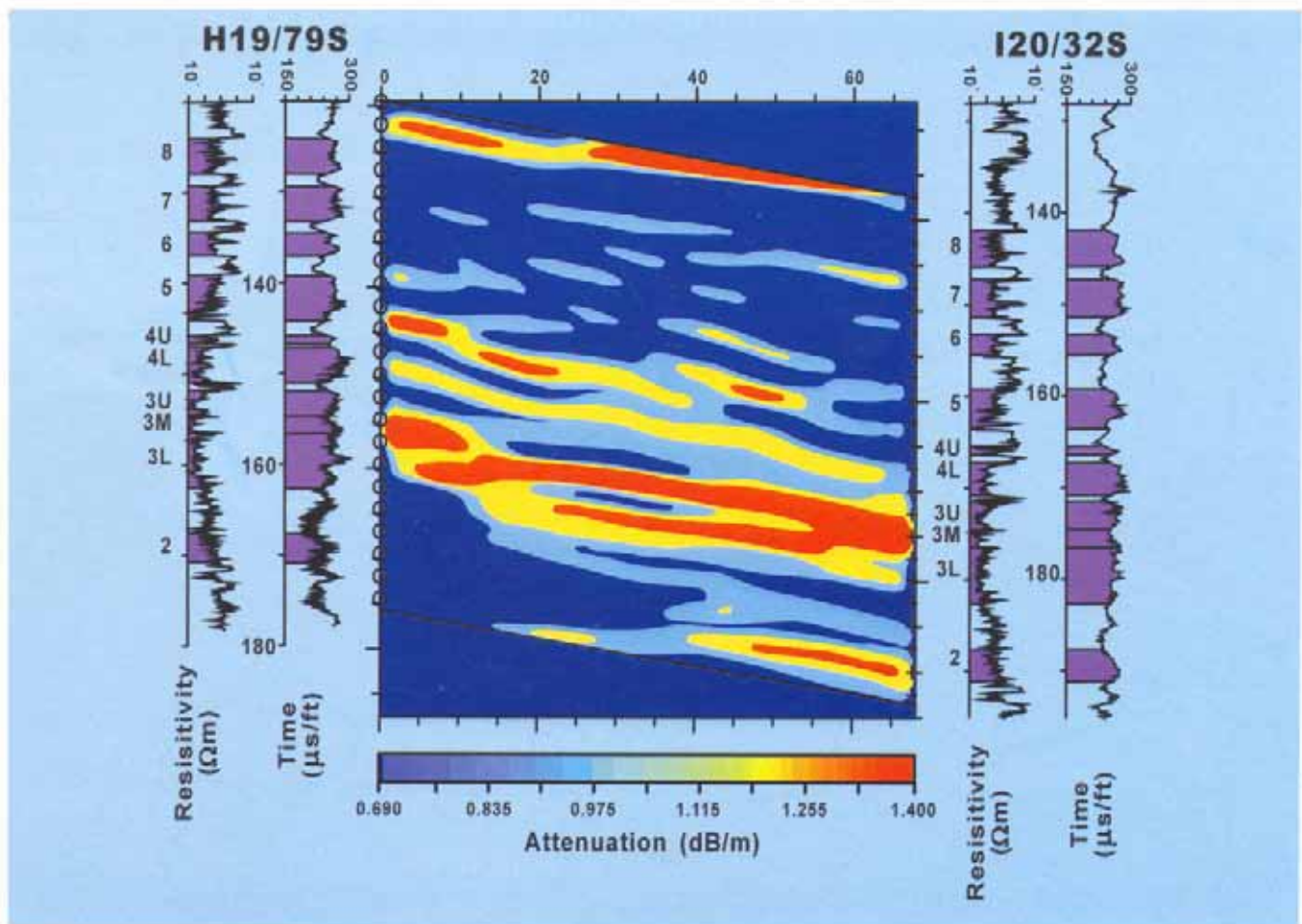




Special Feature:

Geotomography for Metalliferous Mining a Case Study - McArthur River

8-13



In This Issue:

- Why the Maximum Noise Fraction (MNF) Method Cleans Gamma-ray Surveys So Well** 14-17
- Blasts from the Past**
- Old seismic shots** 18-19



Contents

Feature Article

- Geotomography for Metalliferous Mining
a Case Study - McArthur River8-13

Special Features

- Why the Maximum Noise Fraction (MNF)
Method Cleans Gamma-ray Surveys So Well.....14-17
Drift and Break Up - Budget Cuts at AGSO.....20
Australia's Geophysics Research Capability
in Jeopardy.....20-21
Blasts from the Past.....18-19

Regular Features

- Editor's Desk.....1
President's Piece.....2
Preview Deadlines.....2
ASEG Membership Benefits.....2
Executive Brief.....3
Personality Profiles.....3
Calendar Clips.....4
Corporate Members.....4
Society Briefs.....5
ASEG Branch News.....6-7
ASEG Donations.....21
Letters to the Editor.....22-23
Conferences.....24
Industry News.....25-26
Seismic Window.....27
Membership Application.....28
Calendar of Events.....29
Advertisers Index.....29
Classifieds.....30-32

HEAD OFFICE:

PO Box 112, Alderly Qld 4051
Tel: 61 7 3257 2725, Fax: 61 7 3252 5783
Email: secretary@aseg.org.au
http://www.aseg.org.au

PRESIDENT: Mike Smith, Tel: (02) 9529 2355
Fax: (02) 9529 2355, Email: mjsmith.aseg@geoinstruments.com.au

HON SECRETARY: Dave Robson, Tel: (02) 9901 8342
Fax: (02) 9901 8256, Email: robsond@minerals.nsw.gov.au

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

ASSOCIATE EDITORS:

Petroleum: Mick Micenko, Tel: (08) 9384 4309
Email: micenko@bigpond.com
Position Vacant!

Minerals: Steve Mudge, Tel: (08) 9386 8894
Email: vecresearch@bigpond.com

Petrophysics: Don Emerson, Tel: (02) 4579 1183
Fax: (02) 4579 1290, Email: systems@lisp.com.au

Engineering, Environmental & Groundwater: Geoff Pettifer,
Tel: (03) 5133 9511, Fax: (03) 5133 9579
Email: geoffp@geo-eng.com.au

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

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

Editor's Desk

Elsewhere in this Preview is a profile of the newly appointed Preview Editor, David Denham, who will take over in full by the October issue with a transition in the next issue. After two years I felt it was time to move on. My son noticed that I was getting cranky when the last deadline came (and went) and I would not like to Preview suffer because the Editor had gone feral. I will not drop David in the deep end immediately and I will stick around and try to improve the Petroleum content, an area where I have failed to meet my own goals.



David is well qualified for the job but most importantly he is looking forward to the job. I hope all the regular contributors will treat him well.

During the last year or more the ASEG has received a number of approaches to publish/print Preview. The current arrangement with Jenkin Buxton has been in place for two years following a different kind of arrangement that was in place for four years prior to that. In my time as Editor, Preview has been more or less on time and, hopefully, of high quality. The Publications committee felt the best way to manage these approaches was to call for tenders and 6 invitations were sent out including Jenkin Buxton. The PC felt that it was in the best interest of authors, editors, advertisers, conference organisers and the ASEG in general that the same people handle all our publications. Members may be surprised to know that we have 5 different kinds of regular publications as well as the occasional Special Publication. These cost the Society between \$K100 and \$K240 per year. This is serious money and the need to be open and accountable to our members is understood. Tenders were to be reviewed during June and any new arrangements to be in place for the second half of this year in plenty of time for the Perth conference.

In the week before writing the 'Desk' I received several communications reflecting the concern felt by members of the geoscientific community about the declining state of our industry and the double whammy of decreased government spending on research. Nobody needs to explain the meaning of a downturn to me. As a consultant I am at the leading edge of it, but I'm also confident that things will turn around.

Mick Micenko has 'joined' Preview as a contributor to Seismic Window. I am still looking for more help on this front. There is no rule that says we can only have one Window per issue.

ASEG is a non-profit company formed to promote the science of exploration geophysics and the interests of exploration geophysicists in Australia. Although ASEG has taken all reasonable care in the preparation of this publication to ensure that the information it contains (whether of fact or of opinion) is accurate in all material respects and unlikely either by omission of further information or otherwise, to mislead, the reader should not act in reliance upon the information contained in this publication without first obtaining appropriate independent professional advice from his/her own advisers. This publication remains the legal property of the copyright owner, (ASEG).

President's Piece

CRISIS IN EXPLORATION

Approximately half of the geologists resident in Western Australia are reportedly seeking employment. Geophysicists have suffered retrenchment at a similar rate. While the situation in W.A. may be more severe than in other states, the state of our industry must be a serious concern to all geoscientists.



Crisis in Exploration is the proposed title of a seminar planned to increase public awareness and seek solutions to the current dramatic downturn in the employment of geoscientists. This is one of several goals set by a meeting of the presidents of professional and learned societies held in Perth on 16 April, which was attended by W.A. Branch President Jim Dirstein on behalf of ASEG. Representatives of AIG (whose president convened the meeting), GSA, AusIMM, AMEC and the WA Chamber of Mines also attended, together with the Chairman of a new body known as Australian Geologist Skills and Employment Advancement Network (AGSEAN).

An earlier public meeting held in Perth on 9 April by AGSEAN highlighted the unemployment situation and the decline in the use of basic exploration services such as assaying and drilling. Geophysical contracting is effected with equal severity. AGSEAN attracted several political figures to the meeting, and intends to follow up with intensive lobbying to Federal and State Governments. The precise strategy of the campaign will be worked out at follow-up meetings involving all of the geoscientific societies and ASEG will be a strong participant. Ultimately the effectiveness of any lobbying effort depends on the active involvement of as many individuals as possible. The ASEG will seek your direct participation to maximise the effectiveness of the campaign.

AGSO/CRC DISAPPOINTMENTS

Further evidence of the decline in the perceived importance of the resources industry came with the release of news of a 7.38 million dollar decrease in the budget of the Australian Geological Survey Organisation (expected to result in staff level reductions of 72 permanent staff and 17 temporary staff) and the loss of two Cooperative Research Centres (CRC's) in the 1999 funding round (including the CRC for Australian Mineral Exploration Technologies and the Australian Geo-dynamics CRC). Many will also be aware of recent retrenchments in traditional major exploration companies operating in or from Australia. The evolving situation deserves the attention of us all. We will try to keep you informed of the coordinated aims of the professional and learned societies.

ASEG BUSINESS PLAN

The new Federal Executive in Sydney hit the ground running thanks especially to the transitional planning undertaken by Noll Moriarty's team in Brisbane and I take this opportunity to acknowledge that group's preparation of job descriptions for each position, negotiation of the 1999 contract for the ASEG's secretariat service and development of the ASEG Business Plan following extensive consultation with State Branch Committees. The

importance of having a structured business plan is highlighted by the reduction in the Society's funds presented in Preview No. 77 (December 98-January 99). Clearly key goals of the new Federal Executive will be to control (and if possible reduce) costs and increase revenue (mainly in the area of advertising). Another important achievement by the 1998/99 Federal Executive was the preparation of tendering documents for the publishing and promoting of the Society's publications and I thank Andrew Mutton and Henk van Paridon especially for this aspect of their work on the Publications Committee.

Mike Smith

President

mjsmith.aseg@geoinstruments.com.au

Death of Lindsay Ingall

Lindsay Ingall passed away on 21 May 1999. He was suffering from a heart valve problem. Lindsay has been described as the father of our Society. He was instrumental in the formation the ASEG in 1970 and served on the initial Federal Executive. Lindsay was made an Honorary Member in 1988 and was awarded the ASEG Service Medal for extra-ordinary service to the Society over many years in 1998. This was formally presented to him recently in Sydney. An obituary will be published in the next edition of Preview.

Lindsay will be sadly missed by his friends and colleagues throughout the geophysical community.

Preview Deadlines – 1999/2000

August	July 15
October	September 15
December	November 15
February	January 15

ASEG Membership Benefits

- ◆ ASEG Meetings and Conferences
- ◆ Exploration Geophysics (2 issues per year)
- ◆ Preview (6 issues per year)

ENCOURAGE YOUR COLLEAGUES TO JOIN

*Membership Applications,
see this issue or contact:*

Glenn Loughrey
ASEG Secretariat
PO Box 112
Alderley Qld 4051
Tel: 61 7 3257 2725
Fax: 61 7 3252 5783
Email: secretary@aseg.org.au

Executive Brief

In April the Federal Executive transferred from Brisbane to Sydney. On behalf of the in-coming committee, I wish to thank the previous committee for their tireless efforts, in particular the out-going President Noll Moriarty.

With the transfer to Sydney we welcome the following Federal Executive:

President:	Mike Smith
1st Vice President:	Brian Spies
2nd Vice President:	Tim Pippett
Secretary:	David Robson
Treasurer:	Graham Butt
Committee:	Jim Macnae, Derecke Palmer, Ray Shaw, Bob White, Joe Cucuzza, Koya Suto and Noll Moriarty.

Most of the committee members have nominated for several roles. For instance, Mike Smith will look after liaison with other societies while Brian Spies liaises direct with the SEG and looks after publications. Tim Pippett will consult with Conference Committees and with the Internet sub-committee. Bob White will assist on publicity, Jim Macnae and Ray Shaw will examine educational possibilities, while Derecke Palmer will encourage student input.

We are very fortunate that the following sub-committee chairmen are continuing. They are:

Publications:	Andrew Mutton
Membership:	Koya Suto
Honours & Awards:	Bill Peters
Technical Standards:	Paul Wilkes
Research Foundation:	Joe Cucuzza
Conferences:	Craig Dempsey
Internet:	Voya Kissitch
Editor Exploration Geophysics:	John Denham
Editor Preview:	Henk van Paridon

Besides all of the above we very much appreciate the continued services of the Secretariat, Glen Loughrey and his staff at Dellaraine in Brisbane. The FE has recommended that this professional service remain with Glen and his staff.

The following important issues were discussed at the April Committee Meeting:

- Brian Spies to represent the President at the EAEG Conference in June. As part of Brian's workshop commitments he was already attending EAEG.
- Mike Smith to head the ASEG Booth at the SEG Conference at Houston in October. To ensure a successful booth, the committee through the State Branches will invite all members who propose to attend Houston to assist with the booth.
- Koya Suto has sought the assistance of all State Branches to assist in personally following up unfinancial members. Unfortunately we have 360 members who are not yet financial for 1999! Based on the number of financial members the 'capitation levy' to State Branches will be finalised at the end of June.
- David Denham will soon take over Henk's role as Editor of Preview. Congratulations David and many thanks to Henk for his past and current efforts.
- Congratulations to Baker Hughes/Western Geophysical as the Principal Sponsor for the Perth ASEG Conference in March 2000.

- Safety is a very important issue and the FE suggest that an evening workshop on 'ground survey safety' should be held during the Perth conference.
- The FE discussed the possibility of an Annual Conference and will liaise with the Perth Conference Committee with respect to inserting a questionnaire in the conference satchel. Any change to an Annual Conference would have to be after the Brisbane Conference currently being planned for September 2001.
- It was recommended that the presentations of Silver Certificates (25 years membership) be presented at State Branch Meetings.
- To endeavour to simplify the ASEG finances, the Committee has asked the Secretariat to ascertain when the accounts could convert from 'cash accounting' to 'accrual accounting'.

David Robson
Federal Secretary
robsond@minerals.nsw.gov.au

Personality Profiles

TIMOTHY D.J. PIPPETT 2ND VICE PRESIDENT

Tim has been involved in geophysics in one way or another just about all of his working life. After graduating from Canberra College of Advanced Education (now Canberra University) in 1974, he spent 18 months working in the Department of Defence before moving into geophysics with Layton Geophysical International, in Canberra. His time with Laytons included undertaking the gravity re-computations of older petroleum gravity survey in Australia and running geophysical contract work in gravity, magnetics and seismic refraction.



In 1981 Tim moved to Sydney to join EG&G Geometrics International Corp. to manage the airborne geophysics division of the company. With a downturn in the industry, Geometrics reduced the airborne division and Tim moved across to selling geophysical and oceanographic instruments in Australia and SE Asia. This position with Geometrics, later to become Geo Instruments Pty. Ltd., also involved the training of operators on the equipment and the development of new equipment such as the GMS-2 Magnetic Susceptibility Meter, which has become an industry standard.

In 1994, an opening occurred in Australian Defence Industries Ltd. (now ADI Limited) to run the Sub Surface Imaging section and Tim was appointed the Manager. This involved the use of geophysics to locate unexploded ordnance (bombs etc.) in the sub surface and environmental contamination, both in Australia and around the world. There were also offices in USA and Germany.

In 1997, Tim moved out to form Alpha Geoscience Pty. Limited, which undertakes geophysical consulting and contracting for the environmental, ordnance and engineering industries.

Tim is married to Marilyn (who is also the part-time Secretary and Bookkeeper of Alpha Geoscience) and they

have three adult sons. The family attends Shire West Christian Centre where they are involved in the church programs.

Tim has served the ASEG in a number of positions over the years, including Co-chairman of the 1991 Conference in Sydney, Business Manager for the Society for two years and President of the NSW Branch of the ASEG for two years. He is presently the 2nd Vice President of the Federal Executive. He has been a member of the ASEG since 1979.

Calendar Clips

1999

- 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
May 7-10 APPEA 2000 Brisbane - Call for Papers
May 23-26 GPR 2000 Gold Coast

1999 Corporate Plus Members

*Geotrex Dighem Pty Ltd
MIM Exploration Ltd
Mincom Pty Ltd
Oil Company of Australia Ltd
Velseis Pty Ltd
Veritas DGC*

1999 Corporate Members

*Aerodata Holdings Limited
Anglo America Corporation
Ashton Mining Limited
Australian Geophysical Surveys Pty Ltd
BHP World Minerals
Boral Energy Resources Limited
Earth Resource Mapping
ECS International Pty Ltd
Encom Pty Ltd
Geo Instruments Pty Ltd
Geosoft Australia Pty Ltd
Haines Surveys Pty Ltd
Kevron Geophysics Pty Ltd
Maytex Pty Ltd
Normandy Exploration
Pasmenco Exploration
Petrosys Pty Ltd
PGS Australia
Primary Industry & Resources South Australia
Quantec Consulting
Rio Tinto Exploration
Schlumberger Australia Pty Ltd
Scintrex Pty Ltd
Terracorp Pty Ltd
Tesla-10 Pty Ltd
West Australian Petroleum Pty Ltd
Western Geophysical / Baker Hughes
Woodside Offshore Petroleum Pty Ltd
Zonge Engineering & Research Organisation*

ANSIR

AUSTRALIAN
NATIONAL
SEISMIC IMAGING
RESOURCE

Call for Research Proposals Requiring Access to Equipment (for experiments in 2000 and beyond)

Researchers seeking to use equipment of the Australian National Seismic Imaging Resource (ANSIR) in 2000 and beyond are advised that research proposals should be submitted to the ANSIR Director (see below for details) by 16 August, 1999.

ANSIR is a Major National Research Facility created to encourage and assist world-class research and education in the field of seismic imaging of the Earth. It operates a pool of state-of-the-art seismic equipment suitable for experiments designed to investigate geological structures from environmental and mine-scale through to continental scale. ANSIR is operated jointly by the Australian Geological Survey Organisation and The Australian National University.

ANSIR equipment is available to all researchers on the basis of merit, as judged by an Access Committee. ANSIR provides training in the use of its portable equipment, and a field crew to its operate seismic reflection profiling systems. Researchers have to meet project operating costs.

Details of the equipment available, access costs and likely field project costs, and the procedure for submitting bids for equipment time, are available on our World Wide Web site at
<http://rses.anu.edu.au/seismology/ANSIR/ansir.html>.

Any further queries should be directed to:

Dr Barry J Drummond (particularly for projects requiring ANSIR's seismic reflection equipment)
ANSIR Director
GPO Box 378
Canberra ACT 2601

Telephone: +61 2 6249 9381
Facsimile: +61 2 6249 9972
Email: Barry.Drummond@agso.gov.au

OR

Prof Brian Kennett (particularly for projects requiring ANSIR's portable seismic recorders)
Research School of Earth Sciences
Australian National University
Canberra ACT 0200

Telephone: +61 2 6249 4621
Facsimile: +61 2 6257 2737
Email: Brian.Kennett@anu.edu.au

Society Briefs

David Denham, currently the Chief of the Minerals Division in AGSO will take over as Editor of Preview in mid-July this year.

David has experience in most areas of geophysics. He started his career estimating the depth to buried coal measures in Yorkshire using electrical resistivity techniques, before working as a research seismologist with British Petroleum until 1964 when he came to Canberra to work with the BMR.



David's first job in BMR was to assist in the administration of the Petroleum Search Subsidy Act (1957). He was soon bored with the bureaucracy involved with this, and moved to Papua New Guinea in 1965 to take charge of the geophysical observatory in Port Moresby. While there he set up a network of seismographs to monitor earthquakes in the region and used the results to estimate earthquake risk and study the tectonics of the region.

He returned to Australia in 1970 to work on earthquake risk and studies of the Australian crust from seismic sources. In the mid-1970s he compiled the first regional stress map of Australia.

David set up the Australian Seismological Centre in BMR in 1984 and was awarded the Order of Australia in 1985, for service to seismology.

Since then he has headed the 'Minerals', 'Geohazards, Land & Water', and 'Geophysical Observatories and Mapping' Divisions in BMR/AGSO.

During the last few years in AGSO he has been involved with airborne geophysics and regional gravity mapping programs and contributed to filling the last two gaps in the aeromagnetic coverage of the continent earlier this year.

David was, Chairman of Governing Council of the International Seismological Centre from 1994-1996 and President of the Geological Society of Australia from 1996-98. For several years he wrote the 'Science in Government' column in 'Search' and is looking forward to contributing to Preview and the ASEG.

ERRATA

Membership Directory: Apologies to Schlumberger for a printing glitch that caused a loss of detail in their address. It should read 150 Albert Road, Melbourne.

Welcome to new corporate member Petrosys.

Preview 79 Rock Doctor Missing Reference

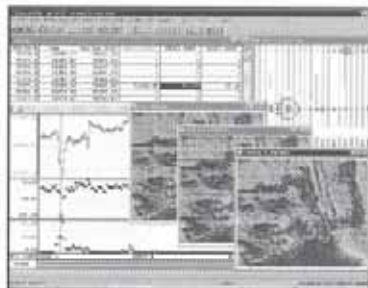
Brown, W.F., 1962. Magnetostatic Principles in Ferromagnetism, North-Holland, p. 51-53.

Focused Software Tools for Geophysics, Geochemistry and Drillhole Geology in an Easy-to-Use Integrated System

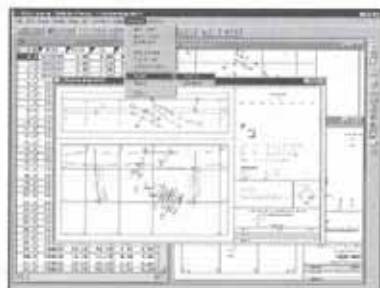
Industry Standard
Software for
Locating Ore Bodies



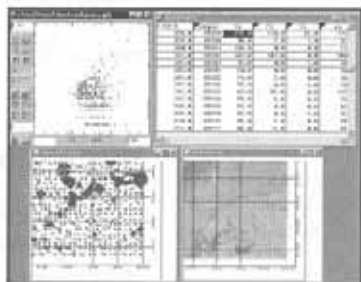
Geosoft Australia Pty. Ltd.
www.geosoft.com



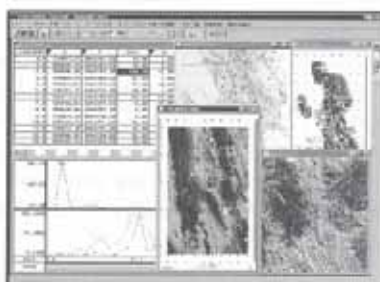
GEOPHYSICS



DRILL HOLE GEOLOGY



GEOCHEMISTRY



INTEGRATED DATA PROCESSING,
ANALYSIS & VISUALIZATION

32 Richardson St., West Perth WA 6005, Australia Tel: (08) 9322 8122 Fax: (08) 9322 8133 e-mail: info@geosoft.com.au

ASEG Branch News

Queensland

Contact details:

President: Troy Peters
Phone: (07) 3279 0400
Fax: (07) 3279 0743
Email: tpeters@velpro.com.au
Secretary: Kathlene Oliver
Phone: (07) 3878 9900
Fax: (07) 3878 9977
Email: Kathlene_Oliver@digicon-brs.com.au



Queensland Branch hosted the Federal AGM in April. A big thank-you to all those who came along to show their appreciation to the dedicated volunteers who have been running the show over the past three years. Of course there's no time for rest! Many of our Federal Executive volunteers, together with other Branch members, are now beginning the huge task of organising the 2001 Conference. ASEG certainly wouldn't be as professional, or benefit as many members, without the work of our volunteers - keep up the great work!

We have held two technical meetings during April and May: 'Polarisation Analysis: What is it? How do you do it? Why do you need it?' given by Natasha Hendrick, and 'FlairTEM - The Alaskan Experience' given by Peter Elliot. Both were well received.

Our Queensland Branch Geophysics Career Night and BBQ, held at the University of Queensland's Exploration Geophysics Laboratory during May, was a big success, and by far our largest gathering for the year to date. Nick Sheard (MIMEX) and Randall Taylor (OCA) both gave very entertaining presentations on 'life as a geophysicist'. The BBQ was expertly prepared by our third year geophysics students, and live music provided by Steve Hearn & Co. In true geophysical fashion, we partied on 'til late in the night.

Our Branch President, Andrew Davids, is heading to Adelaide shortly due to work commitments. Troy Peters will take on the role of President for the remainder of the year. The Branch Committee would like to thank Andrew for all his hard work, and the time he has put in over the past couple of years to ensure the smooth operation of Branch activities.

The Queensland Branch Committee will shortly be organising our Branch program for the latter half of 1999. We have two more technical meetings, a student project presentation night, our annual Golf Day and end-of-year Christmas Party in mind. Details of these events will be posted on our webpage and circulated via email. If you have access to email but are not receiving regular ASEG notices, please ensure you're email details are forwarded onto the ASEG Secretariat.

New South Wales

Contact details:

President: Timothy Pippett
Phone: (02) 9542 5266
Fax: (02) 9542 5263
Email: tpippett@ozemail.com.au

Secretary: Dave Robson
Phone: (02) 9901 8342
Fax: (02) 9901 8256
Email: robsond@minerals.nsw.gov.au

The May meeting of the New South Wales branch was held in conjunction with SMEDG and GSA at the Rugby Club. The topic - on the New South Wales Geoscience Package - was presented by Erwin Scheibner and David Hayward (of the Geological Survey of New South Wales). Erwin summarised the geological/tectonic/geophysical basis for the data and David described the interactive package. The presentation was particularly well received by the 100 people at the meeting and engendered lively discussion.

The Annual Dinner is planned for 21 July 1999.



ACT

Contact details:

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

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

On 30 March, the ACT branch held its 1999 AGM in the main meeting room of the AGSO building. The 1999 committee was elected as follows:

President:	Tim Mackey
Vice President:	Kevin Wake-Dyster
Secretary:	Nick Direen
Treasurer:	Peter Milligan
Committee Members:	Adrian Hitchman, Jane Mitchell, Alice Murray, Prame Chopra, Tony Meixner

The guest speaker for the meeting was Tony Meixner, AGSO. His seminar was titled: "The nature of the Basement to the Cooper Basin, South Australia".

Western Australia

Contact details:

Mailing Address:
A.S.E.G. WA, P.O. Box 1679,
West Perth W.A. 6872
Website: <http://www.aseg.org.au/wa>
Don't forget to check the ASEG/PESA
Golf Links for updates!



President: Jim Dirstein
Phone: (08) 9382 4307 Mobile: 0419 904 356
Fax: (08) 9382 4308
Email: dirstein@iinet.net.au

Secretary: Terry Crabb
(Australian Geophysical Surveys)
Phone: (08) 9414 1266 Mobile: 0407 421 072
Fax: (08) 9414 1277
Email: crabb@agspl.com.au

VicePresident: John McDonald (08) 9266 7194 / Fax: (08) 9266 3407
Treasurer: Bob Groves (08) 9279 6456 / Fax: (08) 9279 6456

Technical and general meetings held every third Wednesday of each month at the Celtic Club, 48 Ord Street, West Perth, from 6pm.

April 1999: No meeting held

May 1999:

Meeting sponsored by Paradigm Geophysical and by World Geoscience:

William Abriel, WAPET *"Stratigraphic quality images from 3D depth imaging - even in the Gulf of Mexico subsalt"*

David Triggs, WGC *"MagSlice: Image Enhancement Software using new techniques in matched filtering"*

If your company would like to advertise at future meetings please contact one of the persons above about sponsorship opportunities.

Distinguished Instructor Short Course (DISC) Perth, September 13, 1999: "The Seismic Velocity Model as an interpretation asset".

Jim Dirstein, as president of the ASEG WA branch, attended a meeting called by the Australian Institute of Geoscientists discussing the current geoscientist unemployment crisis on April 16. Please contact Jim on dirstein@iinet.net.au if you require minutes of the meeting or have suggestions for future ones.

South Australia

Contact details:

President: Michael Hatch
Phone: (08) 8340 4308
Fax: (08) 8240 4309
Email: zongeaus@ozemail.com.au

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

We've had two technical meetings in the time since the last Preview came out (when it rains it pours). The first one was on the 28th of April and was presented by Peter Elliott of Elliott Geophysics International and was titled Geophysics in Indonesia and the social, political, economic and natural environment in which it is applied.

It was an interesting talk for many as Peter has had quite a range of experiences in the last few years working as an independent geophysical contractor in southeast Asia.

The second technical meeting held in April was a Joint Symposium sponsored by the SA branch of the ASEG, along with the local PESA branch, the National Centre for Petroleum Geophysics and Geology, and the Geology and Geophysics Department at the University of Adelaide. The talk was titled: The Special Value of Seismic Attributes, and was presented by Alistair Brown, a consulting reservoir geophysicist, specialising in the interpretation of 3D seismic data. Again, an interesting talk, as Alistair has been involved with 3D seismic work since the mid 1970's.

We are looking forward to a full calendar of events here in SA over the next few months. We will keep everyone posted as things develop.

Victoria

Contact details:

President: Neil Hughes
Phone: (03) 9288 0408
Fax: (03) 9288 0211
Email: hughesn@pasmenco.com.au

Secretary: Trudi Hoogenboom
Phone: (03) 9288 9188
Fax: (03) 9288 0211
Email: hoogenbt@pasmenco.com.au

At the AGM held on March 23, 1999, the 1999/2000 Victorian ASEG committee were nominated and duly elected without too much competition.

President: Neil Hughes
Vice-President: Suzanne Haydon
Secretary: Trudi Hoogenboom
Treasurer: Dave Gamble
Committee: Shanti Rajagopalan, Geoff Pettifer, Esther Harris, Geoff Dunn, Henry Cao, Alan Hogan, Lucy Kirwan, Eric Gozlan

Following the well attended AGM, a dinner was held and ASEG service medals were presented to Dr. Lindsay Thomas and Geoff Pettifer. Eric Phillips (sponsored by Iridium) presented an amusing and informative rendition of his Antarctic journey (see photo page 26).

Monthly meetings held at the Kelvin Club, Melbourne on the 3rd Tuesday of every month have included the following:

April 20 Dr. Xiong Li, BHP research and technology department "Borehole Gravimetry: An old tool has new life"
May 11 Dr. Peter Elliott, Elliott Geophysics "FLAIRTEM-Development and Case Studies"

A committee meeting was held on May 11th to enable planning for future activities.

The search for penguins continues...



geoterrex-dighem

Airborne & Ground Geophysics

Geotomography for Metalliferous Mining a Case Study - McArthur River

Gary N. Fallon¹, Andrew Newland² and Damien Nihill³

This paper was presented at the 4th SEGJ Conference in December 1998 in Tokyo. This conference was co-sponsored by the ASEG. Gary Fallon re-presented the talk at a Queensland local branch meeting and the paper is re-printed here to expose it to a broader Antipodean readership.

Ed

Abstract

Electromagnetic tomography (302 Hz) was used at the mine feasibility stage to identify and map fault throws between boreholes. Limited data analysis indicate this technique was successful in locating the fault attributes to an accuracy of approximately +/- 1 meter. Current available operating mine access is mostly near horizontal and within Number 2 orebody. The electromagnetic tomographic technique was discounted due a poor electrical contrast between 2 orebody and the hanging-wall/footwall lithologies.

An evaluation seismic tomography survey was completed at the start of 1997. This survey examined one 90 x 170 meter (H) block using a hammer source and a symmetrical acquisition spacing of 2 m.

For H block 11% of the initial ray paths were rejected using technical or statistical criteria on data quality. Power spectra analysis indicates the received signal has a large bandwidth of 150 to 1500 hertz with the main power at approximately 750 Hertz. Successive symmetrical decimation of the ray path density illustrated the 2 meters acquisition spacing provided the best resolution. A detailed reconciliation of the Tomogram constructed using the SIRT algorithm, against geological and structural mapping post mining occurred. The tomographic data identified 60% of the mapped faults with an average spatial accuracy of +/- 1.2 m. Though the survey geometry is not favourable for defining fault throws, some faults identified, had throws as small as 0.3 m. The cost of the survey was 0.15% of the then insitu value of ore or equivalent to 15 meters of misdirected development.

Keywords: metalliferous, resolution, electromagnetic tomography, seismic tomography.

Introduction

The McArthur River zinc lead mine is located in the Northern Territory of Australia at latitude 16 26S, longitude 136 06E. The mine is operated by McArthur River Mining Pty Ltd. The deposit consists of seven metalliferous seams separated by waste beds within a Mid-Proterozoic dolomitic shale sequence known as the Barney Creek Formation. For the most part the deposit is

gently dipping. The mineralisation consists of millimetre layers of very fine grained sphalerite and galena interbanded with dolomitic graded beds and pyrite (Logan, 1979 and Hinman, 1996).

Prior to mining, a resource of 104 Mt grading 14.1 per cent zinc and 6.4 per cent lead had been estimated with reserves of 27 Mt grading 14.0 zinc and 6.2 per cent lead. Current mining, using an apparent dip room and pillar mining method, is focused on the higher grade Number Two Orebody located at the base of the mine sequence. Pre-mining investigations identified large resource bounding structures and at least two sub-vertical fault orientations that offset the ore seams. Once mining commenced, a significant increase in the amount of relevant rock exposure revealed four sub-vertical fault orientations. The most significant are sub-vertical northwest trending, east-west trending, north-northwest trending and northeast trending faults with frequencies around 50 metres. Apparent vertical displacements range from a few millimetres to 15 metres. The physical expression of these faults varies from tight surfaces, one millimetre thick to breccia zones tens of centimetres thick healed by remobilised sphalerite, dolomite, galena, marcasite, pyrite and quartz (McKinstry, 1996).

The successful application of a geophysical technique depends largely on the existence of physical property contrasts. For structural definition in any region there are generally two geophysical signatures expected:

1. The particular structure(s) attributes alter the physical properties on such a scale that a direct response is observed.
2. The structure is identified indirectly by causing the juxtaposition of contrasting lithology's or the spatial variations in marker horizons.

The physical expression and known characteristics of the structures at McArthur River suggest the second response is the most likely form of geophysical expression.

Petrophysical Analysis

To provide a framework for geophysical technique selection and survey design a statistical analysis on a small number of laboratory physical property core measurements and five borehole geophysical logs were conducted. These analysis are summarised in Table 1 below.

Clearly density provides a good contrast between ore and waste, whilst velocity and resistivity are variable. The base of 2 orebody has a strong electrical contrast, but in it's entirety the compressional velocity of 2 orebody provides the strongest (~7%) contrast with the surrounding lithology.

¹ MIM Exploration Pty Ltd

² Formerly BHP Engineering, Now Geosensing Solutions (Newtuk Consulting)

³ McArthur River Mining Pty Ltd.

Table 1. McArthur River Basal Ore Sequence Petrophysical Property Summary

Lithology	Average Thickness (m)	Grade (%) Zn/Pb/Fe	Density (g/cc)	Compressional Velocity (m/s)	Resistivity (Ω m)
3 lower Orebody	1.00	15.9/8.7/12.8	3.45 (0.12)	5185 (150)	16 (18)
2 / 3 Beds	5.00		2.95 (0.18)	5173 (270)	11 (2)
2 Orebody	3.00	18.2/7.2/6.2	3.40 (0.11)	4860 (340)	22 (12)
1 / 2 Beds	2.90		2.85 (0.10)	5243 (440)	830 (950)
1 Orebody	2.80		3.00 (0.05)	5491 (250)	380 (200)
Tuff(s)	0.08		~1.80	4367 (170)	26 (4)

Note: a) Bracketed numbers are standard deviations.
 b) Density calibration is not reliable.
 c) Ore shown in bold text

Considering the compressional velocity, it is instructional to examine the amount of variability with respect to density. Figure 1 is a summary crossplot of the borehole geophysical data for two holes within the orebody. Using the series and parallel "rule of mixtures" for density and velocity respectively, we have included the dolomite/sphalerite and shale/sphalerite bounds. These bounds represent a maximum as insitu porosity and fracture variations will reduce these limits. Mineralogical differences will contribute to the horizontal variations observed. Generally the data seem to conform to the dolomite/sphalerite trend. The different orebodies in the lower half of the stratigraphy all lie within the dense - low velocity quartile of figure 1 and display a limited amount of statistical overlap with the waste at approximately 3.30 g/cc.

The highly laminated nature of the ore suggests anisotropy is likely to be present, however this has not been studied at a laboratory or borehole level. If this is the case then the measurement orientation will influence the determined data. The borehole logging derived compressional velocity should be higher than the in seam measurements.

Pre-Mining Electromagnetic Tomography

An electromagnetic tomography trial was conducted as part of the pre-feasibility structural drilling project. The survey used the RIMÓ II H-field borehole tomographic system operating at 302.5 kHz on a 2.5 meter spacing for the transmitter and receiver points. The tomographic reconstruction process used a priori geological infor-

mation as a constraint in the Youla inversion Rogers (1987). One of the resultant tomograms are presented in figure 2 and clearly show's the existence of a fault between the transmitter (I20/32S) and the receiver (H19/79S). At the reduced level of two orebody this fault is approximately 15 meters from H19/79S with 4 meter displacement east block down. A second tomographic panel orthogonal to the above, failed to outline any vertical displacement in the ore. Subsequent underground geological mapping identified an east block down, fault located 15 meters from H19/79S with a variable 1.5 - 3 meter displacement and no geological evidence for a structure within the limits of the second panel.

The ability of the data to resolve the ore stratigraphy and the above fault, empirically suggest the resolution capabilities are approximately +/- 1 meter or one quarter the wavelength.

Post Mining Seismic Tomography

The poor electrical contrast of 2 orebody and the limited geometrical access created by mining suggest in-seam transmission tomography may be the best geophysical technique for routine fault delineation.

A 48 channel ruggedised 16 bit digital seismic acquisition system originally designed and manufactured by BHP Research for coal in-seam seismic and tomographic surveys. The sampling rate used was 50 microsecond and 2048 point record length. Total gain with IFP of the seismic system is 120 dB. The seismic source was a 7 kg hammer with a piezoelectric transducer for zero time initiation. Valid data was obtained up to the maximum ray path length of 138 meters. No stacking was used, but three repeat shots were recorded with the "best" of each shot being used for processing. The average time taken per shot record is 2 minutes. For good signal coupling the 18 Hz geophones were attached to the mine tunnel wall via plaster of paris Luo et al. (1997).

During the data acquisition phase several sources of adverse noise were encountered and these were :

1. Mining activity either drilling or meshing.
2. Transport related activity either vehicular movement or graders.
3. People movement.
4. Crusher activity.
5. Vent fans.
6. Poor or double hit with the hammer.

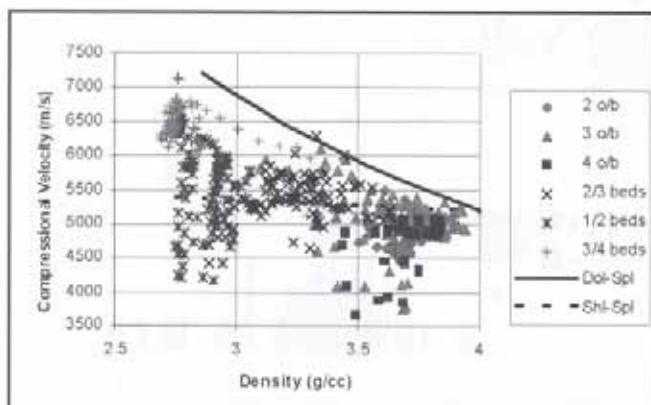


Figure 1. Petrophysical summary crossplot from two boreholes within the mineralisation.

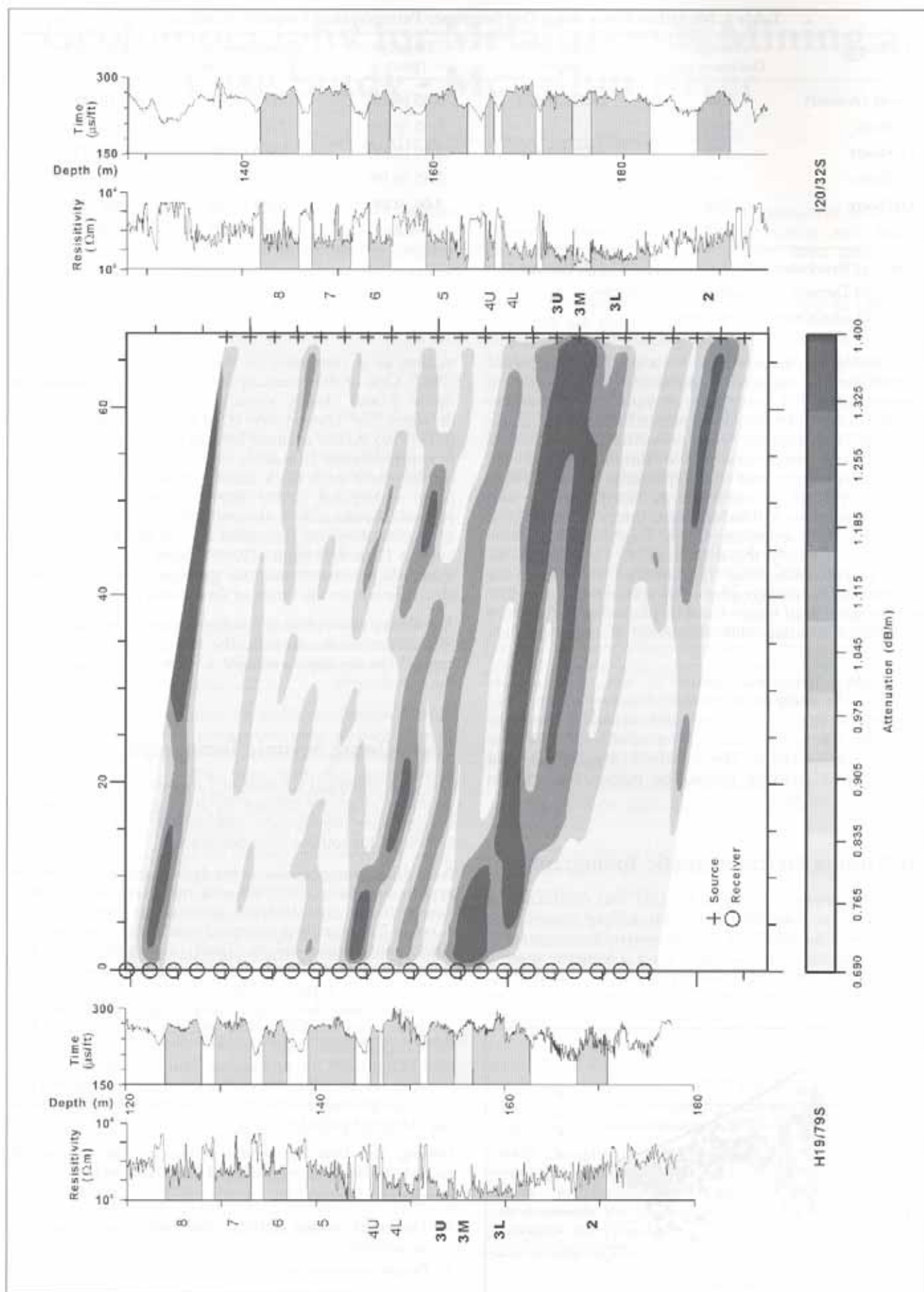


Figure 2. 302.5 Hz Electromagnetic attenuation tomogram for boreholes H19/79S and I20/32S. Respective focused resistivity and travel time sonic logs have been included with the different orebodies shaded and named.

The first three forms of noise contain too much power within the frequency range of interest and are best totally avoided (see also Luo et al. 1997). The underground crusher was variably operational and where we could locate repeat shot to geophone records with the crusher on and off they provided inconclusive results. A vent fan motor located approximately 15 meters north of the survey area, caused a significant increase in noise levels and had to be turned off for the duration of recording. The vent fan's general noise characteristics are broadband, with a significant increase in the spectral power approximately between 500 and 700 hertz. Poor hammer strikes where the hammer was allowed to "bounce" did effect the data quality and in most cases the shot was repeated.

Static corrections were calculated for each shot via a linear regression of the "ray" distance against arrival time (Mason 1981). Conventional wisdom purports this delay to the hammer trigger switch. For H block this does not appear to be the only source of delay, with constant acquisition logistics the average delay for the two spreads are different i.e. Spread 1 at 1.96 milliseconds and spread 2 at 0.50 milliseconds (Figure 3). When the average travel time is 17 milliseconds, the impact of this delay "error" on the data quality is variable and can be significant.

The static correction process also provided the correlation coefficient for the linear regression. A low (<0.9) coefficient was found to be caused by, either; a noisy shot record or a few erroneous travel times, which were edited. Thus, in summary, at each step various shot records are closely scrutinised and either rejected or accepted. Table 2 below presents the accumulative percentage rejection for each step.

Tomographic reconstruction used a 3 dimensional version of MIGRATOM (Jackson and Tweeton 1993) and the Simultaneous Iterative Reconstruction Technique (SIRT) algorithm. Software constraints limited the final model mesh size to 3.9 x 3.7 blocks on levels 10 meters apart, within a 190 x 90 x 40 meter block. The start point for the tomographic reconstruction routine was to assume a uniform earth with an average velocity of 5100 m/s.

Table 2. Summary of the data percentage rejection.

Processing Stage	Actual Percentage Rejection
Manual pick	2.5
Tx-Rx Crossplot edit	1.4
Negative delay correction	3.1
Correlation criteria	4
Total	11

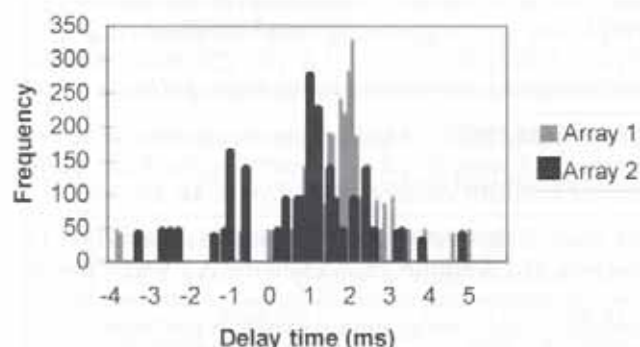


Figure 3. Static correction histogram for all the data.

Interpretation

The average power spectra has a mean peak at approximately 750 Hz and a drop off at approximately 1500 Hz. With an average velocity for the region in the order of 5100 m/s a signal wavelength of 6.8 meters can be calculated.

As indicated previously structural features are most likely to be identified by abrupt changes in the velocity model. For H block there are several features identified, most of which are closely related to the identified faults from development mapping (Figure 4). These have been summarised in Table 3. To understand the effects of survey geometry on resolution the original 2 (5024 rays) meter data has been symmetrically (source and receiver) decimated to simulate a 4 (1280 rays) and then 8 (315 rays) meter acquisition mesh. A visual inspection of the resultant tomograms indicate the increase in data variance with sample spacing, most likely due to the corresponding decrease in data constraint. The decimation results have been analysed against the mapped geology in a similar manner to the original spaced data and the results are presented in Table 3.

Pre-mining geological data and development mapping produced an interpretation containing 5 faults, one of which was a miss-interpretation and the remaining four were all defined by the tomography survey. Only structures 4 and 7 (Table 3 and Figure 4) were correctly interpreted pre mining. Post mining reconciliation mapping identified 15 faults, 9 of these were partially defined by the seismic tomography (see Table 3). The weighted average spatial accuracy was +/- 1.3 meters, representing approximately one third of the wavelength which is slightly better than the 44% wavelength derived by Becquey et al. (1996). An additional 3 features were defined as faults and their actual "sources" are still unknown. The successive decimation of the data showed a general reduction in the number of faults and the percentage of respective strike lengths defined. Perhaps, more importantly from an economic perspective, there was also a significant increase in the number of unknown features, which may be processing artefacts. The survey design and acquisition geometry is not favourable to estimating the fault throw, however, the smaller throw faults appear to have the best accuracy in location. An empirical observation suggests the amplitude difference on either side of the fault may be related to the throw size.

Of the unidentified post mining faults (6) we could not establish any unique commonality or criteria which may help for future identification or survey design.

The most obvious result from the data is the apparent poor correlation between the determined velocity and the mapped lithology. The north western two thirds of H block is almost as expected however the remaining one third is totally contrary. In this south eastern portion the low velocity zone corresponds to the 1/2 beds, and the quality of the hammer strikes are generally poor suggesting incompetent lithology. Perhaps this particular region has seen a degradation in the rock mass character of the 1/2 beds. Two orebody within this region has a uncharacteristically high velocity of 5400 m/s. A 12% increase in velocity is hard to rationalise, as lithological variations are unlikely and the excess insitu stress (estimated at -60 MPa, after McCreary et al., 1992) would cause pillar failure.

Table 3. Fault Identification Summary.

Fault ID	Actual Throw (m)	2 meter Acquisition mesh		4 meter Acquisition mesh		8 meter Acquisition mesh	
		Spatial Accuracy (m)	%	Spatial Accuracy (m)	%	Spatial Accuracy (m)	%
1 (pre-mine)	0.1	+/- 0.0	60	-	0	-	0
2	0.2	+/- 0.0	35	+/- 0.0	35	+/- 2.5	25
3	0.2 - 1.0	+/- 2.9	50	+/- 2.9	40	-	0
4 (pre-mine)	0.5 - 1.7	+/- 0.9	85	+/- 1.2	80	+/- 1.2	85
5 (pre-mine)	0.2 - 1.8	+/- 0.8	75	+/- 0.8	75	+/- 0.8	60
6	1.6	+/- 2.2	30	+/- 2.2	15	+/- 2.0	35
7 (pre-mine)	2.8 - 3.0	+/- 2.0	80	+/- 1.8	70	+/- 2.3	25
8	0.1 - 0.3	+/- 0.7	85	+/- 0.7	85	+/- 0.7	50
9	0.8 - 2.8	+/- 1.5	20	+/- 1.8	60	+/- 2.5	60
Undefined		3		5		6	

Cost Analysis

The H Block survey cost approximately \$30,000 AUS which represents around 0.2 per cent of the insitu value of the ore mapped or the equivalent to the cost of 15 metres of development in waste. This low cost technique can be used to minimise uncertainty in mine planning and become even more cost effective by increasing the volume of rock under investigation. A major shortcoming of this survey, however, was its inability to map fault displacement. When the mine starts to produce from higher orebodies, the survey design and acquisition geometry may become favourable to estimating the fault throw.

Conclusions

Petrophysical data collection and analysis provided a good basis for sound technical decisions on the selection of an appropriate technique and survey design. The electrical resistivity is dominated by the presence of galena and pyrite whilst the sphalerite and dolomite dominate the mineralogical contribution to the compressional velocity.

For fault detection and throw delineation between boreholes electromagnetic tomography identified the conductive orebodies and has demonstrated resolution capabilities to one quarter a wavelength.

In seam transmission tomography can provide a spatial resolution for faulting of approximately one third a wavelength at 80 meters separation. This resolution is only achievable after extensive static corrections and careful data quality analysis. Successive symmetrical decimation of the original data suggest the acquisition mesh should also be similar to the desired resolution.

Acknowledgements

These results are published with the kind permission and thanks of McArthur River Mining and MIM Exploration. Thankyou to Eila Kangas whom completed the figure reproduction and presentation. Particular efforts throughout the project by the following people are

acknowledged and thanked: Mark Neil (METS), Teresa Tully (MIMEX), Steve Prevely (MRM), John Doyle (BHPE) and John Kingman whom all provide valuable insight and technical support throughout the project. Over time the patience and advice offered by Dr's Peter Hatherly, Peter Fullagar and Xun Luo (CSIRO/CMTE) significantly contributed to our understanding of mine tomography.

References

- Becquey M., Laurent J. and Meynier P., 1996 "Crosswell tomography and reflection imaging- Lodeve test site." *First Break*, 14, No 8, 321 - 327.
- Hinman, M., 1996. Constraints, timing and processes of stratiform base metal mineralisation at the HYC Ag-Pb-Zn deposit, McArthur River. In eds. Bailer T. et al., MIC'96, New developments in metallogenic research, The McArthur river, Mount Isa, Cloncurry minerals province, 56-59.
- Jackson M.J. and Tweeton D.R., 1993 MIGRATOM - geophysical tomography using wavefront migration and fuzzy constraints: US Bureau of mines.
- Logan, R., 1979. The geology and mineralogical zoning of the HYC Ag-Pb-Zn Deposit, McArthur River, Northern Territory, Australia. Unpublished MSc thesis. Australian National University.
- Luo X., Hatherly P. and Fallon G., 1997 "Determination of ore boundaries using seismic tomography at a metalliferous mine in Australia." Proceedings of the international symposium on engineering and environmental geophysics Chengdu, China. Ed He Zhenhua, Sichuan publishing house of science and technology, 86-92.
- Mason I. M., 1981 "Algebraic reconstruction of a two dimensional velocity inhomogeneity in the high Hazles seam of Thoresby colliery." *Geophysics*, 46, 298-308.
- McCreary R.G., McLaughly J., Potvin Y., Ecobichon D., Hudyma M., Kanduth H., Coulombe A., 1992 "Results from microseismic monitoring, conventional instrumentation, and tomography surveys in the creation and thinning of a burst-prone sill pillar.", *Pure and Applied Geophysics*, 139, no 3/4, 349-373.

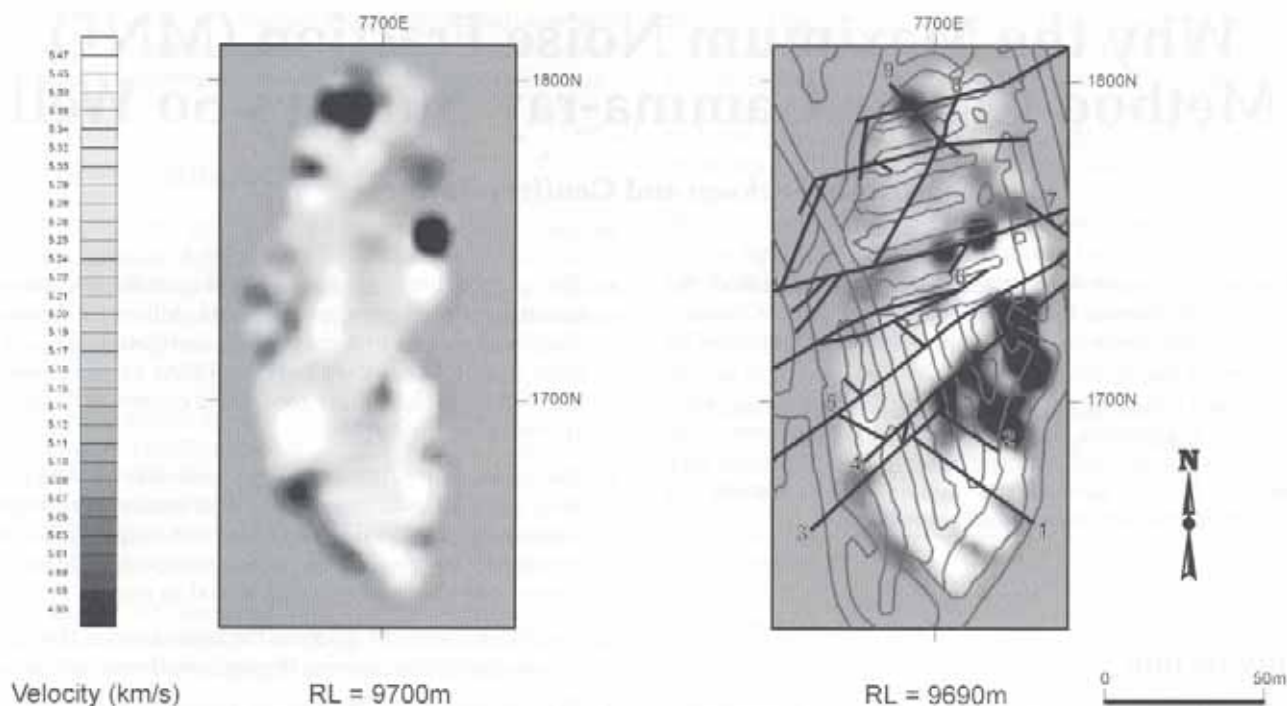


Figure 4. Compressional wave transmission tomograms for H block on the two central reduced levels. For RL 9690m the mine development is shown in light font and the mapped structures in bold font. Please refer to table 3 for the structure number.

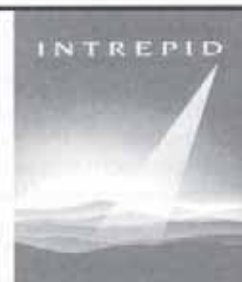
McKinstry, F., 1996. A study of the fluid evolution in the late stage, vein hosted mineralisation at McArthur River, N.T. Unpublished Honours thesis. James Cook University of North Queensland.

Rogers P.G., Edwards S.A., Young J.A., and Downey M., 1987 "Geotomography for the delineation of coal seam structure." *Geoexploration*, 24, 301 - 328.

Intrepid Geophysical processing and interpretation software

Magnetic - Radiometric - Marine and Land Gravity

- Acquisition through to regional interpretation and modelling.
- Powerful, easy to use software runs on Windows and Unix.



<i>Acquisition processing</i>	<i>Mainstream processing</i>	<i>Interpretation</i>
• Magnetics	• Powerful visual editors	• Euler
• 256 channel Radiometrics	• Gridding & Grid stitching	• Naudy Auto Modelling
• Marine gravity and Bathymetry	• Fourier, line and spatial filters	• Depth methods
• Land gravity	• Complete projection support	• Auto anomaly picking
• Complete Levelling	• Visualisation & hardcopy	• Interpretive mapping

- Web enabled data archiving and distribution system
- Advanced integration with ERMMapper, Arc View, ArcInfo, ModelVision and Potent.

DFA also provide a full range of data processing services - call for details.

Desmond FitzGerald and Associates

Unit 2, 1 Male St. Brighton Victoria, Australia, 3186.

Tel +61 3 9593 1077
info@dfa.com.au

Fax +61 3 9592 4142
www.dfa.com.au

DFA Perth

138 Grand promenade, Doubleview, W.A. 6018.

Tel +61 8 9244 9313
john@dfa.com.au

Fax +61 8 9244 9313
www.dfa.com.au

Why the Maximum Noise Fraction (MNF) Method Cleans Gamma-ray Surveys So Well

Bruce Dickson and Geoffrey Taylor

Preview 75 (August 98) was used as a forum to publish the results of the Gamma Ray workshop held last year in Sydney. The following paper by Dickson and Taylor is published to complement that review. However I feel that Preview is not the appropriate forum for detailed technical debate which is more suited for Exploration Geophysics or at ASEG conferences or workshops. Preview still welcomes case studies and tutorial type material. Preview also invites a volunteer to become an Associate Editor dedicated to Radiometric issues.

Ed

Introduction

Two methods have appeared recently for dramatically reducing the noise in aerial gamma-ray survey data. These are the noise adjusted singular value decomposition (NASVD) and maximum noise fraction (MNF) methods, each technique consisting of statistical linear algebra operators applied to a large proportion of the 256 channel raw spectral data of a survey, prior to integrating counts in the K, U and Th windows and proceeding to conventional processing.

NASVD was described by Hovgaard (1997) as a way of locating the spectra of nuclear accident radio-elements in a typically noisy airborne gamma-ray survey by isolating them, by singular value decomposition, in the principal components of a weighted, uncentred data matrix. It is assumed that airborne survey data has the Poisson distribution of the random decay process, so that the average spectrum reasonably describes the noise variance. The best estimate of the noise in each channel is concluded to equal the square root of the counts in the average spectrum, weighted by the relation of each individual spectrum to the total survey mean spectrum. The data are "noise adjusted" for this assumed variance (but not mean centred) before SVD factorising to obtain principal components of the adjusted spectra. Noise reduction is achieved by the omission of most of the factors.

The MNF method was originally proposed by Green et al. (1988) for ordering multispectral data in terms of "image quality" and has since been widely adapted for processing many forms of remotely sensed images and other multivariate data. The application of the MNF method to aerial gamma-ray survey data has been described by Nielson et al. (1996) and Dickson and Taylor (1998).

A number of workers are troubled by aspects of the Maximum Noise Fraction (MNF) method of noise reduction of gamma-ray survey data. In a recent paper (Hovgaard and Grasty, 1998) and in an article in *Preview* (Minty, 1998), opinions have been advanced querying our implementation of the method. In this article we briefly demonstrate why the MNF technique should be the preferred method for statistical noise-reduction.

The more considered doubts of the MNF method arise from one of these four groups of related views:

- The assumption that in an aerial gamma-ray survey counts in each spectral channel follow a Poisson distribution, and that there is no correlated noise. It is then inferred that the "best" estimate of the noise is derived from the square root of the counts of the mean spectrum of the survey.
- The Maximum Autocorrelation Function (MAF) we have used for estimating noise distribution is improper - it reveals correlated noise; it includes "signal"; it leads inevitably to removal of "real geological features"; it "interprets short wavelength signal as noise".
- The MNF method "assumes the noise level is the same on one particular channel throughout the survey area".
- The method finds "too many principal components" for gamma-ray spectra.

In answer to these concerns, we would like to first note some properties of the Poisson distribution, and then demonstrate aspects of MNF, MAF and NASVD applied to data sets which test the comments and illustrate the strengths and weaknesses of the methods.

The Poisson distribution

A Poisson distribution represents the number of events occurring randomly in a fixed time at an average rate of m events / per unit time. Radioactive particle emission is a well-known example of a Poisson process, provided that the measurement time scale is much shorter than the radioactive half-life. The probability of n counts in time

t is given by $P(n) = \frac{(mt)^n}{n!} e^{-mt}$. For $t = 1$, the mean and variance of this probability function are both equal to m .

It follows from the definition of a Poisson process that if one adds sets of independent Poisson distributed variates, a new Poisson distribution is obtained. Thus particle counts from the aggregation of different radioisotopes in a sample also follow a pure Poisson distribution. If the average count rates changes during the course of a counting experiment, however, the underlying condition for a Poisson process is violated and the counts cannot be expected to conform to a Poisson distribution. This latter situation is more analogous to an airborne survey than counting of a single sample.

In an airborne survey, only one time interval for each sample is counted, in a spatially defined sequence, using an instrument that smears and partly correlates the successive samples. As well there are local variations such as changing vegetation and soil moisture, airborne radon, aircraft movements that change the angle and height of the detector, cosmic radiation and electronic noise from the instrument itself. Our tests on many airborne surveys have failed to obtain a reasonable probability for the hypothesis of the Poisson distribution for any of them. Thus, since the

noise distribution in a survey cannot be stated; use of a parametric statistical model is appropriate and we may only hope to derive an estimate of the noise distribution.

The MNF technique

Aerial gamma-ray data constitutes a multivariate data set with n channels $Z_i(x)$ $i = 1, \dots, n$ where x is the set of channel counts of each observed sample. Each measurement consists of signal, $S(x)$ and noise components, $N(x)$ so that $Z(x) = S(x) + N(x)$. Because $N(x)$ is uncorrelated with $S(x)$, $Cov(Z(x)) = \Sigma = \Sigma_S + \Sigma_N$.

The noise fraction of the i^{th} channel is defined to be $Var[N_i(x)] / Var[Z_i(x)]$, that is, the ratio of the noise variance to the total variance. The maximum noise fraction transform is a linear transform $Y_i(x) = a_i^T Z(x)$, $i=1, \dots, n$ such that the noise fraction for $Y_i(x)$ is maximum among all linear transforms orthogonal to $Y_j(x)$, $j=1, \dots, i$.

Green et al (1988) demonstrated that the vectors a_i are the left-hand eigenvectors of $\Sigma_N \Sigma^{-1}$, and that μ_i , the eigenvalue corresponding to a_i , equals the noise fraction in $Y_i(x)$. It follows from the definition of the MNF transform that $\mu_1 \geq \mu_2 \geq \dots \geq \mu_n$, and the MNF components will show steadily increasing "image quality".

Cleaning in effect combines only the desired parts of the decomposition indicated by the eigenvalues $\mu_1 \dots \mu_n$ which sort the components by noise fraction. The high between-channel correlations found in gamma-ray spectral data are reflected in the dominance of a few eigenvalues in the data covariance matrix and this dominance passes through the computed transform. Having few large data eigenvalues is the key to the success of the process.

Computing the transform for very large noisy data sets containing unequal channel variance is not trivial and steps are necessary to ensure numerical stability. We normalise noise to the identity matrix and rotate the data distribution in n dimensional space according to the noise, to obtain a final decomposition, which provides the eigenvector solution. Efficiency may be gained by separating forward and inverse transforms.

An Artificial Data Set

To apply the MNF procedure to our survey data we need to solve for $\Sigma_N \Sigma^{-1}$. Σ is readily calculated from $Z(x)$ whereas Σ_N is more difficult. If there is a priori knowledge of the noise characteristics of a data set, Σ_N may be supplied directly. For example, a data set comprised of one spectrum with pure Poisson distribution is described by a matrix Σ_N whose elements are zero apart from the diagonal values which are equal to the mean of each channel.

We constructed such a data set by applying a random-number based Poisson generator to the mean gamma-ray spectrum of a recent aerial survey. A total of 21,000 spectra were produced, to represent a hypothetical survey collected over unvarying material under conditions leading to a pure Poisson distribution of measurements. These spectra were subsequently processed using the standard three-window method, first without noise reduction, then after NASVD processing, and then after the MNF method (using the readily calculated Poisson Σ_N

for MNF processing). The degree of cleaning was assessed by the RMS difference of the calculated K, U, and Th values from their smoothed equivalents after application of a 7 point running mean. The results obtained are given in Table 1 and show clearly that the MNF method removes most noise. There is no possibility that "real geological features" or "short wavelength signal" are missing from this uniform "concentration" noise-cleaned set. MNF works better, even when the data set has been specifically tailored to conform to the assumptions of the NASVD model, because it examines the signal-to-noise ratios of the data components and is not a sorting of variance.

Table 1. RMS Residuals from smooth data - Poisson distributed spectra after processing

Method	Eigenvalues retained	Total Count	K	U	Th
No noise cleaning	-	1.37	5.84	14.06	7.27
NASVD	2	1.30	1.28	1.54	1.52
NASVD	6	1.30	1.51	1.82	2.03
MNF / calc Σ_N	8	0.38	0.13	0.24	0.13

The NASVD Technique and Outer Products

Why does NASVD not perform as well on a data set which meets its prime assumption as MNF? Singular value decomposition was developed (e.g. Golub & Reinsch, 1970) as a computationally intensive but effective procedure for orthogonally factorising matrices approaching degeneracy (the smallest singular value is the 2-norm distance to the nearest degenerate matrix). The factors obtained are a matrix (Σ), zero except for diagonal singular values σ_i , and two matrices (U, V) of singular vectors. V is regarded as an ordered set of spectral principal components.

One use found for this procedure is data compression (Andrews and Patterson, 1976). When our data matrix A having n channels is SVD factorised as $U\Sigma V^T$ the decomposition may be expressed:

$$A = U\Sigma V^T = \sum_{i=1}^n \sigma_i u_i v_i^T$$

where $u_i v_i^T$ is the outer product of a column of U with the corresponding column of V . To compress the data matrix A , the very small singular values need only be set to zero (equivalent to decrementing n), and the surviving columns may be stored in considerably less space than A occupies. NASVD is a form of compression where expansion immediately follows, and some of the original variance is thereby omitted in the result. It is usual to sum 6 or 8 outer products after visual inspection of the singular values and their corresponding eigenvectors in V and then proceed to construct a reduced-variance replacement for A . The difficulty is that while V separates our weighted data's variance into components, the greater part of most being noise, it does not necessarily transfer all of the actual survey noise distribution to the rejected section, nor fully transfer signal information to the retained section, so that some noise (both by addition and subtraction) is returned in the expansion. Survey segments having disproportionate local variance in particular markedly disturb the retained eigenvectors.

The problem of pseudo-inversion of data matrices was studied intensively during the early period of lunar and planetary satellite reconnaissance. For example, Andrews and Patterson (1976) provided an outer products derived approximation, applicable if the SVD expansion of a matrix blurring or noise function is available. Pratt (1978) discussed the general problem of the inverse of matrix data systems in the presence of additive noise, which commonly leads to severe numerical instability and so renders cleaned estimates unreliable. Where the system is overdetermined, Pratt developed a least squares approximation by regression, expressed in terms of the noise covariance matrix Σ_N . These solutions are not equivalent to NASVD, even if the Poisson noise model is assumed.

This conclusion is not surprising when we consider the experience of others in using SVD to separate mixed signals in the presence of noise. For example, Clark and Clark (1998) found that SVD was excellent in separating signals, which were mixed in a linear fashion from a series of templates. However, in the presence of noise, SVD appeared to attempt to fit the noise using the template signals and gave poor separation. We believe the same process is occurring here with our artificial data set.

Real Data and the Estimation of Σ_N

Processing aerial survey data requires a different approach for the evaluation of Σ_N , as we do not know a priori the noise distribution. Instead, an analysis of the data will be required to quantify the noise covariance and for this purpose the autocorrelation of the data can deliver meaningful information.

Switzer & Green (1984) developed a system known as minimum/maximum autocorrelation factors (MAF), which may be applied to estimate the noise correlation matrix for certain kinds of noise. The MAF procedure is appropriate if there is high correlation of the signal at adjacent samples along a sampling line (as in an gamma-ray survey) whereas noise shows only a weak spatial correlation. A MAF transformation chooses orthogonal linear combinations $Y_i(x) = b_i^T Z(x)$ showing increasing spatial (in the vector sense) correlation and can be described in terms of the between-neighbour comparisons of the data. The required covariance matrix, obtained from the autocorrelation function, may be computed in the space or frequency domain as appropriate to the scale of the problem. The vectors b_i are the left-hand eigenvectors of $\Sigma_\Delta \Sigma^{-1}$, where $\Sigma_\Delta = \text{Cov}(Z(x) - Z(x+\Delta))$. An estimate of Σ_N is obtainable as a scaling of Σ_Δ .

Obtaining Σ_N by the MAF transformation followed by the application of the MNF transformation yields a spatial extension of principal component analysis in the sense that the final transform components now maximise autocorrelation. The first component is the linear combination of the data that that maximises autocorrelation, and so on for the others, subject to orthogonality. Noise is of necessity isolated at one end of the component set.

We tested the MAF procedure on our Poisson-distributed artificial data set. The mean ratio of the diagonal values of the MAF-derived Σ_N to the average spectrum was 0.999 ± 0.013 demonstrating that the procedure has correctly estimated the variance of the data set. The off-diagonal terms ranged from -5.4 to 4.1, which indicate the

degree of approximation. The MNF procedure was then applied using the MAF estimate of Σ_N . The results (Table 2) show a small degradation in the noise cleaning, indicating that the off-diagonal terms have affected the result slightly. However, the cleaning achieved by MAF/MNF for a data set having constant signal with Poisson noise still exceeds that obtained by the NASVD method. This result confirms the similar conclusion reached by Dickson and Taylor (1998) using a set of laboratory obtained natural spectra and applying the MAF/MNF procedures.

Table 2. RMS Residuals from smooth data - Poisson distributed spectra after processing

Method	Eigenvalues retained	Total Count	K	U	Th
MNF /calc Σ_N	8	0.38	0.13	0.24	0.13
MNF/MAF Σ_Δ	8	0.38	0.17	0.26	0.15

Although the noise distribution of an aerial survey cannot a priori be stated, the application of the non-parametric MAF procedure for Σ_Δ enables a satisfactory, though imperfect estimate without assumptions of a particular noise model. After the autocorrelation computation, we have observed that some of the signal covariance may be found in non-diagonal locations of Σ_Δ . This is discussed by Green et al (1988), but in practice has little effect on the noise cleaning as can be demonstrated by another test.

We have previously published the result of MNF/MAF processing of the survey over the Lynas Find area of Western Australia (Dickson and Taylor, 1998). We have also shown that this data set is not Poisson distributed. We repeated the processing of this data, but this time used the mean spectrum of the survey to supply a calculated Σ_N as if the data were Poisson distributed. There are no off-diagonal terms in this matrix, and so no signal "bleed-through". The results (Table 3) show the noise-reduction by the MNF method is only slightly degraded by this choice of imperfect noise model. Minor inaccuracies in the noise covariance matrix produces only minor effects on the processed maps and the MNF procedure appears particularly robust to the estimation of the noise covariance.

Table 3. RMS residuals from smooth data - Lynas Find survey after processing

Method	Eigenvalues retained	Total Count	K	U	Th
No cleaning	-	12.42	20.74	29.26	22.37
NASVD	8	12.17	19.89	19.49	17.80
MNF - Calc Σ_N	25	12.43	20.60	8.26	14.81
MNF - MAF Σ_Δ	25	12.40	20.51	8.25	14.82

Conclusion

The operation of NASVD and MNF/MAF procedures on a test data set with known Poisson-distributed noise reinforces a familiar adage, namely that a job is best done with the appropriate tool. Where noise reduction is

required, the tool should be optimised to isolate noise. This the MNF procedure does by using a measure of signal-to-noise ratio. If, however, one is interested in isolating different isotopes by obtaining the least number of spectral shapes that explain the data variance, then NASVD may be considered. MNF can not be applied to that task.

For gamma-ray surveys to be optimally cleaned using linear algebra techniques, the actual survey noise distribution must be derived on a case-by-case basis. We can not assume foreknowledge of the noise characteristics of aerial data. Our tests show that autocorrelation (the MAF procedure) provides a reasonable estimate of noise distribution and does not significantly affect the subsequent MNF processing which appears robust to departures of the noise model from reality.

Bruce Dickson
CSIRO Exploration & Mining
PO Box 136, North Ryde NSW 2113
Ph: 02 9490 8767
Fax: 02 9490 8921
E-mail: B.Dickson@syd.dem.csiro.au

Geoffrey Taylor
Pitt Research
45 Hackney Rd, Hackney SA 5069
Ph: 08 8362 9966
Fax: 08 8362 9977

References

- Andrews, H.C., and Patterson, C.L., 1976. Singular Value Decompositions and Digital Image Processing, IEEE Trans. Acoustics, Speech and Signal Processing, ASSP-24, February, 26-53.
- Clark, C. and Clark, A.F. 1998. Spectral identification by singular value decomposition. *Int. J. Remote Sensing.*, **19**, 2317-2329.
- Dickson, B.L. and Taylor, G.M., 1998. Noise reduction of aerial gamma-ray surveys. *Exploration Geophysics*, **29**, 324-329.
- Hovgaard, J., 1997. A new processing method for airborne gamma-ray spectrometer data (Noise Adjusted Singular Value Decomposition). Am. Nucl. Soc. Sixth Topical Meeting on Emergency Preparedness and Response, pp 123-127.
- Hovgaard, J. and Grasty, R.L., 1997. Reducing statistical noise in airborne gamma-ray data through spectral component analysis. In *Proceedings of Exploration 97: Fourth Decennial Conference on Mineral Exploration*, (ed A.G. Gubins), pp. 753-764.
- Golub, G.H., and Reinsch 1970. Algol procedure svd, *Num. Math.* **14**, 403-420, 1970.
- Green, A.A., Berman, M., Switzer, P. and Craig, M.D., 1988. A transformation for ordering multispectral data in terms of image quality with implications for noise removal. *IEEE Trans. Geosci. and Remote Sensing*, **GE-26**, 65-74.
- Minty, B., 1998. Recent developments in the processing of airborne gamma-ray spectrometric data. *Preview*, August, 12-24.
- Nielson, A. A., Larsen, R. and Conradsen, K., 1996. Multivariate statistical analysis of airborne gamma detector data. IMM Dept. Math. Modelling, unpublished report, p. 25.
- Minty, B. and McFadden, P., 1998 Improved NASVD smoothing of airborne gamma-ray spectra. *Exploration Geophysics*, **29**, 516-523.
- Pratt, W.K., 1978. *Digital Image Processing*, John Wiley and Sons, New York.
- Switzer and Green, A., 1984. Min/max autocorrelation factors for multivariate spatial imagery. Dept. Statistics, Stanford University, Tech. Rep., 6p.



HAMPSON-RUSSELL SOFTWARE SERVICES LTD.

Has opened an office
in Australia
to better serve our
Australian and Asian
Customers

21 Churchill Avenue
Subiaco (Perth), WA
6008 Australia

Jim Dirstein

Ph: (61) 8-9382-8900

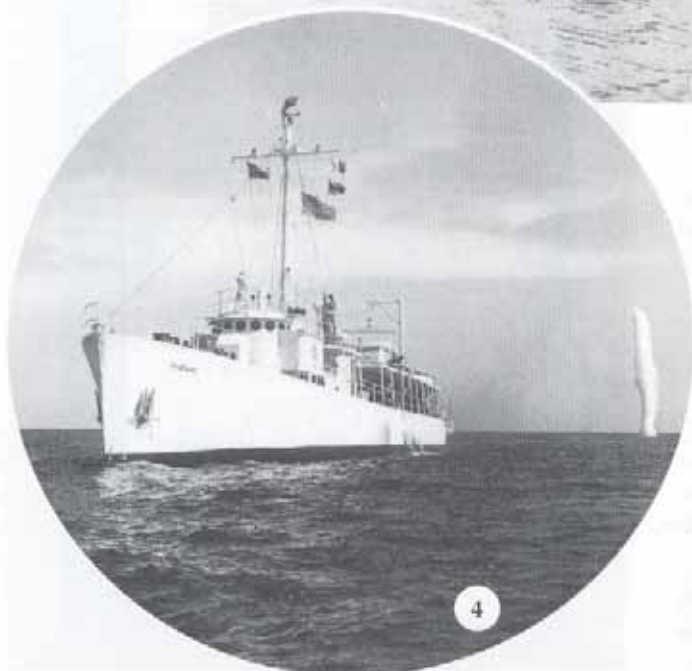
Fx: (61) 8-9382-8911

jim@hampson-russell.com

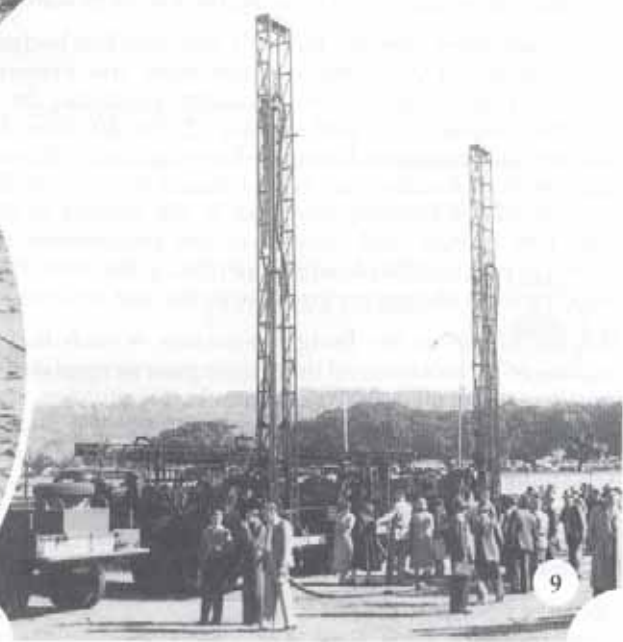
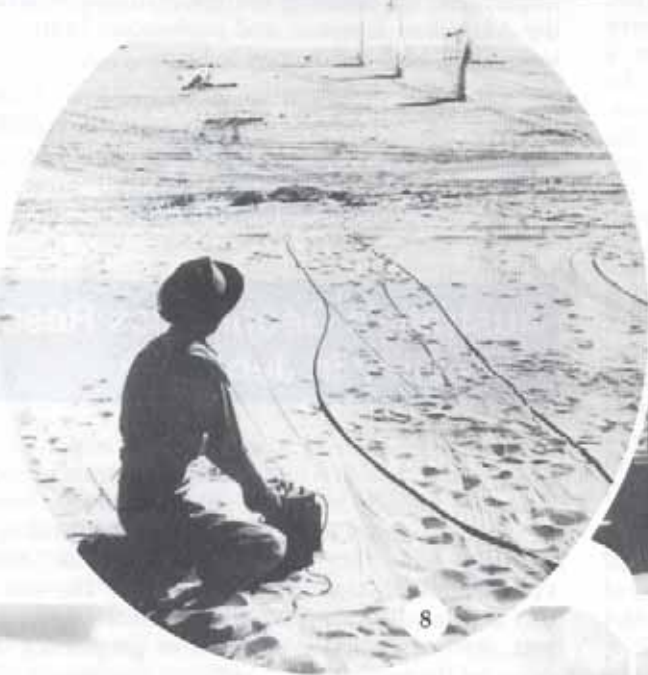
www.hampson-russell.com

Blasts from

From the collection of Jack Webb formerly of the University of Queensland. The origin of the photos is uncertain but they all appear to be from GSI origins. For Captions PTO.



the Past



Captions to "Blasts from the Past" photographs:

1. Principles of Seismic Reflection.
2. Dog Box and Doodlebugger, North America.
3. Marsh Buggy Seismic Crew, South Louisiana.
4. Marine Seismic Survey, MIV Team.
5. Dynamite Source - Australian Seismic Survey, (Note the Land Rovers).
6. Worden Gravity Meter lightweight, insulated by a thermos bottle.
7. Drilling Rig.
8. Multiple Dynamite Shooting in Arabia.
9. GSI Equipment Display Perth 1955.
10. Tellurometer Surveying, Refraction Survey West Texas. A high frequency radio pulse is transmitted to the 'rod' where it is retransmitted to the transponder. Accuracy of a few inches in several miles can be obtained with proper correction (mainly for moisture content of the air) ref Sheriff.
11. Multiple Dynamite Surveying.

Drift and Break Up – Budget Cuts at AGSO

Almost exactly 3 years after funding cuts forced the Australian Geological Survey Organisation (AGSO) to shed approximately 100 staff history is repeating itself. This time the organisation is facing the loss of 89 staff.

The organisation does not have its own one-line budget, was transferred after the election from the Primary Industries portfolio to the Industry portfolio. In a document issued to all staff on May 12, the day after the budget was announced, Executive Director, Neil Williams, said 'AGSO's funding has been reduced because of the non-renewal of funding provided in the context of the 1998/1999 budget and because of the requirement for AGSO, in part, to offset funding provided in the 1998/1999 budget for its offshore programs over the next few years.

The magnitude of the budget reduction is such that it requires re-consideration of the relative priorities and size of functions across all AGSO operations. In this situation, staff reductions are unavoidable. To accommodate the savings and enable AGSO to maintain an operational program AGSO will need to reduce staffing levels by 72 permanent staff and 17 temporary staff including temporary staff affected by the forthcoming closure of the AGCRC [Australian Geodynamics Cooperative Research Centre].

AGSO's budget is outlined below. AGSO's Operational Funds decrease by \$7.38M. This comprises cessation of funding provided for Law of Sea (\$1.6M) and the NGMA Initiative (\$3M), offsets (\$3M per annum) for "Oil in Frontiers Initiative" which started in 1998/1999 - the balance comprises new funds to cover AGSO's premium for the new insurance fund ComCover.'

Appropriation \$'000	1998/99	1999/00	2000/01	2001/02
Operational Funds	47,861	40,473	41,201	42,087
Accrual Provision & Capital Use Charge		3,927	3,915	3,856
Property and P&E	27,067	15,887	15,867	16,057

In essence, to be able to continue to deliver on identified government priorities; AGSO must shed staff across the board. But because the major priorities are 'Law of the Sea' work and the offshore 'Oil in Frontier Zones', the brunt of staff reductions will be taken by AGSO's

Minerals Division, which will lose 28% of its permanent staff and 50% of its temporaries.

Professor Peter Cullen, President of the Federation of Australian Scientific and Technological Societies (FASTS), said the Government's declared commitment to build the nation's education and research capacity sat strangely with its lack of support for the sector.

He detailed five major problem areas:

- Low international commodity prices
- Only one geoscience-based Cooperative Research Centre applicant was successful in attracting funding in the April 1999 round
- A funding cut of 15 per cent to the Australian Geological Survey Organisation (AGSO) in the 1999 Budget
- Wholesale sackings of exploration and research staff in the petroleum and minerals industry.
- Severe financial pressures on the university sector, including geoscience departments

"The Government is not responsible for all these problems, but it does have an interest in protecting the skill base of our geoscientists. Instead the skills base is just slipping through our fingers at the first signs of a downturn," he said.

Staff losses at AGSO would include many who had been responsible for building the international reputation of the Australian minerals and exploration industry as an innovative, high-technology industry."

Dr Bob Day, President of the Australian Geoscience Council (AGC), said annual expenditure on exploration is about \$2 billion. "These decisions do nothing to help an industry which in 1996/97 exported minerals and petroleum worth \$41.3 billion," he said.

Australia's Geophysics Research Capability in Jeopardy

Australia's position as a international leader in mineral exploration research is under threat following unsuccessful renewal applications for two mining industry Cooperative Research Centres (CRCs) in the recent CRC funding round. An application for an extension to the Australian Petroleum CRC was also unsuccessful. The loss of two CRCs, coinciding with significant reductions in industry and university funded research in geophysics, are bad news for the industry.

The two CRCs that face closure are the CRC for Australian Mineral Exploration Technologies (CRC AMET) and the Australian Geodynamics CRC. Of seven applications in the mining and energy sector, only two received funding in the current (1998) CRC selection round - Clean Power from Lignite (brown coal) and the A.J. Parker Centre for Hydrometallurgy.

The two unsuccessful applications were for a new CRC in Geophysical Exploration Technologies (to follow on from the CRC for Australian Mineral Exploration Technologies, or CRC AMET) and a renewal of the Australian Geodynamics CRC. It is now likely that CRC AMET will close after a wind-down period of a year or two, and the Geodynamics CRC will close at the end of 1999/2000.

CRC AMET's Director, Brian Spies, said the integrated geophysical and geological research capability created in CRC AMET was a valuable national asset, and in the long term the Australian mining industry would become less competitive internationally without the collaborative activities provided by CRCs. "I believe it is important that we do everything we can to keep an integrated Australian research and education program alive during these difficult times," he said. "It is particularly disturbing that Australia is likely to lose two professorial geophysics positions at Macquarie and Curtin Universities."

Canberra sources said that one of the reasons for the lack of success among mining industry CRC applications was the unwillingness of companies who wished to become core members of new CRCs to commit cash over a seven-year period. It was pointed out that CRC selection guidelines require both strong industry participation and substantial cash contributions. If industry was not prepared to support CRC applications with dollars it was unlikely that any future assessment panel would rate an application highly. Discretionary cash is seen as essential to provide flexibility for a CRC's Board of Management to employ resources effectively.

Brian Spies said CRC AMET was exploring ways of keeping together significant components of its research capability. He said the Centre had secured reduced Commonwealth Government funding for an eighth year, which nominally ends in June 2000, and was exploring with its participants methods of extending to a 9th year. It would consider mounting a bid for further funding in the year 2000 selection round, but success would be predicated on solid and substantial industry and participant support.

It was reported that BHP was closing its research centre in Melbourne and its R&D funding will be cut by about \$100 million a year. About half the company's research staff employed in Australia and the US are expected to lose their jobs. The company will rely more heavily on contract research in future.

What are CRC's

CRCs, or Cooperative Research Centres, are supported under a government-supported initiative designed to promote collaborative research and education programs in the fields of natural sciences and engineering, with a strong focus on commercial and other applications. The program was launched in 1990 and there are currently 67 centres. Centres are normally funded for a period of seven years, with the possibility of renewed funding under after the Centre's first term under a competitive bidding system.

At present, Australia has three CRCs with geophysical components The CRC for Australian Mineral Exploration Technologies (CRC AMET, www.crcamet.mq.edu.au), which is focussed on airborne electromagnetics.

The Australian Petroleum CRC (www.petroleum.crc.org.au), with activities in upstream petroleum geoscience.

The Australian Geodynamics CRC (www.agcrc.csiro.au) which is focussed on the geodynamics of the Australian continent.

For more information see www.dist.gov.au/crc/

ASEG RF – Donations

ASEG RESEARCH FOUNDATION

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

NAME:

COMPANY:.....

ADDRESS: (for receipt purposes)

AMOUNT OF DONATION: \$.....

Do not detach - To be completed by ASEG Research Foundation

ASEG RESEARCH FOUNDATION



Receipt of donation

Received from

The Sum of.....

dollars being a donation to the ASEG RESEARCH
FOUNDATION

\$.....

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

Signed:

(This form should be retained for tax purposes)

Letters to the Editor

* Remember this year's best letter wins a carton of ASEG wine.

Ed

ASEG Business Plan

I am the newly elected secretary of the ACT Branch; I would like to raise an issue regarding the recently released ASEG Business Plan. As I was "between branches", and did not have a chance to comment on the draft before our previous executive approved a response, I thought I would raise the issue in Preview.

The issue concerns the membership goals, in particular

"For minerals members, focus on making the ASEG the world's premier geophysical Society by attracting inter-national exposure and members".

I would seriously question whether this is a realistic goal. The ASEG is barely 30 years old and has comparatively few members (c.1200) compared to its sister societies (SEG, EAGE) which are much older (c. 70 & c. 50 y.o. respectively) and have much larger memberships (c. 15 000, 5000). These institutions dwarf us in terms of money, prestige and intellectual resources. The resources of these titans are primarily channelled into knowledge sharing through two vehicles, journals and conferences. Dangerously extrapolating from personal experience, it is my assumption that most members of professional societies join to access these two vehicles.

Regarding journals, SEG's *Geophysics*, with a relatively small focus on minerals, is still the journal of choice for many of our members to publish their work. For example, in *Geophysics* Nov-Dec 1998 vol 63 (6), 5 out of 12 "minerals"-oriented papers had Australian authors viz. Lilley, Reid & Macnae, Minty, McFadden, Kennett. This volume was published at the same time as our conference edition of *Exploration Geophysics*, which could have also provided a forum for these papers. All of these authors, save Brian Kennett, published other papers in our conference volume at the same time. One has to wonder why these authors were having a "bob each way" - is it because *Geophysics* is considered more prestigious than E.G.? (In fact this is the case, as a 1998 DEETYA research quantum audit of university publications showed: *Geophysics* was considered a first-rank international journal, whereas *Exploration Geophysics* didn't even make it on to the list!) This problem of stature needs to be addressed, at least for academic members, whose funding is often tied to publications in a way that reflects poorly on the ASEG.

And in terms of conferences, can we ever hope to attract the global interest excited by a conference with > 1200 exhibitors and > 2500 delegates, such as the New Orleans '98 conference? Based on Hobart, or even Sydney 1997, I think not.

Yet it is our journals and conferences that will determine whether or not we will be regarded as "the world's premier geophysical society" for minerals - unfortunately it appears that this goal could never be met, because we just don't have the resources to compete.

I believe we should rewrite the goal to incorporate a more achievable target, one which capitalises on our relative strengths.

These include:

- A high ratio of minerals to petroleum papers in our journal (average 7:3 over the last 3 years, versus 1:4 in *Geophysics*). This is a positive benefit for members from the minerals sector, and may allow reasonable competition with SEG, IF the standard of papers is maintained and/or improved.
- A high proportion of published, peer-reviewed case studies. These are almost impossible to find in *Geophysics*, due to SEG's editorial policy of directing case studies to *The Leading Edge*. This focus of E.G. should be encouraged, because again, it makes us the journal of choice for important contributions showing how things actually "are" in practise (versus how they might be in theory, which is the strength of a journal like *Geophysics*).
- Our geopolitical position. Australia lies on both the Indian and Pacific Rims, and at the edge of South Asia, all regions which are resource rich and under-explored. These contain remote and inhospitable environments which make on-the-ground-geology difficult, and geophysical methods challenging. We have the established intellectual capital and freedom of publication to provide a forum for ideas on these regions, and to discuss adaptations of "old-world" ideas to them. The last few years have seen a trickle of papers from this region published in *Exploration Geophysics*, viz. papers on Taiwan, PNG, and the Solomon Is in E.G. 29(3/4); Namibia, Vanuatu & India in E.G. 28(1/2); India and Canada in E.G. 27(1); Nigeria and India in E.G. 27(4); and Canada in E.G. 27(2/3). What about endeavouring to increase this volume, and striving to be the premier geophysical society in the Indian-Pacific hemisphere? This hemisphere is also where our largest minerals explorers are expanding their operations (viz. Rio Tinto, BHP etc.), thus providing both a source and an audience for such papers.
- Our links to New Zealand: where do Kiwi geophysicists publish their work? In the tiny, low-circulation New Zealand Journal of Geology and Geophysics, which they have to share with geologists. What about offering Trans-Tasman memberships and becoming the Australasian SEG?
- We are not American. Believe it or not, this is an advantage for scientists from some non-aligned or openly anti-US nations, who still want to have their work published in a western forum; many of these scientists may suffer censorship (or worse) if they attempt to publish in *Geophysics*. In E.G. we have a journal which can promote science in a forum relatively free of international politics.
- As a supporter of international geophysical education. Some Australian universities have longstanding geophysical links with countries in Africa, Asia and the Pacific. Increasingly, these countries are supplying students into the geophysical disciplines (viz. undergrad and PhD enrolments at UWA, Curtin and Macquarie for evidence). These students, often from poorer countries, should be encouraged by the ASEG as the core of our future international membership base. Incentive programs, exchanges, scholarships or Research Foundation grants, membership discounts, sister-society sponsoring, conference support and student mentoring all spring to mind as ways to

encourage these students to value the ASEG. The international goodwill generated by such exercises will also be of immense value to Australian professionals as we increase our offshore operations.

These are but a few ideas that I have been kicking around, but they point to an opportunity to fill a niche market. I believe that if we revised the membership goal and policies, focussing on our strengths, we may not become the world's premier geophysical society, but rather the geophysical society of choice in a region that will be at the heart of 21st century resource developments.

I look forward to seeing debate regarding these ideas.

Nick Direen
Nick.Direen@agso.gov.au

Unemployed Geoscientists

The growing number of unemployed exploration geologists and associated exploration personnel is now at alarmingly high levels following the continuing reduction in the industry's expenditure on exploration. There seems to be little expectation of the situation improving in the near future so employment outside the industry is the only alternative for many. The possibility that this valuable resource may wither with time is just too sad to contemplate, particularly in a country that boasts enormous exploration potential.

Surely the current situation is a wonderful opportunity for Federal and State Geological Surveys to employ large numbers of these experienced professionals for detailed geological mapping programs throughout our resource-rich, but under-mapped, continent. Three to five years of intense mapping would produce a wealth of new geological information and, who knows, may even uncover a few new mines, or even a new mineral (or petroleum) field. Digital databases could be developed further as well as the analysis of the enormous quantity of open-file airborne geophysical data, most of it acquired by Governments and in need of analysis.

Unemployed exploration personnel, and their families, would rejoice in being gainfully employed and would welcome the opportunity to utilise their skills and develop their careers.

Stephen Mudge
Consulting Geophysicist
vecresearch@bigpond.com



SCINTREX

SURVEY & EXPLORATION TECHNOLOGY

Scientrex Pty. Ltd and Scientrex Airborne Systems & Surveys have merged to form Scientrex Survey & Exploration Technology. Globally, we supply integrated ground and airborne geophysical services from our Perth, Toronto and Rio de Janeiro offices.



Our core technologies include:

- The best high-resolution gravity acquisition with conventional ground and helicopter supported gravity, HeliGrav™ and ocean bottom gravity.
- PDS-3™ and 3D-GM™ helicopter-borne 3 dimensional magnetic gradient.
- Ground resistivity/IP, magnetics, SIROTEM and VLF.
- Fixed winged magnetics radiometrics and helicopter EM systems.
- Scientrex developed MIP/MMR.
- Borehole logging with Scientrex/Auslog equipment.



Perth Head Office

20 Century Road
Malaga, WA 6090
Tel: (08) 9248 3511
Fax: (08) 9248 4599
email: scintrex@scintrex.aust.com

Queensland Office

PO Box 1119
Proserpine, QLD 4800
Tel: (07) 4946 1517
Fax: (07) 4946 1518
email: splqld@scintrex.aust.com

14th ASEG Conference & Exhibition Perth 2000

Conference News



Perth Conference Update

Organisation for the Perth Conference has moved into high gear. Most of the papers are in and the Technical Papers Committee, under Tony Endres, is frantically trying to complete the first programme for our Call for Registrations. Tony tells us that the technical content submitted so far is dazzling, with a much improved turn out from the petroleum sector, thanks to help from our SEG and EAGE co-ordinators, Bill Abriel and Geoff King.

Exhibition space is selling fast and Exhibition Co-ordinator, Mark Russell and the team at Promaco, are delighted that they have had to re-design the layout to accommodate more booths. The VIP suites overlooking the Exhibition and Lecture area are also proving popular for companies wishing to have a more private, hands on, display of their software and as hospitality suites.

Principal Sponsor Announced

We welcome **Baker Hughes - Western Geophysical** as the Principal Sponsor for the conference. Sponsorship Co-ordinators, Alan Sherrard and Val Baird, have also been kept busy with enquires and offers. It's great to see the resilience and foresight shown by the industry in the face of some of the leanest times on record for both the oil and minerals sectors. Although many of the plums from the sponsorship packages have been taken up, opportunities remain for recognition. Val and Alan would also welcome suggestions from sponsors on things they may have overlooked, although, if the toilet paper is again to be sponsored they insist that the green ink will have to be of higher quality than last time - or at least, stay on the paper!

Mindful of the security risk fake animals presented at the traffic-stopping dinner in Hobart, the committee have decided to use live animals only - this time, specifically lions, rhino's and zebras. Yes, we will have the conference dinner at the Perth Zoo, in their African savanna. We couldn't imagine a better place for a heard of wild geophysicists, especially those who were at the table at the back of the dining room in Adelaide, 1995. Members of the "Ferrets down your Trousers" Club will be disappointed to hear that Zoo rules preclude this activity, however, rest assured we will have something else to offer you. No, Richard Gere has not been invited as guest speaker. (see www.gerbils.com)

John Jackson is piecing together a workshop programme to limber up the brain cells prior to the conference. One of the highlights will be a round up of the past 8 years of CRC AMET (Co-operative Research Centre for Australian Mineral Exploration Technologies). If you have an idea for a workshop, John wants to hear from you.

Helen Anderson and Dom Howman are working with the WA Education Department to put together a students day to remember. Included in this, is an opportunity to spend some time educating the teachers. Helen already has

significant financial support from exploration and service companies for this day. However, more support would be welcomed to help provide the teachers with service kits they can take back to their classes.

The publicity hungry Mike McLerie and Larry Tilbury will be "in your faces" over the next few months making certain that every voting Australasian knows about the choices they must make in 2000. Their spies in Hobart tell them that a penguin answering to the name of Mawson was seen buying sun glasses, sun screen and thongs recently. Could things be hotting up down south or has he got other ideas???

John McDonald is holding the financial reins as treasurer and reportedly has a extensive library of cook books which include such delicacies as Ledger Confit, Invoice Roulade and his piece de resistance Profit and Loss a la Provencale. Our favourite though is his Balance Sheet Pudding with a light Fudge sauce.

Hope to see you all in Perth in March 2000.

*Kim Frankcombe and Mike Sayers
Co-Chairmen of the 14th Australian Society of Exploration Geophysicists Conference and Exhibition*

Conference Organising Committee

Co-Chairmen	Kim Frankcombe	9316 2074
	kfranco@ozemail.com.au	
	Mike Sayers	9263 6575
	mike_sayers@wapet.com.au	
Technical Papers	Tony Endres	9380 7329
	tendres@geol.uwa.edu.au	
Exhibitions	Mark Russell	9322 8122
	mark.russell@geosoft.com.au	
Sponsorship	Alan Sherrard	9226 0199
	alans@paradigmgeo.com	
	Valerie Baird	9226 0199
	val@paradigmgeo.com	
Students		
Co-ordinator	Dom Howman	9226 7194
	howman@geophy.curtin.edu.au	
Treasurer	John McDonald	9266 7194
	mcdonald@geophy.curtin.edu.au	
Conference Editor	Mike Dentith	9380 2676
	mdentith@geol.uwa.com.au	
Workshops	John Jackson	9263 5555
	jackson@sog.com.au	
Publicity	Mike McLerie	9263 6567
	mkm@wapet.com.au	
Social	Nick Hoskins	9445 9007
	nhoskins@gds.com.au	
SEG/EAGE Link	Bill Abriel	9263 6079
	wla@wapet.com.au	

Conference Organisers

Promaco Conventions Pty Ltd
PO Box 890 Canning Bridge WA 6153
Tel: 9332 2900 Fax: 9332 2911
promaco@promaco.com.au
Attn: Don Pearce

Telephone Prefix within Australia (08) International 61 +8.

New Software Revolutionises AEM Data Processing

Australian-developed software that will revolutionise the processing of data gathered in airborne electromagnetic (AEM) surveys was launched commercially at the Prospectors and Developers Conference in Canada during March.

The software, EM Flow, is the product of six years' research by the Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET) and is marketed by Encom Technology Pty Ltd of Sydney.

EM Flow is designed to rapidly process the large data sets produced by the new generation of airborne EM hardware, and produce conductivity maps of the sub-surface in forms that can be readily understood by explorationists. The software is applicable to all airborne EM systems, including the TEMPEST AEM system developed by CRC AMET and operated by World Geoscience Corporation Ltd, QUESTEM, GEOTEM, SALTMAP, DIGHEM and SPECTREM. EM Flow runs on any modern PC, and will complete in hours processing tasks that would take days or weeks with older software, or previously would not have been possible.

The software was developed by a group of CRC AMET researchers led by Professor James Macnae at Macquarie University in Sydney. The work was sponsored by a syndicate of Australian and overseas mining companies through the Australian Mineral Industries Research Association Ltd (AMIRA). Enhancements to the present version of EM Flow are being developed by the Centre under a follow-on AMIRA project.

The Technical Director of Encom, Dr David Pratt, said he expects EM Flow to reach a substantial export market. The Director of CRC AMET, Dr Brian Spies, said: "This new software will help build Australia's reputation as a world leader in the development of exploration software in the same way as the TEMPEST airborne EM prospecting system has established Australia's reputation in the hardware area.

EM Flow is part of CRC AMET's comprehensive software development program which included a geophysical modelling software suite, EM Vision, which has been marketed by Encom around the world since 1994. A third software package, known as AEMIT, designed for "quick look" processing of data, would be made available later in the year.

An image produced from data processed by EM Flow is available for downloading from the CRC AMET Web site <http://www.crcamet.mq.edu.au>.

State of the Art TEM is Announced

The SIROTEM Transient EM System, a wholly Australian product, was developed by the CSIRO in the early 1970's at a time when there was very little Australian made equipment. SIROTEM was designed especially to combat the difficulty in Australia related to the shielding effect of the highly conductive overburden. SIROTEM employed long delay times to be able to record the delayed signals from the bedrock due to this shielding. Geo Instruments has been pleased to be associated with this development of SIROTEM from its Mark 1 to Mark 3 Model.

It was realised for some time that the technology used in the design of the SIROTEM Mark 3 model could be improved by recent technological advances. These requirements were researched by Geo Instruments following impetus from a SIROTEM users meeting. It was suggested there that a distributed acquisition system somewhat like seismic geophone strings was desirable using multiple transient EM receiver sensors recording at the one time. Out of this was born the Array Receiver Transient EM Intelligent System. The acronym for this system ARTEMIS, also the name of a Greek goddess, is now used instead of a SIROTEM Mark number to indicate its radical departure from earlier models.

Good features of the SIROTEM technology were incorporated with a number of very up to date innovations. One is the actual measurement of the magnetic field ("B" field) as well as the time derivative of the field (dB/dt) which up until now has been the only way of measuring the transient EM response. Another innovation was to do away with cable connections. Recent investigations by Geo Instruments have shown that the cables that are traditionally used to connect receiver coils to their electronics package are in fact a source of substantial unwanted common mode noise. Hence all ARTEMIS receivers have now been designed to detect the transmitter waveform pulse remotely as a way of achieving synchronisation. Apart from avoiding this source of noise, it also means that a substantial gain has been made logistically by removing the need to deal with many cables and connections.

ARTEMIS is capable of acquiring data from up to 256 receivers at any one time. It has been designed to operate with any standard transmitter which the user possesses. Indeed a SIROTEM can be used as a transmitter only for this purpose. The receivers weigh only 7kg each and are 45cm square and 5cm thick. The bandwidth of the receivers is 100kHz, permitting measurements for a range of applications from shallow environmental to deep mineral surveys. The information recorded in the intelligent receivers is downloaded to a common PC which has the controlling software that is supplied with the ARTEMIS system. It also provides set-up parameters and quality control displays. The positions of the receivers from GPS or some other coordinate system and the position and other characteristics of the transmitter loop are also supplied to the software. Following the acquisition of data the information can be interpreted using standard software packages such as EM Vision from Encom Technology, another fine Australian product.

Further details on ARTEMIS can be obtained from www.geoinstruments.com.au.

Unsung Hero of South Australian Science Announced

Australian Science Communicators [SA] are pleased to announce that the Unsung Hero of South Australian Science in 1999 is Mr. John Mignone. The Award was presented by the SA Minister for Industry, Hon. Iain Evans, MP at the annual award breakfast on Friday, 30th the Investigator Science Centre.

Mignone is a geologist and educator who has been the driving force behind the production of the interactive information package "Resources - Working for the right Balance" which consists of a video, CD-ROM and a comprehensive book. Mr. Mignone was the author of the latter two components. The package is now in use in more than 525 schools throughout South Australia and has recently been introduced into schools in Queensland, Western Australia and New South Wales. The CD-ROM has also received recognition from overseas. A review of this kit was published in Preview 73, April 1998.

Mr. Mignone has played a pioneering role in originating working models and easy to understand presentations which would communicate the correct scientific basis of resource identification and use to teachers, students and aboriginal communities. To reach remote areas, Mr. Mignone often spends weeks living rough to ensure that all communities have an equal opportunity to access the programmes. Often his health has suffered after prolonged trips to areas with inadequate water and food supplies. The award recognises Mr. Mignone's commitment to communicating science and furthering the understanding of science in the community.

Alpha Geoscience Buys Conductivity Meter

Alpha Geoscience are pleased to announce that it has purchased an EM-31 Conductivity Meter and EM-61 Deep Metal Detector and these will be available for rental from their Sydney office. Both units have digital acquisition capabilities and are imminently suitable for environmental geophysics tasks.

For information contact www.alpha-geo.com.

Petrosys Management Restructure

Petrosys, Australia's leading supplier of geoscientific mapping and data management software for the upstream petroleum industry, has announced a change in management and a consolidation of ownership.

Effective May 21, 1999, Volker Hirsinger will assume the role of Managing Director of Petrosys and its international subsidiaries. Current Managing Director Mr. Wence Sulda will step down to pursue personal interests and will be progressively reducing his shareholding. Executive Director Michael Brumby and Volker Hirsinger will be increasing their shareholding in Petrosys.

Messrs. Sulda and Hirsinger founded Petrosys in 1984 to provide software for petroleum exploration and production. Their flagship products include the Petrosys Mapping Suite, and the dbMap database product. Petrosys have offices in Houston Texas, Adelaide Australia, and Scotland.

Mr. Hirsinger has issued a statement thanking Mr. Sulda for his contribution over the past 15 years, and emphasising Petrosys' commitment to the continuing development of its role in the petrotechnical IT market.

In a statement, Mr. Sulda congratulated Messrs. Hirsinger and Brumby on their decision to increase their shareholdings. He said "with existing management in place, Petrosys has a strong future and will continue its impressive growth rate".

Contact info@petrosys.com.au

Victorian Branch News



They did us proud! Geoff Pettifer, widely credited with transforming Preview, and Lindsay Thomas, who kept the Society's books balanced, seen with Shanti Rajagopalan, former Branch President.

Flagstaff GeoConsultants



A total exploration service, with specialist geophysical skills.

World-wide experience - all continents

Australia: Suite 2, 337a Lennox Street,
PO Box 2236

Richmond South, Victoria 3121

Phone: (03) 9421 1000

Fax: (03) 9421 1099

Email: postman@flagstaff-geoconsultants.com.au

Website: www.flagstaff-geoconsultants.com.au

Flagstaff GeoConsultants Pty Ltd (ACN 074 693 637)

Hugh Rutter	Geophysicist	Geof Fethers	Geologist
Nigel Hungerford	Geophysicist	Paul Hamlyn	Geologist
Michael Asten	Geophysicist	Ross Caughy	Geologist
Alaster Edwards	Geologist	Jovan Silic	Geophysicist

Seismic Window

Mick Micenko

Consulting Geophysicist
micenko@bigpond.com

3D Time Slices - Hands Free Interpretation

With 3D seismic data, a powerful tool is the use of time slices to provide a map view of the zone of interest. A map view can show true strike direction and indicate dip magnitude. This example is from the Carnarvon Basin, offshore Western Australia. These time slices are approximately 10 x 11 km.

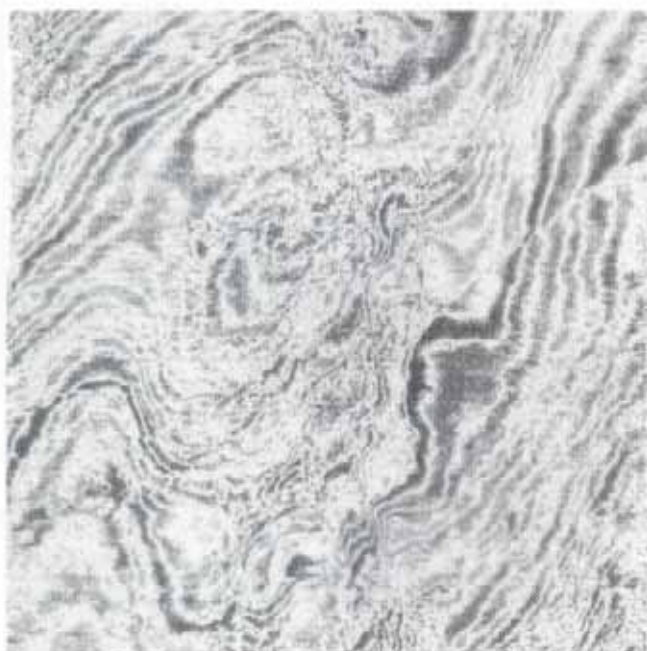


Figure 1. Time Slice.



Figure 2. Semblance Slice.


Figure 1 is a time slice showing the seismic amplitude at a constant two-way time. On this display we can see the strike direction is generally NE-SW with relatively steeper dips (indicated by the more closely spaced reflectors) in the SE and NW. There are also indications of faulting.

By also viewing a semblance or continuity time slice, we can improve the structural interpretation. The continuity display, Figure 2, at the same two-way time shows a number of NE-SW trending faults. Did you find them all on Figure 1? These faults are well focussed and were formed during a period of late Jurassic rifting. There is also a more blurry, less linear N-S trending fault that was formed in the Late Cretaceous and has significant lateral movement.

With the use of seismic time slices we have obtained a good structural story for the area before any horizons were picked.

SEG Distinguished Instructor Short Course The Seismic Velocity Model as an Interpretational Asset Phillip Schulz

Perth September 13, Adelaide September 17.
For more information, contact local branches.



**SOLO
GEOPHYSICS**
MINERAL EXPLORATION SERVICES
EST. 1975

Gravity & GPS, EM, I.P. & Magnetics
3A McInnes St. Ridleyton S.A. 5008
Tel: (08) 8346 8277 Fax: (08) 8346 0924
email: solo@enternet.com.au
Regional office: MT ISA.

Calendar of Events

1999

September 28 - October 1

South African Geophysical Association/SEG
6th Conference & Exhibition
Call for Papers

Contact: SAGA 99

93 Upper Orange Street, Oranjezicht,
Cape Town, 8001 S.A.

Tel: (27+) (21) 461 7278

Fax: (27+) (21) 461 9871

Email: nmilloyd@new.co.za

October 27-29

Second International Symposium on
Three-Dimensional Electromagnetics
University of Utah, Salt Lake City, U.S.A.
Call for Papers - 31 March

Tel: (1+) (801) 581 3547

Fax: (1+) (801) 585 3540

Email: pewanna@egi.utah.edu

October 31 - November 5

SEG Convention Houston
Call for Papers

www.seg.org/seg99

2000

March 12-16

Australian Society of exploration Geophysicists
14th Conference and Exhibition, Perth
"Exploration Beyond 2000"

Address: PO Box 890
Canning Bridge WA 6153

Tel: (61+) (08) 9332 2900

Fax: (61+) (08) 9332 2911

Email: promaco@promaco.com.au

May 7-10

APPEA 2000 Call for Papers
Brisbane, Queensland
Innovation for the Third Millenium

Call for Papers

Mr. S. Taylor

APPEA Technical Papers Committee Secretary,
Santos Ltd., GPO Box 1010, Brisbane, Qld 4001

Email: steve.taylor@santos.com.au

Other enquiries: www.appea.com.au

May 23-26

The Eighth International Conference on Ground
Penetrating Radar
(GPR 2000) Gold Coast, Queensland, Australia.

Call for papers

Email: gpr2000@csee.uq.edu.au

Website: <http://www.cssip.uq.edu.au/gpr2000>

Advertisers Index

AGSO	30
Alpha Geoscience Pty Ltd	30
ANSIR	4
Australian Geophysical Surveys	30
BA Dockery & Associates	30
Baigent Geosciences Pty Ltd	30
Bartington	IFC
Desmond FitzGerald	13
Flagstaff GeoConsultants	26
Geo Instruments	OBC, 30
Geophysical Imaging Services	30
Geophysical Software Solutions	30
Geosoft Australia Pty Ltd	5, 31
Geotrex-digham	7
GMA International	IFC
Haines Surveys	31
Hampson-Russell Software Services Ltd	17
Leading Edge Geophysics	31
McSkimming Geophysics	31
Outer-Rim Exploration Services	31
Pitt Research	31
PT Geoservices	31
Scintrex	23
SenseOre Services Pty Ltd	32
Solo Geophysics	27
Southern Geoscience Consultants	32
Systems Exploration (NSW)	32
Tesla Group	32
Third Millenium Technologies	32
Zonge Engineering & Research Organisation	29

GEOPHYSICAL SERVICES

Field Surveys, Data Interpretation, Equipment Sales, Rental & Repairs
15 Years in Australia, 25 Years Worldwide

- Geophysical Consulting
- Minerals Exploration
- Subsurface Structural Mapping
- Environmental Studies

Survey Methods:
Induced Polarization Techniques (IP),
MT/AMT, CSAMT, TEM, NanoTEM,
Downhole MMR and TEM



ZONGE

ENGINEERING & RESEARCH ORGANIZATION (Aust) Pty Ltd

98 Frederick Street, Welland, South Australia 5007

Fax (61-8) 8340-4309 Email zonge@ozemail.com.au

(61-8) 8340-4308

Offices World Wide

USA: Tucson Arizona; Anchorage & Fairbanks, Alaska; Sparks, Nevada.
Antofagasta, Chile; Rio De Janeiro, Brazil; Jakarta, Indonesia.

Website: www.zonge.com