bar late highstand deposits suitable for dredging and land fill, versus the dominantly mud-prone transgressive and early highstand prodelta deposits.

Multi-Component Processing in Exploration Seismology

Natasha Hendrick
PhD Student
Department of Earth Sciences,
University of Queensland
Supervisor: S. Hearn
Work in progress

Multi-component seismic recording has been available to the hydrocarbon exploration industry for several decades. Processing schemes, however, have often simply involved application of single-component scalar techniques to each component individually. There is considerable scope for exploitation of the true vector nature of these data. Triaxial recordings contain a wealth of information on the particle motion of seismic wave modes, which can ultimately lead to improved understanding of structural and geological properties of the host rock.

The quantitative measurement of seismic particle motion is referred to as polarisation analysis. It forms the basis for all true seismic vector-processing techniques. Hendrick and Hearn (1998) provide an overview of polarisation analysis aimed at enhancing understanding and utilisation of the multi-component processing technique.

Particle-motion parameters determined using polarisation analysis can be practically exploited in a number of ways. Earliest applications of polarisation analysis were in earthquake seismology to locate epicentres and identify arrival times of different phases.

In the exploration context, Shieh and Herrmann (1990), and Perelberg and Hornbostel (1994) use polarisation analysis to selectively reject unwanted noise events (e.g. out-of-plane energy and ground-roll). Probably most significant is the potential of multi-component processing techniques to extract pure compressional (P) and shear (S) wave sections. Perelberg and Hornbostel (1994) give synthetic examples of P and S separation using weighting functions based on particle-motion parameters. Lewis et al. (1991) and Mu (1996) use rotation and projection of the vector wavefield to recover P and S data. A modified form of controlled direction reception is presented by Greenhalgh et al. (1990) to separate P and S-waves. Cho and Spencer (1992) and Richwalski et al. (1998) illustrate a novel approach of combining polarisation analysis and velocity analysis to separate wavefields in multi-component data. Recovery of a pure P-wave section has positive implications for conventional surface reflection processing techniques. In addition, separated S energy can provide details on anisotropy, fracture characterisation and porosity.

A detailed comparison of a number of single-trace time-domain polarisation analysis algorithms is presented in Hearn and Hendrick (1998). Current work indicates that multi-component techniques that integrate multi-trace information into the polarisation analysis scheme have the potential to overcome limitations associated with the historically popular single-trace vector-processing algorithms. A number of multi-component, multi-trace methods used for P and S separation will be demonstrated and further developed on both synthetic and real VSP and surface seismic data.

Integrating Downhole Geophysical Logs into Orebody Modelling

Matthew Kay
PhD Student
WH Bryan Mining Geology Research Centre
University of Queensland
Supervisors: R. Dimitrakopoulos and P. Fullagar
Completion date: February, 1999

Geophysical techniques have been important tools in the mineral exploration for many years. They have contributed either directly or indirectly to the discovery of many mineral deposits. Therefore the potential exists for geophysical data, when used in conjunction with traditional data, to influence many stages in the mining process such as in-mine exploration, orebody modelling, recoverable reserve estimation, mine design and planning, grade control and production. Indeed some estimates suggest that geophysical techniques can increase the profitability of a mining operation by millions of dollars.

However, as geophysical logs will, in general, provide only imprecise rock property information, the main justification for using these logs is that they are more cost effective than conventional sampling techniques. But this, in turn, requires the worth or value of a given

dataset to be assessed. With such an assessment, it would then be possible to select both the most cost-effective combination of sampling techniques and the optimal number of samples for a particular application.

Given the potential benefits that can arise from using geophysical data in the mine environment, this study aims to develop and test a methodology for assessing the economic value (worth) of integrating downhole geophysical logging data in metalliferous mining. To achieve this aim the following objectives will be met:

(i) identify and implement an appropriate methodology for assessing the worth of a given dataset;

(ii) test the effectiveness of (i) in optimising the joint collection of downhole geophysical log and assay data for ore-waste delineation and ore reserve estimation;

(iii) identify and implement a geostatistical framework suitable for integrating downhole geophysical logging data with conventional mine data.

Seismic Interpretation of the Cook Structure, ATP-259P, Cooper-Eromanga Basin

Andrew McMahon
Bachelor of Applied Science (Geophysics)
Department of Earth Sciences
University of Queensland
Supervisor: S. Hearn

The Cooper-Eromanga Basin has been a productive oil producing area for Australia since the 1960's. Covering an area of approximately 130 000 km2 in the north-eastern corner of South Australia and the south-west part of Queensland, it is one of Australia's richest onshore oil and gas reserves.

Seismic interpretation has been the primary tool in the exploration of oil and gas for the last 40 years. Due to the dearth of empirical literature on seismic interpretation, the first objective of this study was to draft a document showing a step by step account of the fundamental techniques involved in seismic interpretation. To achieve this, and to investigate the regional structure of the Cook platform, three horizons have been mapped. These are the 'P' horizon (near 'Basement' unconformity), the 'E" horizon (near top Birkhead Formation) and the 'C' horizon (near top Cadna-Owi Formation). Additionally the 'D' horizon (near top Doonmulla Member) has been investigated to examine the pinchout of the Triassic over the Cook area.

The resultant two-way time contour maps show an elongated NW-SE trending anticline. The Cook structure shows prominently at all horizons and is approximately 90-120m in height. Although a small structure, it has proved to be economically viable due to the multiple, vertically stacked reservoir pools.

It is shown that there is thinning of the Pre-Permian to Doonmulla sequence towards the east of the Cook structure. Although the thinning depocentre is approximately 10 km from the Cook wells, the two-way time contour maps show a dominant structure which would lead any hydrocarbons which migrated through the Triassic at the unconformity straight to the Cook anticline.

Further investigation into the exact position of the Pre-Permian to Doonmulla depocentre would be beneficial, but is has been shown that there is little scope for any migrating hydrocarbons to migrate to a different area.

Geosciences at the Australian National University

At the ANU both the Research School of Earth Sciences (RSES) and the Department of Geology prepare students for careers in the geosciences. The RSES is part of the Institute of Advanced Studies (IAS), the original part of the ANU. The IAS was set up over 50 years ago to carry out basic research. The RSES comprises about 150 people, including some 30 academic staff and about the same number of research students. Research interests cover a wide spectrum of geophysics and geochemistry.

The Geology Department trains undergraduate and postgraduate students in a variety of geology-related subjects. Its undergraduate studies include a third-year Geophysics course and options for Honours level Geophysics study. While Honours projects are available at the RSES its energies are mainly directed towards postgraduate research in a variety of disciplines, including Geomagnetism, Seismology, Geodynamics, Geophysical Fluid Dynamics, Petrophysics, Ore-Genesis and Geochemistry. More information on the scope of research interests at the RSES is available on the worldwide web at http://www.rses.anu.edu.au/.

A variety of scholarships is available to students contemplating study at the RSES. These include:

- Summer Research Scholarships – available for Australian and New Zealand 3rd and 4th year students contemplating an Honours year. The scholarships are intended to expose the students to research during a summer vacation, and cover the cost of travel to and from Canberra and a weekly allowance. More information can be found at http://rsesa.anu.edu.au/sfinfo/Summer.html.
- A.L. Hales Honours Year Scholarships – for students in the 4th year of a BSc Hons degree. The scholarships meet travel expenses for students coming to the ANU and an additional allowance to assist with other expenses.
- PhD Scholarships – a variety of scholarships is available for Australian and overseas students who wish to conduct PhD research at the RSES.

Detailed information about these scholarships is available at http://rsesa/sfinfo/scholarships.html or by writing to:

School Secretary
Research School of Earth Sciences
Australian National University
Canberra ACT 0200
or via email (school.secretary.rses@anu.edu.au).

The ANU has a graduate handbook online at:
http://www.anu.edu.au/pad/pubs/handbooks/1998/pg/gradhb/ which contains a variety of information for prospective graduate students.

Interactions between aeromagnetic data and electromagnetic induction in the Earth

PhD PROJECT: Adrian Hitchman
Email: adrian@rses.anu.edu.au
SUPERVISOR: F.E.M. (Ted) Lilley

ABSTRACT:
Time-varying magnetic fields induced in Earth become part of the total magnetic field measured by aeromagnetic mapping. The CICADA project (Clarifying Induction Contributions to Aeromagnetic DAta) is concerned with such induction effects, looking both for ways to improve the resolution of the mapping, and to exploit aeromagnetic data for information on conductivity structure.

There are presently four main strands to the CICADA project:

- Analysis of aeromagnetic crossover misfits for conductivity information. Using a Fourier technique, magnetic daily variations have been reconstructed which show evidence of induced fields.
- Global Sq total-field curves.

Because the diurnal variation in the total-field is of prime importance in aeromagnetic mapping, type curves for Sq, for the whole globe, have been derived from the analysis of Campbell for the International Year of the Quiet Sun.

- Total-field magnetic amphidromes.

Near a conductivity contrast, for particular inclinations of the main magnetic field, total-field fluctuations of period less than one hour may be undetectable with a scalar magnetometer. This phenomenon has been termed a "magnetic amphidrome".

- Micropulsations and the coast effect.

Because of the importance of micropulsations as a noise source, and the presence of the coast-effect when aeromagnetic surveys take place over continental shelves, three-component observations of the coast effect have been made with a line of magnetometers at right angles to an Australian coast, including a seafloor magnetometer on the continental shelf.

EXPECTED DATE OF THESIS SUBMISSION: July 1999

ASEG Research Foundation

The ASEG Research Foundation (ASEG RF) was constituted in September 1989, with the first projects supported in 1990. The overall aim of the ASEG RF is to attract high caliber students into our profession and thus ensure a future supply of talented, highly skilled, geophysicists for industry. The ASEG RF achieves its aim by promoting research in applied geophysics specifically by providing research grants at the B.Sc.(Hons.) and M.Sc level and Ph.D. projects.

The ASEG RF has been able to do its work as a result of donations from industry. The ASEG RF has recently negotiated a more formal funding mechanism with the ASEG. The ASEG will donate $30,000 per annum, as well as a proportion of the annual corporate membership fees. Direct donations from companies will continue to be encouraged and sought, however, particularly from those who are not members of the ASEG. These arrangements will assist in developing a more sustainable financial base for the ASEG RF.

ASEG members from mining and petroleum as well as from academia serve on the ASEG RF Committee an honorary basis. No ASEG RF funds are used for operating expenses, all administrative costs are borne by the committee members. The office bearers and the currently active committee members are as follows:

Office Bearers

Chairman:	Mr. Joe Cucuzza	AMIRA
Vice-Chairman:	Mr. Nigel Hungerford	Consultant
Secretary:	Mr. Doug Roberts	Boral Energy Resources Limited
Treasurer:	Mr. Peter Priest	Chartered Accountant
Immediate past-Chairman:	Mr. Bob Smith	Riotinto Exploration
Ex-officio member	Mr. Noll Moriarty	President - ASEG

Committee members

Prof. David Boyd	The University of Adelaide
Mr. John Denham	Consultant
Dr. Mike Dentith	The University of W.A.
Prof. Don W. Emerson	Systems Exploration Pty Ltd
Mr Nigel J Fisher	Consultant
Prof. Stewart Greenhalgh	University of Adelaide
Mr. Wes Jamieson	Consultant
Dr. Steve Hearn	Digicon
Dr. David King	Lowell Petroleum
Mr. Gert Landerweerd	Woodside Offshore Petroleum Pty Ltd
Mr. Steve Mudge	Consultant
Mr. Mike J. Sayers	West Australian Petroleum Pty. Limited (WAPET)
Dr. Norm Uren	Curtin University of Technology
Mr. Peter K Williams	Resolute Limited

Applications for grants are invited from Institutions around September of each year. Second round applications are also sought in February. The person responsible to supervise the student submits a two to three page summary of the project. The application must detail the aims of the project, degree level, and the nature of the expenditure. It is not necessary when submitting an application for a student to be identified. However, successful Institutions will need to submit the student's CV and approved by the ASEG RF before the grant is paid. Project selection is made by sub-committee of specialists on the basis of the project's quality, relevance to either mineral or petroleum exploration or potential to impact on exploration technology or know-how. In this way we support quality research projects in exploration geophysics of interest to a wide cross-section of the mineral and petroleum industry.

For each project, a liaison officer is appointed, who is a member of ASEG (but not necessarily of the ASEG RF Committee), and who monitors the progress of the project and report to the Committee. On the completion of the project, a copy of the thesis is forwarded to the ASEG RF. Theses are stored at the Australian Mineral Foundation library in Adelaide and are accessible through the library. Furthermore, the ASEG RF requires that an abstract be published in "Preview" and any publication as a paper is first submitted to "Exploration Geophysics" at the completion of the project. The supervisor is normally expected to co-author the publication and is responsible for submission.

The project supervisor is also responsible for drawing the grant funds as required and for managing the expenditure. The supervisor ensures that a research report and financial reconciliation is provided to the ASEG RF on completion (or cessation) of the project. Grant funds must be accounted for and, if not used, returned to the ASEG RF.

The following Table summarises the current projects as well as those offered in the 1st rounds for 1999 grants.

1998 Grants

Institution	Supervisor	Degree	Topic
Univ Tas	Dr M Roach	Hons	Geophysical mapping for gold exploration in NE Tasmania
Univ WA	Dr A Endres	PhD	Geophysical Characterization of Aquifer Heterogeneity & Hydraulic Properties
Univ Melb	Dr L Thomas	Hons	Detailed magnetization properties of recent basalts
Curtin Univ	Dr B Evans	Hons	The effects of stress on seismic imaging of geology
Macquarie Univ	Dr K Gohl	Hons	High resolution seismic imaging of prospective mineralisation zones
Curtin Univ	Dr P Okoye/ N Uren	PhD	Determination of velocity field and anisotropic elastic parameters in layered transversely isotropic media.

1st Round 1999 Grants

Institution	Supervisor	Degree	Topic
Flinders Uni	Dr G Heinson	Hons	Fractured rock hydrogeophysics at Clare Valley, South Australia
UQ	Dr S Hearn	Hons PhD	Tomographic analysis of multi component seismic data in a mining environment. Defining the link between "Geophysical Signatures" and Ore deposit models
UWA	Dr M Dentith		
Curtin Univ	Dr B Evans	Hons	The effects of variably stressed and cemented rock on seismic wave propagation
UQ Curtin	Dr S Hearn Dr B Evans	Hons MSc	Evaluation of seismic multiple attenuation using prestack trace inversion. The use of seismic methods for delineating coal seams, sensing the presence of methane, and stress orientation.

Research Foundation Students

The success of the ASEG RF is measured by the success of the students that have worked on projects supported by the Foundation. The following three students exemplify the high caliber of the professionals that we are attracting to our industry.

Barry Bourne graduated with a BSc in geology from the University of Western Australia in 1991. In 1992, with the assistance of a scholarship from the ASEG Research foundation, he completed an honors degree entitled "Physical Property Variations Within Archaean Granite-Greenstone Terrain of the Yilgarn Craton, Western Australia: The Influence of Metamorphic Grade". This was later published in Exploration Geophysics. He began his career with CRA Exploration in 1993, working on mineral exploration projects in northwest Queensland based in Mt Isa. Experience gained included work at Century for base metals, the Mt Isa Eastern Succession for copper/gold and uranium in the McArthur Basin. In 1996 he moved to Perth with CRA Exploration (later Rio Tinto Exploration) to work in nickel (Honeymoon Well), uranium (Kintyre) and diamond exploration. Barry is currently senior geophysicist for Homestake Gold of Australia coordinating all geophysical activities in Western Australia. He is a member of the ASEG and SEG.

Natasha Hendrick obtained a Bachelor of Applied Science (Geophysics)(Honors 1), from University of Queensland in 1993, and was awarded a University Medal. Her honors project 'Evaluation of Seismic Trace

Inversion Techniques' was supported by the ASEG Research Foundation. Natasha was subsequently awarded an Australia-at-large Rhodes Scholarship. This provided her with the opportunity to undertake twelve months research on seismic waveguides within the Department of Engineering Sciences at the University of Oxford, UK. Upon her return to Australia Natasha worked for some time as a Research Assistant within the Department of Earth Sciences at the University of Queensland. During 1995-96 Natasha was employed by Veritas DGC (formerly Digicon) as a Special Project Geophysicist, working on PSDM and velocity-model building projects. In 1997 Natasha returned to the University of Queensland to begin her PhD on 'Applications of Multicomponent Processing in Exploration Seismology'. The project is supported by an Australian Postgraduate Award (Industry), the industry partner being Veritas DGC (Australia). Natasha was selected by APEA as the K.A. Richards Memorial Scholar for 1988. She expects to complete her degree in late 2000.

Natasha is an active member of her ASEG state branch committee. She is also very involved in Guides Queensland, and is an Assistant State Commissioner, as well as a canoe instructor and cast member of Scout/Guide musical revues.

John McMonagle graduated from the University of Queensland in 1992, with Honors in Applied Science (Geophysics). His thesis, entitled 'Removal of Coherent Noise in Shallow Seismic Reflection', was supported by the first ASEG Research Foundation grant to UQ, and provided experience in seismic field work, data processing and software development. After graduation John worked for a short period with MIM Exploration, doing TEM processing, modelling and inversion, prior to joining Veritas DGC (formerly Digicon). He worked for several years in their Brisbane office on 2D and 3D land, transition zone, and shallow marine seismic data processing. In January 1995 John transferred to the dedicated Veritas processing centre in Assen, The Netherlands. Here he gained a variety of experience working on high volume land, transition, and shallow marine surveys in northern Holland and Germany. During 1996 John spent six months traveling in Europe. The breadth of John's geophysical and computational knowledge was taken advantage of when he returned to Australia in mid-1996, joining the support group of Verities DGC (Australia). He is now a key member of this group, performing a range of functions including applications programming, system and network administration, in-house technical training, and development of intranet web pages. Johns activities away from geophysics are just as wide-ranging. He is interested in just about any sport, and participates in several. His cultural activities include an avid interest in music. He is an accomplished multi-instrumentalist, with a real flair for rock guitar - and a guitar collection to match.

Joe Cucuzza
Chairman - ASEG Research Foundation
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CRC AMET

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Curtin University

HONOURS PROJECTS COMPLETED IN 1998:

MINERAL GEOPHYSICS:

Integration of geophysical, geological and other remotely sensed data to produce and interpret a three-dimensional model of the geology over Paddington South, WA.
Kirsty Beckett

Verification of apparent conductivity calculations from frequency domain airborne em systems.
Grant Donnes

Review of airborne radiometric methods and a comparison of noise reduction techniques.
Shane Evans

Evaluation of airborne and ground multifrequency electromagnetic data for iron ore exploration.
Andrew Fitzpatrick

Geophysics and diamond exploration in the North Kimberley Province, WA.
Russell McChesney

Comparative study of electromagnetic techniques used for salinity investigations, Lake Toolibin, Western Australia.
Sheryl Murphy

Analysis of digital elevation models for gravity terrain corrections.
John Taylor

PETROLEUM GEOPHYSICS:

The seismic effects of offshore pinnacle reefs.
Bryn Bender

Semi-elastic plane wave depth migration.
Malcolm Griffiths

The effects of high-velocity layering on seismic wave propagation.
Damian Leslie

Stress-induced seismic anisotropy : the effects of stress on seismic wave propagation.
Troy Thompson

MASTERS PROJECTS COMPLETED IN 1998:

Attribute analysis applied to high resolution 2-D seismic data from Kianga, Queensland.
Jonathan Cocker

Three-dimensional window seismic migration.
Robert Han

A comparison of observed and theoretical seismic reflection travel times of simple three-dimensional models.
Oystein Lie

Numerical simulation of seismic multiples.
Christopher Manuel

Laboratory analysis of anisotropy on models of horizontal layered sub-surface.
Javier Peyriere

PhD PROJECTS COMPLETED IN 1998:

Multiple attenuation via wavefield transformations.
Matthew Lamont

Mathematical modelling of electrical potential in 3-D inhomogeneous anisotropic media.
Ping Li

Determination of anisotropic elastic parameters from surface seismic surveys.
Waluyo Waluyo

PhD PROJECTS IN PROGRESS IN 1998/99:

Transient electromagnetic exploration for groundwater within paleo-channels of the North Eastern Goldfields, Western Australia.
Brett Harris

Analysis of seismic wave propagation in multi-layered anisotropic media
Ruiping Li

Development and application of processing techniques for signal enhancement using multi-system resistivity measurements.
Kamkar Rouhani

The seismic expression of analogue sandbox models
Donald Sherlock

Processing techniques for the enhancement of electromagnetic signals in geophysical exploration.
Michael Sykes

Macquarie University

PhD PROJECTS COMPLETED IN 1998:

Current gathering in AEM data.
James Reid

Efficient induced polarisation and resistivity measurements.
Kanglin Lu

Regolith studies along AGSO deep seismic lines.
Xiaoli Xi

PhD PROJECTS IN PROGRESS 1998/99:

Analysis and interpretation of the AEM response of the Australian Regolith.
David Annetts

Multi-dimensional inversions and approximate interpretation of airborne electromagnetic data.
Juiping Chen

CRC AMET – Abstracts

Short Summary of PhD Project

RESEARCH STUDENT:
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SUPERVISOR:
Prof. James 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:
August 1999.

PUBLICATIONS / PRESENTATIONS:
None.

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

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

Integration of Geophysical, Geological and Other Remotely Sensed Data to Produce, and Interpret, a Three-dimensional Model of the Geology Over Paddington South, Western Australia.

By Kirsty Beckett B.Sc (Geophysics)
Department of Exploration Geophysics, Curtin University
Supervisor: Vernon Wilson (Curtin University)

ABSTRACT

The cost of purchasing quality data sets has reduced dramatically over the past decade. This has enabled the explorer to purchase multiple data sets for exploration purposes. Consequently, a need has arisen to develop a method of interpreting the large number of data sets now available to the explorer.

Integration is the process of comparing and contrasting numerous data sets to produce a single interpretation. The resulting interpretation possesses improved accuracy and reliability over standard remote sensing or geophysical

data interpretations. The production of a three-dimensional geological setting from integrated data allows the maximum amount of geological information to be presented to the explorer in a single interpretation.

This dissertation looks predominantly at modelling the regolith in the search for zones of potential gold mineralisation in the Paddington South region, northwest of Kalgoorlie, Western Australia.

Airborne magnetic, radiometric and Landsat TM data sets were integrated to produce a regolith map - highlighting the surface features of the area - and a structural map - highlighting the basement structure for the area. Aerial photography and geological maps where used to support the geophysical and remotely sensed data integration. The resulting data integrations were then combined with airborne electromagnetic data to produce a map highlighting areas of potential mineralisation and a three-dimensional image of the region.

The integration process is important for future exploration programs. Only through the incorporation of airborne electromagnetic data into integration processes can a three-dimensional geological section be created. From the three-dimensional image, the explorer can gain a better understanding of the geological setting before commencing extensive drilling programs. Consequently, regions of little geological interest can be eliminated from the survey region, concentrating exploration on zones of potential mineralisation thereby reducing the costs of exploration.

The Seismic Effects of Offshore Pinnacle Reefs

Bryn Bender B.Sc (Geophysics)
Department of Exploration Geophysics, Curtin University
Supervisor: Assoc.Prof. Brian Evans (Curtin University)

ABSTRACT

The seismic response to offshore pinnacle reefs is a phenomenon on the seismic record that has the potential to cost oil companies millions of dollars. The effects observed on seismic data acquired near pinnacle reefs are such that pseudo-prospects may be interpreted. Sideswipe reflection energy is responsible for pinnacle reefs located outside of the 2-D plane of data collection to be processed as an image at later times in the seismic section. This has the result of generating anomalous structures in the sub-surface that can look very appealing to the seismic interpreter.

Physical modelling can be used to simulate field seismic techniques in a controlled environment using scale models of geological structures. During this research, pinnacle reef models were constructed and the seismic effects were observed. Diffraction patterns and velocity pull-up from the models were the main effects investigated. The effectiveness of industry standard F-K filtering was also analysed with respect to attenuating the diffractions from the reef models.

Investigations into the nature of the diffraction patterns lead to the derivation of a formula that can be used to determine the height of the reef model using sideswipe data. From the knowledge of the water depth and two-way travel times from two survey lines to the nearest edge of the reef, the height of the reef can be calculated. Also, it is possible to locate the position of the reef with respect to the survey line. A master curve that was compiled from the survey data of different models makes the assessment of location a relatively simple process.

Attribute Analysis Applied to High Resolution 2-D Seismic Data from Kianga, Queensland

John Cocker B.Sc (Geophysics)
Department of Exploration Geophysics, Curtin University
Supervisor: Assoc. Prof. Brian Evans (Curtin University)

ABSTRACT

Two two-dimensional seismic surveys, one using the Mini-Sosie system of recording and the other a conventional explosive source recording, were acquired on a coal mining lease in central Queensland, Australia. The aims of the surveys were two fold. The first was to determine if either of the seismic methods could be used to resolve fine structural details to assist in mine planning, and hence horizontal drilling for coal-seam methane extraction. The second was to compare the resolution of the two methods. Careful processing and analysis of the explosive seismic data revealed detailed structural information including the location, nature and throw of faults, definition of fracture zones, and the identification of seam-splitting. However, the lower frequency content of the Mini-Sosie data provided poorer resolution. Instantaneous amplitudes were shown to correspond to measured gas desorption rates. Overlaying of interpreted faults and instantaneous attribute sections reveals compartments of adsorbed gas along with sealing faults. Further analysis demonstrated that the seam thickness could also be predicted with a high degree of accuracy. This has significant implications for increasing the economic viability of extracting coal-seam methane and hazard prediction ahead of mining.

Verification Of Apparent Conductivity Calculations From Frequency Domain Airborne EM Systems

Grant Donnes B.Sc (Geophysics)
Department of Exploration Geophysics, Curtin University
Supervisor: Vernon Wilson (Curtin University)

ABSTRACT

The calculation of apparent conductivities from frequency domain electromagnetic (EM) field data uses both the real and imaginary parts of the measured secondary EM field. The purpose of this thesis is to analyse the calculated conductive responses from two frequency domain airborne EM systems with the interpreted responses from two time domain ground systems.

DIGHEM V and the GEM-2A are two towed bird frequency domain electromagnetic systems, which have flown the same area over conductive sediments in the northwest of Australia. A near surface conductive target simulating a conductive clay cap over a weathered Kimberlite pipe has been selected from the two surveys for detailed ground follow-up.

The two ground time domain electromagnetic systems employed are SIROTEM and EM 47-S, which have traversed the same path as the two airborne systems over the conductive anomaly. A small transmitter loop size (50m by 50m) provided exceptional near surface detail, which was required for the analysis.

Analysing conductivities from the ground and airborne surveys was completed using a variety of methods including proprietary and commercial software. These

methods all have shown many similarities and notable differences attributable to the different inversion techniques and computational algorithms used.

The results have been displayed in various formats, the most effective being the comparison of the 1D-inversion pseudo-sections, which show clearly the similarity between the two geophysical methods. The overall results were extremely inspiring as the ground geophysics showed very close resemblance to the conductive features and structures measured from the air.

Review of Airborne Radiometric Methods and a Comparison of Noise Reduction Techniques

Shane Evans B.Sc (Geophysics)
Department of Exploration Geophysics, Curtin University
Supervisors: Paul Wilkes (CurtinUniversity and CRC AMET) and David Richards (Rio Tinto)

ABSTRACT

Airborne radiometric surveying has a major problem where the statistical noise content is high by following Poisson statistics. This results in the images having a "speckled" appearance decreasing the amount of geological information that can be extracted from the image. Maximum Noise Fraction (MNF) and Noise Adjusted Singular Value Decomposition (NASVD) are two techniques that have been developed to combat this problem and can be applied to multichannel radiometric data.

The two noise reduction techniques have been applied to the Kintyre and Badgeradder radiometric datasets from the Rio Tinto database. This thesis reviews airborne radiometric techniques and examines the effects that the noise reductions have on the raw data with the aim of determining the most effective technique. The investigation was performed by inspecting the resulting grids and the difference grids as well as analysing the data statistics. The difference grids were produced by subtracting the noise reduced data from the data that had not been noise reduced. Recommendations have been made on which technique should be used on certain radiometric responses and to what extent they should be applied. Other investigations have used the standard deviation of the data as an indication of data quality, this study shows that that this is not always a good practice.

Evaluation of Airborne and Ground Multifrequency Electromagnetic Data for Iron Ore Exploration

Andrew Fitzpatrick B.Sc (Geophysics)
Department of Exploration Geophysics, Curtin University
Supervisors: Paul Wilkes (CRC AMET and Curtin University) and Marcus Flis (Hamersley Iron Pty Limited)

ABSTRACT

Multifrequency electromagnetic prospecting (EM) measures the geo-electric properties of the sub-surface at multiple depths. At the frequencies used by these methods, two phenomena dictate the measured response. The first is the result of eddy current flow, which reflects conductivity distribution. These generally produce a positive in-phase and quadrature response. The second phenomenon results from magnetic polarisation, which commonly generates a negative in-phase response only. This reflects variations in magnetic permeability of the sub-surface. The response due to conductive eddy currents is frequency dependent, whilst the response from a magnetic polarisable source is frequency independent.

Interpretation of multifrequency EM can often be difficult, due to the large amounts of data that are generally collected. To assist in interpretation, automated algorithms have been designed to derive geological parameters from the observed EM data. Two methodologies exist for such inversions. The generalised approach calculates an apparent resistivity distribution for each coil configuration or frequency. The second approach is to model the data to a more specialised model such as a layered earth.

Unfortunately these algorithms often ignore the effect of magnetic permeability and assume the halfspace to have a magnetic permeability value equivalent to free space. These approximations are valid in most geological environments, except highly magnetic areas, as exhibited in the Hamersley Province.

This project evaluates the use of ground and airborne multifrequency electromagnetic prospecting methods for iron ore exploration in the Hamersley Province. In addition, the practicality of utilising current interpretation methods and modelling of multifrequency data is examined. A new multi-layer inversion package is assessed. The results of the methods used are directly correlated to known geology.

The DIGHEM airborne data successfully mapped lithological units from the Hamersley Group and Fortescue Group. The method does not directly detect mineralisation, but provides information that can assist in identifying potential targets. The GEM ground survey conducted at Yandicoogina clearly detected horizontal layers within the palaeochannel, although it was unclear on which layers were actually detected.

In summary, multifrequency electromagnetic methods effectively map lithological variations within the Hamersley Province that are not distinguished by the total magnetic intensity. Another advantage is that these systems can be restricted for shallow economic targets. Although, the method does not directly detect iron ore, it shows variations of conductivity and magnetic permeability, which can assist in identifying potential target sites. The method would be useful in areas where magnetic data are highly complex, by providing auxiliary information to assist exploration.

Semi-Elastic Plane Wave Depth Migration

Malcolm Griffiths B.Sc (Geophysics)
Department of Exploration Geophysics, Curtin University
Supervisor: Prof. John McDonald (Curtin University)

ABSTRACT

An investigation into the use of mode converted waves to image beneath shallow high velocity layers has been carried out. The ability of the semi-elastic plane wave depth migration software to image below high acoustic impedance boundaries has been demonstrated through the use of a numerical dataset and a physical modelling dataset. Both of these show the energy transfer between transmitted compressional waves and corresponding converted shear waves whex~ passing from pre-critical to post-critical angles.

High velocity layers such as the shallow carbonates present off the northwest coast of Western Australia block the penetration of compressional wave energy and reduces the overall quality of seismic data acquired across these areas by generating significant amplitude multiple trains with near vertical incidence. Fortunately such geological features favour the generation of high amplitude mode converted waves particularly at post critical angles. This suggests that imaging beneath high velocity layers may be possible by acquiring data containing these mode converted waves. However, in order to do this we must first have sufficiently long offsets.

The following processing steps were applied to the data:

- Plane wave decomposition with the option of alias suppression.
- Migration velocity analysis in the plane wave domain.
- Green's function computation using a modified ray tracing algorithm.
- Pre-stack depth migration based on the velocity-depth model.

This process converts standard shot records from the x-t domain into the tau-p domain using a modified slant stacking technique. This is followed by migration velocity analysis, a velocity/depth model building procedure. During this stage two velocity/depth models are constructed; the first is purely a compressional wave velocity field whereas the second replaces the compressional wave velocity through the high velocity layer with the corresponding shear wave velocity. In this way events which show double mode conversion through this layer can be migrated correctly. The velocity model building is then followed by depth migration in the plane wave domain.

The method outlined generates two depth migrated sections, one of which represents the migrated section using the compressional wave velocity field and the other representing the migrated section using the shear wave velocity field. Each migrated section provides unique information about the formation. A combined stack can also be generated with a small amount of additional processing which would then reveal the major lithological changes down the section. However, stacking was not performed on the migrated sections presented here due to the phase problems encountered.

Three-Dimensional Window Seismic Migration

Robert Han Wei Kwang
Department of Exploration Geophysics, Curtin University of Technology
Supervisor: Prof. Norm Uren (Curtin University)

ABSTRACT

A seismic record section is a graphical representation of a seismic survey which takes no account of the actual geometry of the sub-surface reflectors. Such a seismic section may be considered to be a record of seismic energy received at surface recording stations. This time section picture is ambiguous, since the direction from which the waves approach the surface is unknown. Migration of the seismic data is a process which involves mapping the recorded time seismic section onto another section in which events are repositioned to their correct sub-surface locations.

Many approaches to the seismic migration process have been developed, both in the space-time and Fourier domains. These are very computationally intensive, particularly when the reflectors are steeply dipping, since reflections from them are received at some distance laterally from the sub-surface reflectors.

There is a need to reduce this computation time. Two innovative techniques were introduced to meet this objective. They involved:

- The use of a finer sampling rate with a non-formula interpolation method on input data. This dispenses with the highly repetitive calculations involved in interpolation.
- The use of output windows in the migrated seismic section. This restricts the output to an area of particular interest, e.g. coal beds cut by local faults.

In implementing these innovations, the diffraction stack migration process is utilised here as a fundamental migration technique that is capable of handling 2-D post-stack and 3-D post-stack migration processes.

These techniques were successfully implemented and no loss of information was observed when implemented for a full or contracted window output, whether it was for a 2-D or 3-D output. Thus a computationally intensive migration process has been applied in an economical fashion, producing a high quality image in a selected area of interest.

Short Summary of PhD Project

RESEARCH STUDENT:
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Curtin, Exploration Geophysics

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SUPERVISORS:
Prof. Norm Uren and
Dr Richard Martin (Anaconda)

PROJECT TITLE:
Transient electromagnetic exploration for ground water within palaeo-channels of the North Eastern Goldfields; Western Australia.

OBJECTIVES:
To optimise the use of transient electro-magnetic methods in exploration for groundwater within conductive channel structures.

EXPECTED OUTCOMES:
New methods of processing TEM data specifically for identifying aspects of channel structure critical in ground water exploration.

Identification of the most effective TEM survey parameters for resolving channel structure (including an assessment of the effectiveness of taking E fields measurements).

An investigation of the reliability of 1D and 3D software in simulating the TEM response caused by an inductive source over large, conductive channel structures.

START DATE:
EXPECTED DATE OF THESIS SUBMISSION: June 1999.

PUBLICATIONS / PRESENTATIONS:

Harris, B.D. and Das, U.C. — Computation of frequency do-main CSEM apparent resis-tivity, presented at the 1996 EAGE conference and exhibition.

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

Harris, B.D. and Das, U.C — Optimization of primary waveform for electro-magnetic surveys, pre-sented at the 1998 EAGE conference and exhibition.

SOFTWARE WRITTEN:

1. A Multi-system frequency domain apparent resistivity program. Numerical Solution.
   - Fortran 90.
2. A program to compute the frequency domain electric and magnetic fields on the surface of a 1 layer earth from a VMD, HMD, VED, HED source on the surface, (analytical solution).
   - Maple V5.
3. A program to compute the frequency domain electric and magnetic fields located anywhere in a two layer earth from a arbitrarily located, VMD, HMD, VED, HED source.
   - Maple V5.
4. A program to convolve an impulse response with any transmitted waveform to obtain the system response.
   - Fortran 90.
5. A program to compute frequency domain electric and magnetic fields located anywhere in a multiple layered earth from an arbitrarily located, VMD or HMD source. Only the VMD source programs is universally working.
   - Maple V5.
6. The subprogram to convert frequency domain to time domain (step or impulse response) in the 3D integral equation program EM3D
   (using Anderson 800 point cosine filters).
   - Fortran 90.
7. A sub-program that integrates electrical dipole sources to a finite line source.
   - Fortran 90.

Short Summary of PhD Project

RESEARCH STUDENT:
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SUPERVISOR/S:
Prof. James 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 data.

START DATE:
February 1996.

EXPECTED DATE OF THESIS SUBMISSION:
August 1999.

PUBLICATIONS / PRESENTATIONS:
Chen, J., and Macnae, J. C., 1997, Terrain corrections are critical for airborne gravity gradiometer data: Expl. Geophy., 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.

Development and Application of Processing Techniques for Signal Enhancement Using Multi-System Resistivity Measurements

Abolghasem Kamkar-Rouhani
Department of Exploration Geophysics, Curtin University
Supervisor: Prof. Norm Uren (Curtin University)

ABSTRACT

DC electrical surveying involves the injection of current into the earth, and the measurement of the electrical potential differences this produces. A number of electrode configurations such as the Schlumberger and Wenner arrays, dipole-dipole and pole-pole geometries are in common use for electrical surveying. New acquisition systems enable the convenient collection of data with a number of common configurations at the same time.

It is found however that while the recovery of layered structure from electrical surveys can be effective, the sensitivity and resolving power of such systems in detecting the presence of anomalous three-dimensional (3-D) bodies is poor. This is mainly due to the dominance of conduction pathways through the layered earth compared to the influence of small 3-D conductivity anomalies.

Theoretical relationships between the responses of various survey geometries to the layered earth may be established as is shown in this thesis, but their response to 3-D targets differs strongly. This thesis introduces a new procedure for anomalous target detection by the computation of *an apparent resistivity residual* using multi-electrode configuration survey data. This procedure, applicable to a variety of electrode geometries, reduces the dominance of the layered earth response and enhances the signal from 3-D structures.

In the development and testing of this new apparent resistivity residual, numerically modelled data were used. In order to obtain suitable test data of high accuracy it was necessary to make improvements to modelling software. For this purpose, recently developed techniques in numerical modelling such as the biconjugate gradient method, new digital linear filters for computation of Hankel transforms, and spectral formalism were employed in an integral equation approach for the software developed in this thesis.

The computed apparent resistivity residual was found to depend on the array type and dimensions, the nature of the anomalous zone, depth of the anomalous zone, geological layer geometries, and resistivity contrasts of the layers involved. While the apparent resistivity residual signature requires some measure of interpretation, it is shown to enhance the resolution and detectability of 3-D targets in a layered environment.

The presence of random noise produces some degradation in the performance of the residual technique, but a normalisation procedure has been developed to alleviate the problem. A preliminary field trial showed that survey profiles of apparent resistivity residual were able to locate a subsurface conductive anomaly in an area in Western Australia.

A transitional zone is defined as a layer in the earth where resistivity varies as a continuous function of depth. A theoretical formulation for the electrical response of an earth structure composed of anomalous 3-D bodies in the presence of transitional layers is introduced. Tests on synthetic survey data showed that the apparent resistivity residual is an effective anomaly detector in transitional layer environments.

A multisystem method of computing an apparent resistivity residual has been developed theoretically and tested on both synthetic and field data. This new approach when applied to resistivity profiling is more sensitive to, and gives greater resolution of, localised anomalies than is possible using conventional profiling procedures.

Short Summary of PhD Project

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SUPERVISOR:
Prof. James Macnae

PROJECT TITLE:
Efficent 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 intergral equation e-field modelling program.

START DATE:
March 1994.

EXPECTED DATE OF THESIS SUBMISSION:
August 1999.

PUBLICATIONS / PRESENTATIONS:
K. Lu and Jim Macnae, 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.

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

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

J. Macnae and K. LU, 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.

Numerical Simulation of Seismic Multiples

By Christopher Manuel B.Sc (Geophysics)
Department of Exploration Geophysics, Curtin University
Supervisor: Prof. Norm Uren (Curtin University)

ABSTRACT

There is a need for the numerical simulation of multiple reflections in order to gain a better understanding of the processes which occur in the subsurface leading to the formation of multiples. At present there is a general need for a method of identifying multiple events in a shot record. Since multiple attenuation methods are generally each directed towards a certain type of multiple, there is a need to determine which multiple types are in a section so that the most appropriate attenuation method can be applied.

By using numerical simulation techniques our understanding of the seismic method is increased thus allowing us to further improve and refine the technique of seismic exploration. Unfortunately, the two most popular techniques used for the simulation of seismic wave propagation (ray tracing and finite-difference) are not ideal with the results often being governed by the complexity of geological models, the amount of computational time required, and the funding available.

However, a new method is now available which simulates seismic wave propagation including reflection. This method incorporates Huygen's principle and uses a generalisation of the exploding reflector method, which involves the direct travel times along a reflector being used as the initial times as the reflector is exploded, via use of the exploding reflector method, towards the surface. There is a need to extend this simple reflection concept (Lambert, 1996) to simulate seismic multiples and this was achieved in this research by repeatedly implementing the generalised exploding reflector method. A multiple reflection simulation program was produced using this idea.

The software produced from this research is fully automated and user friendly. It enables the user to specify the number of reflections required, a velocity model for each stage of wave propagation (including whether a certain layer in a certain stage has P- or S-wave propagation), the size of the model, and the spatial sampling interval. The velocity model developed for each stage of wave propagation is able to contain horizontal and/or irregular interfaces, which makes the program very suitable for modelling actual geological sequences.

Through an extensive forward modelling study, it was found that the program could map the three common multiple types (water bottom, surface and subsurface peg-legs) through each stage of wave propagation to result in a synthetic seismogram which is representative of the arrivals recorded on the surface. Parameters that were varied in this modelling study included layer thicknesses and velocities, model offsets, and boundary rugosity. These parameters could correspond to phenomena observed in the geological and geophysical environments such as sediment consolidation, rock type and streamer length.

Several applications were found for the software and these were in the fields of the forward modelling of field data, down-hole modelling, and velocity analysis. This last application will prove to have the greatest applicability in industry since the velocity analysis could be performed on events that have either a hyperbolic or non-hyperbolic moveout. The velocity analysis program could also be used to produce accurate velocity models for use in an advanced seismic pre-stack partial depth migration package which utilises multiple reflections.

Geophysics and Diamond Exploration in the North Kimberley Province, WA

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Supervisors: Paul Wilkes (Curtin University, CRC AMET) and Dr Robert Ramsay (Striker Resources)

ABSTRACT

Orientation surveys over the 800 my Ashmore pipes in 1997 identified gravity, magnetic and frequency domain electromagnetic methods (FDEM) as useful tools for delineating kimberlites in the resistive and magnetically quiet Warton Sandstone of the North Kimberley of Western Australia. This project expanded these grids to gain further knowledge of the geophysical response of the pipe cluster and the nearby Banksia region. As part of this expansion, the UTS-Geophex GEM2B FDEM system was compared with the Geonics EM34. Similar orientation surveys were then conducted on the Skerring kimberlite, which is hosted in the more conductive and magnetically responsive basaltic Carson Volcanics in an attempt to characterise the geophysical response of kimberlites hosted in such backgrounds.

A negative gravity response was observed over the kimberlites, due to the decreased density associated with kimberlite weathering. The amplitude of this response varied, perhaps as a result of differing depths to the weathering front.

Both FDEM systems identified more conductive regions, attributed to the clay rich weathering products from kimberlites. However, other conductive regions were also mapped. The quadrature response of the GEM2B displayed good spatial correlation with the EM34 apparent conductivity data. However, it was noted that in less conductive regions, the quadrature response is more sensitive to subtle variations in earth conductivity.

The magnetic response over the kimberlites varied from strongly positive to strongly negative. The analysis of the in phase response from the GEM2B, magnetic susceptibility results from samples collected and the analytic signal of the magnetic response show that, the kimberlites have a higher magnetic susceptibility than the host rocks. Palaeomagnetic polar reconstruction data suggests that remanent magnetic effects may be responsible for the lower and negative responses.

The variable nature of the responses to each technique emphasises the need for an integrated approach to the detection of kimberlites. This integrated approach, in conjunction with both geological and geochemical data, serves to greatly increase the success rate of kimberlite detection.

Comparative Study of Electromagnetic Techniques Used for Salinity Investigations, Lake Toolibin, Western Australia

Sheryl Murphy B.Sc (Geophysics)
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Supervisor: Vernon Wilson

ABSTRACT

The Lake Toolibin area is typical of many areas within the south-west region of Western Australia in that it has been extensively cleared for agricultural use. The area forms part of the groundwater catchment for Lake Toolibin and has been surveyed in order to study the problem of dryland salinity.

Salts within the soil increase the conductivity of the soil. Therefore, electromagnetic methods which measure conductivity, have the potential to be used to ascertain the quantity of salt within the soil profile. Downhole frequency domain EM39, surface time domain EM47, and SALTMAP time domain airborne EM have been used in this investigation of dryland salinity at the Lake Toolibin area. The individual ability of each method to detect the salt profile within the soil horizon has been studied and compared with the ability of the other electromagnetic methods to do the same.

The EM39 tended to give a similar conductivity profile with depth as the conductivity from the salt analysis of drillhole cores. In some cases however, clays and other such conductive earth materials were influencing the conductivity values recorded by the EM39. The EM47 results were best fitted to a three layer model, with the middle layer being the relatively more conductive layer. The results of modelling the airborne EM tended to correspond well with the modelled results for the EM47. Both methods could not give a conductivity profile with depth that was as detailed as that obtained from the EM39. However, both gave a good indication as to whether the site contained high or low quantities of salt with depth.

It is recommended that no electromagnetic method be used in isolation. Many factors influence salt distribution and there are a multitude of different conductivity depth profiles that can be observed at different sites. Therefore, it is suggested that a more widespread investigation is required before making any strong, generalized conclusions regarding how salt is distributed, as well as how effective each electromagnetic method is in outlining areas of salinity.

Laboratory Analysis of Anisotropy on Models of Horizontal Layered Sub-surface

Javier Peyriere
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Supervisor: Dr Bruce Hartley (Curtin University)

ABSTRACT

Until now, earth sub-surfaces have generally been considered as isotropic media. This assumption cannot be used any more for all seismic surveys. A particular case of non-isotropic earth sub-surface is the case of multi-layered media. This corresponds for instance to alternate thin beds of marls and carbonates.

Our goal is to study laboratory analogous models of multi-layered sub-surfaces: phenolite models. We want to define the type of anisotropy of three different models of phenolite respectively called phenolite A, B and C. This can be done finding the elastic parameters of the models through transmission experiments using the Physical Modelling System (PMS).

The PMS experiments correspond to analogous reverse VSP surveys. They cover different angles of propagation through the medium. P-wave, and for small offsets S-wave, travel times are measured for the different positions of the surveys.

Plexiglass, an isotropic medium used in industry, has been used to calibrate the experiments on phenolite models. We apply time corrections due to the system instruments and the surrounding water. We then obtain group velocity magnitudes (V_P and V_S) for each receiver position of the surveys.

The velocity surfaces give the symmetry of the models. Phenolite A is transverse isotropic (TI) the two other models present more complex cases, probably orthorhombic symmetries. From V_P magnitudes for every measured direction of propagation and from the value of V_S along the symmetry axis, we obtain transverse isotropic elastic parameters.

Hence, through the experiments we have been able to obtain the TI elastic parameters, but also to define the symmetries of our models and to compare the anisotropy magnitudes of the models. This shows that 'analogous multi-layered sub-surfaces' can be TI or of more complex symmetries. In the future we should be able to develop a program to calculate the elastic parameters for orthorhombic symmetries. Finally, it would be of interest to do a similar study to real earth reverse VSP 3D surveys.

Mathematical Modelling of Electric Potential in 3-D Inhomogeneous Anisotropic Media

Ping Li
Department of Exploration Geophysics, Curtin University / CRC AMET
Supervisor: Prof. Norm Uren (Curtin University)

ABSTRACT

In the realistic application of geophysical methods to mineral exploration, the effects of electrical anisotropy and inhomogeneous media on electrical potential measurements must be considered. A study of these aspects by exploration researchers and geophysicists is essential in the interpretations of potential, resistivity and induced polarization surveys. This research studies the effects of three dimensional (3-D) anisotropic and inhomogeneous earth media on electric potential, and develops a set of new solutions. These solutions are significant for the interpretation of both resistivity and induced polarization responses for typical field situations.

A very large class of important theory and applications in geophysics requires analytical solutions for determining the potential due to a point source in an inhomogeneous arbitrarily anisotropic half-space. This thesis is concerned with the further development and application of the image source method to provide these analytical solutions.

Forward modelling in geophysics is the computation of the geophysical response of specified geological structures. In principle this may be uniquely computed, but specific situations provide a significant challenge.

The method of images has been used for many years for the solution of three-dimensional isotropic and two-dimensional anisotropic media problems in halfspace. In this thesis I generalise this method of images to the inhomogeneous anisotropic three-dimensional case with reflection and transmission coexistent boundary conditions. New concepts, such as three dimensional anisotropic total reflection, anisotropic divergence, the three dimensional anisotropic transmission image, two layer anisotropic reflection image streams and the principles of the anisotropic point image are introduced. These new anisotropic point image concepts are then applied in obtaining solutions to representative problems previously unsolved.

Based on my exact analytical solutions, this thesis models the effects of three-dimensional anisotropic and inhomogeneous earth media on the electric potential when bodies of arbitrary shape, position and anisotropic resistivity are embedded in the medium.

The integral equation method is widely used in mathematical modelling in geophysics for reasons of easy computer programming and high accuracy. Using this method geophysical responses such as the electrical potential, apparent resistivity and induced polarization due to 3-D mineral deposits in three-dimensional isotropic and two-dimensional anisotropic media have been successfully simulated numerically. The key to these problems is to obtain the Green's function for Green's second identity. In this thesis the integral equation method is applied to the more general case of electrically inhomogeneous anisotropic half space media containing anomalous bodies. One example is given in this thesis for demonstration purposes, but the concepts and methods which I develop are widely applicable to an extensive range of models.

Short Summary of PhD Project

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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:
February 1995.

EXPECTED DATE OF THESIS SUBMISSION:
April 1999.

PUBLICATIONS / PRESENTATIONS:
"Comments on the electromagnetic smoke ring concept" J. E. Reid and J. C. Macnae: Geophysics (submitted).

"Doubling the effective skin depth with a local source" J. E. Reid and J. C. Macnae: 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.

Short Summary of PhD Project

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SUPERVISORS:
Dr. Patrick Okoye & Prof. Norm Uren

PROJECT TITLE:
Analysis of Seismic Wave Propagation in Multi-layered Anisotropic Media.

OBJECTIVES:
To develop techniques to quantify the degree of velocity anisotropy in multi-layered subsurface media and then to correct for their effects.

EXPECTED OUTCOMES:
Inversion of velocity field and anisotropic elastic parameters for horizontal layered transversely isotropic media with a vertical or tilted symmetry axis.

Examination of the effects of anisotropy on normal moveout for multi-layer reflection.

START DATE:
July 1997.

EXPECTED DATE OF THESIS SUBMISSION:
July 2000.

PUBLICATIONS / PRESENTATIONS:

Li, R., Okoye P. and Uren N., 1998, Review of the short-spread moveout velocity estimation in transversely isotropic media: SEG/EAGE/CPS Beijing'98 Internat. Geophys. Conference and Exposition, Expanded Abstracts, 63-68.

Li, R., Okoye P., Uren N. and McDonald J. A., 1998, Analytic study of the short-spread moveout velocity estimation in a transversely isotropic medium: 68th SEG Annual Internal. Mtg., Expanded Abstracts, 98, 1472-1474 (2 pages missing).

Li, R., Okoye P. and Uren N., 1998, Inversion of velocity field and anisotropic elastic parameters for layered VTI media: Exploration Geophysics, 29, 477-483.

SOFTWARE WRITTEN:

A computer code can recover the elastic parameters for single and multi-layered TI or I media, if the velocity field is known.

A computer code to determine the individual layer's elastic parameters, using the resolved elastic parameters of the other layers and the overall layers.

Seismic Imaging of Sandbox Models

Donald H. Sherlock B.Sc (Geology)
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Supervisor: Assoc. Prof. Brian Evans (Curtin University)

SUMMARY

Analogue sandbox models provide cheap, concise data and allow the evolution of geological structures to be observed under controlled laboratory conditions. Seismic physical modelling is used to study the effects of seismic wave propagation in isotropic and anisotropic media, and to improve methods of data acquisition, processing and interpretation. By combining these two independent modelling techniques, the potential exists to expand the benefits of each method. For seismic physical modelling, the main advantages are that the seismic data collected from these models contain natural variation that cannot be built into conventional solid models that are machined with predetermined structures, which results in a more realistic image. In addition, the cost and construction time of these models is significantly reduced. For sandbox modelling, the ability to record 3-D seismic images before the model is manually sectioned for conventional 2-D structural interpretation allows far more detailed study of subtle 3-D structures than previously possible.

Previous attempts to use unconsolidated sands for seismic physical models have been unsuccessful due to the lack of control or understanding of the natural variations that occur throughout the models. This research has allowed many of the drawbacks to be overcome, although at this stage the models are still limited in their structural complexity. Progressive refinements indicate that in the near future this technology will be readily adaptable to all forms of analogue sandbox models.

However, over and above the original aims of this research, the successful recording of seismic reflections within unconsolidated sands presents an opportunity to dramatically expand the role of seismic physical modelling. This comes at a time when many are predicting its demise due to the continual improvements in numerical modelling, even though numerical modelling is still very limited in its application to 3-D issues.

Acoustic Wave Propagation in Unconsolidated Sands

Experiments with acoustic wave propagation in sands have previously dealt only with the transmission of seismic energy, to record velocity and attenuation data. The recording of reflection data allows the effects of small scale variations in grain packing to be imaged and provide much needed insight into the controlling factors on wave propagation in unconsolidated sands.

Such experiments have shown that strong seismic reflections may occur from the interface between sands where only a minor contrast in acoustic impedance exists. These results indicate that reflections within unconsolidated sands depend not only on the impedance contrasts between the sands, as is the case with consolidated sediments, but also on how the sands interact at the interface where the packing is often significantly different to either of the sand layers. Reflections have also been recorded within single bodies of sand that are basically homogeneous but contain small scale variations in grain packing as a result of natural sorting that occurs with deposition.

Time-lapse 3-D Seismic

The use of sands in seismic physical modelling also allows fluids to be incorporated into the models for the first time, providing a much more realistic analogue of hydrocarbon reservoirs. The computer controlled modelling system allows perfect acquisition repeatability which makes it an ideal environment to study the time variant aspects of reservoirs that occur with production. Time-lapse 3-D (or 4-D) seismic is becoming increasingly important in the management of hydrocarbon production yet there is a distinct lack of model data to support some of the fundamental conclusions being made. Subtle anomalies on difference sections may in fact be artefacts of the different acquisition footprints or manufactured from the complex data processing that is necessary to allow comparison of legacy data sets.

The ability to perfectly repeat the data acquisition on sandbox models bypasses these problems such that any anomalies seen on the difference sections can be directly attributed to changes that have occurred within the model. The development of 4-D seismic physical models will also provide a number of other advantages which are:

1. Inexpensive, real seismic data.
2. The absence of complications from seasonal or climate factors.
3. Rapid data turn around in a matter of days, rather than having to revisit an area years later.
4. Potential to control the variations that occur within the model and compare the seismic interpretations against the known changes.

Short Summary of PhD Project

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SUPERVISOR/S:
Prof. Norm. Uren and Phil McInerney (North Exploration)

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 new acquisition and processing techniques to aid interpretation of EM data.

EXPECTED OUTCOMES:
A multi-system acquisition and processing technique to enhance the target response in small-loop frequency-domain EM data.

A multi-system acquisition and processing technique to enhance the target response in large-loop time-domain EM data.

Application of the Radon transform as a means of image enhancement via the selective scaling of linear events in the transform domain. Also, to use the Radon transform to remove 'herringbones' from AEM data maps.

START DATE:
February 1996.

EXPECTED DATE OF THESIS SUBMISSION:
June 1999.

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.

Sykes, M.P., and Das, U.C., 1998, Removal of herringbone effects from AEM data maps using the Radon transform: Exploration Geophysics, 29, p 92-95.

Sykes, M.P., and Das, U.C., 1998, The Radon transform and its application to airborne electromagnetic data: 60th EAGE conference and technical exhibition, Leipzig.

Sykes, M.P., and Das, U.C., 1998, Reduction of the layered earth response in time-domain electromagnetic surveys for mineral exploration: 13th ASEG conference, Hobart.

SOFTWARE WRITTEN:
A simple code to compute residuals from electric field and dB/dt measurements.

Stress-induced Seismic Anisotropy: The Effects of Stress on Seismic Wave Propagation

Troy Thompson B.Sc (Geophysics)
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Supervisor: Assoc.Prof. Brian Evans (Curtin University)

ABSTRACT

The stress field within the Earth is a first order geophysical property and an important controlling factor on the microscale structure of rocks. The dynamic nature of the Earth's stress field is a result of present day tectonism, including uplift and extension, however stress-induced phenomena are also influenced and complicated by remanent stress-history effects. The resultant anisotropic sedimentary layers present within the Earth allow the remote interpretation of stress-induced effects using the seismic method. Interpretation objectives include the determination of in situ stress directionality, fracture orientations and the delineation of hydrocarbon reservoirs. Stress has the potential to affect nearly all physical rock properties; it will therefore influence seismic wave propagation as well as the interpretation of petrophysical properties and geophysical seismic data.

In this thesis, the effects of stress history on the acoustic and elastic properties of artificially manufactured sandstones have been investigated in the laboratory using ultrasonic techniques. Homogeneous mixtures of quartz sand and epoxy resin were allowed to harden under the application of different forming stress magnitudes. This was followed by unloading under anisotropic stress conditions satisfying uniaxial strain criteria. The resultant sandstones exhibited azimuthal velocity, amplitude and Poisson's ratio anisotropy with a 90-degree periodicity. Pronounced, well-defined shear-wave splitting was also prevalent. As forming stress was increased the average velocity of all body waves decreased, attenuation increased and the percentage anisotropy increased.

The azimuthal anisotropy was consistent with the symmetry of the anisotropic stresses during unloading. The severity of the anisotropic trends observed favoured an interpretation focussing on microcrack development; however, visual proof of microcracking has not been obtained at this stage. Thus, acoustic trends including shear-wave splitting are accounted for by the formation of intergranular microcracks (breaking of the epoxy bond) in the plane parallel to maximum stress during unloading. As forming stress is increased so too is the length of the unloading path with larger stress anisotropy. This in turn induces a higher density of aligned microcracks inducing a larger acoustic anisotropy.

A technique was developed for the preparation of anisotropic sandstones, which is a cheap and relatively simple method for the creation of geological models of known anisotropy for future physical modelling research. Materials that bear a close resemblance to actual sedimentary lithologies can be utilised. The developments of this research have led to numerous related pathways for future physical modelling research into stress-induced phenomena and their implications to the field of geophysics.

Determination of Anisotropic Elastic Parameters from Surface Seismic Surveys

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Supervisor: Prof. Norm Uren (Curtin University)

ABSTRACT

The methods of exploration seismology originally sought to determine the depth and shape of geological structures from travel time information. In recent years great effort has been devoted to better determining the physical properties of those structures using the more detailed information contained in the seismic record.

Until recently conventional seismic data processing assumed that the media was isotropic. However, realistically we know that most layers are anisotropic. The assumption of isotropy leads to significant errors in seismic interpretations. To account for the anisotropy, methods to obtain better estimates of complex physical properties of the media are required before more accurate seismic data processing can be achieved.

The determination of anisotropic parameters from surface seismic measurements has thus far proved quite difficult. Limited techniques for determining the anisotropic elastic parameters based on travel times have been introduced, but this problem is far from solved.

I extended the existing published equations for anisotropic AVO to the more general cases of tilted axes of symmetry and dipping reflectors, and formulated an equation of my own. On the basis of physical modelling experiments, my own equation was selected as the most appropriate for the models used in this research.

A new method based on amplitude response is introduced in this thesis and enables the determination of the following anisotropic parameters from surface measurements: axial P-wave velocity alpha, elliptical parameter epsilon and anelliptical parameter delta.

Comparison between observed amplitude versus offset curves to curves computed by my new amplitude response equation enables delta and alpha to be determined. The parameter epsilon is found from observations at the "Epsilon point", a characteristic illuminated by this research. This technique is quite robust for anisotropic parameter determination and errors using this technique are less than 5 percent.

Thus, a new technique is presented which determines anisotropic elastic parameters (alpha, delta, epsilon) from surface seismic surveys. This provides a useful mechanism for determining formation properties before drilling, and enables anisotropic migration away from boreholes.

Regolith Studies Along AGSO Deep Seismic Lines

Xiaoli Xie
CRCAMET / Macquarie University
Supervisor: Prof. James Macnae

ABSTRACT

The thesis focuses on understanding the role of electrical structures of the weathered layer known as regolith and its associated electromagnetic (EM) response. This understanding is essential for improving EM exploration technology for both geological mapping and mineral exploration across regolith-dominated terrain, which covers much of Australia. Research has been carried out both on methodology and on a case study.

The case study was undertaken over a traverse, where airborne electromagnetic (AEM), seismic refraction and geological logging data were available. The objective was to reconstruct regolith structure and examine the potential of the AEM method for geological mapping using conventional geophysical methods. Because of the high electrical conductivity and low seismic velocity nature of regolith, and the electrically resistive and high seismic velocity nature of bedrock, both electromagnetic (EM) method and seismic methods can be used to investigate regolith structure. In this case, the velocity structure was used to constrain the geometry of the regolith, under the assumption that any mapped interface would have an electric structure consistent with velocity structure. Ground EM and DC-sounding surveys were carried out over four selected traverses along the line over typical geological sites and specific AEM anomalies. Regolith structures were reconstructed by combining all of EM, DC-sounding, seismic and geological data. The results showed that the EM method could provide a surprisingly good rendition of the actual physical properties of the model.

The regolith model derived from the case study showed that the regolith was characterised by a highly irregular thickness and a relatively uniform conductivity with a high contrast to bedrock. To handle more complex regolith models, a 2.5-D AEM modelling program has been developed. Examples using synthetic data show that the method is very successful when applied to a regolith layer model with an irregular boundary and extremely high conductivity contrast between the regolith and bedrock. Using the numerical results from the 2.5-D synthetic modelling, it is demonstrated how the AEM response changes with the variation in irregular lower boundary of regolith or terrain. The limitations of EM 1-D inversion were shown to be that resolution was limited by the 'footprint' of the AEM system, with shallow boundaries resolved to about 0.5 times the footprint, and deeper boundaries to 1.4 times the footprint.

An automatic and fast approach based on the generalized reciprocal method (GRM) has been developed to determine regolith velocity structure using seismic refraction data. A significant enhancement has been implemented to the GRM method to achieve a fast and automatic processing tool on 1) making use of multifold data and automatic layer picking; 2) automatically determining refractor velocity and its lateral variation; and 3) depth inversion. Synthetic and field data show that the approach is powerful and effective. The method was successfully applied to the field data in the case study.