Preview

Australian Society of Exploration Geophysicists

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FEATURES

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The cover image is part of the painting by Eugene von Guerard 1811-1901: North east view from northern top of Mount Kosciusko 1863, see article on page 17 for the story behind the painting.

AESC 2006 covered almost everything

I think the most lasting memory I will have of the Melbourne AESC Convention is the huge diversity on offer at the meeting. I could have stayed every day at Ken Lawrie's magnificent, Environmental and Geological Hazards and Risks Symposium, which covered a huge range of themes and topics and went continuously for four days from the start of Monday to the end of Thursday – even eating into the lunch break (no pun intended!). But then I would have missed the Geothermal talks, the Mineral Exploration sessions and the New Geophysical Techniques, together with special industry symposia. The four excellent Keynote speakers did a magnificent job, and my only complaint was that the outstanding Mawson Lecture took place in one of the smallest rooms, but that was a small price to pay for the overall quality and breadth of what was on offer. A typical day had 11 simultaneous sessions, as well as the posters! So we were spoiled for choice.

In this issue of *Preview* I have selected the Keynote Address by Nick Sheard and three of the presentations that I thought would be of interest. Two of these are on the Extended Abstract CD but one is not. I recommend that members have a look at the Conference Website: www.earth2006.org.au, where the short and extended abstracts from the convention are now available to view and download.

In the October *Preview* we plan to offer more coverage of the Conference in pictures. So there will be something to look forward to in a couple of months.

Perth 2007 in good shape

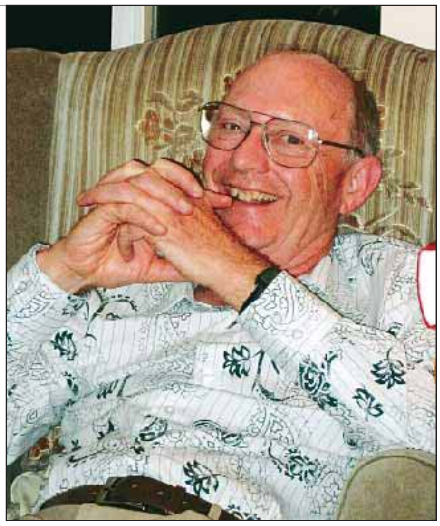
Although we can treasure our memories of Melbourne we have something very exciting to look forward to in November 2007. The ASEG and PESA will be hosting Exploration and Beyond at the Perth Convention and Exhibition Centre. Brian Evans and Howard Golden will be the Co-Chairs for this meeting, and I understand that already several of the booths at the Exhibition have been booked. It bodes well for an excellent meeting in the Resource Capital of Australia, so make sure the 18-22 November 2007 is in your diaries now.

New people working for ASEG

We would like to welcome Emma Brand from Queensland, who has joined the Federal Executive as Chairperson of the very important Membership Committee and Jennie Powell from Western Australia, who is now writing Webwaves in *Preview*. Jennie's first contribution is in this issue and I would like to take this opportunity to thank the previous Webwaves scribe, Jill Slater, who wrote this column from 2004. She moved from Perth to Adelaide to work with Santos and I am hopeful she will be able to write a few articles on petroleum exploration from time to time.

ASEG Membership

I would like to draw your attention to the Executive Brief section on our membership levels. The information was provided by Emma Brand and, as you can see, there is a slightly worrying decline in numbers - though this is nowhere near as bad as that experienced in some of the other professional societies in Australia.



David Denham

I would encourage everyone to try and attract new members. Not only do larger memberships lead to a more diverse and vital society, but also bigger numbers help to gain more sponsors and boost advertising revenue in our journals and on our website. So give some thought as to how you can attract new members.

New Website

Finally, as mentioned in Executive Brief we have a new website. Phil Schmidt has been very busy working with The Regional Institute to set this up. So have a play with the new site because Phil and the RTI need feedback on how it can be improved.

David Denham

James Reid

AESC2006 a great success

The recent Australian Earth Sciences Convention, held jointly by ASEG and the Geological Society of Australia was a huge success on technical, social and financial fronts. The final number of registrants was more than 1000, and exceeded all expectations. The success of the conference is of vital importance, as it represents our society's major source of income. Conference revenues are essential for covering the costs of publishing our journals Exploration Geophysics and Preview. On behalf of the Federal Executive I would like to thank the entire organizing committee, including Suzanne Haydon and Ray Cas (co-chairs), Jim Macnae, Ron Palmer, Mike Asten, Paul McDonald, Shanti Rajagopalan, Bob Smith, Geof Fethers, Rick Squire and Fons VandenBerg, for their excellent work over the last couple of years.

I would also like to take this opportunity to acknowledge this year's recipients of ASEG awards:

The **ASEG Gold Medal** is awarded for exceptional and highly distinguished contributions to the science and practice of geophysics, resulting in wide recognition within the geoscientific community. This year, the award went to **Art Raiche** of CSIRO Exploration and Mining. This is only the fifth gold medal awarded by ASEG, and I warmly congratulate Art on his achievement.

The **ASEG Service Medal** has been awarded to **Timothy Pippett** of Alpha Geoinstruments, and recognizes Tim's very significant contributions to the ASEG over many years, including terms as Federal and NSW branch President.

John Watt of the Geological Survey of Western Australia, and current Federal Treasurer has been awarded an **ASEG Service Certificate** in appreciation of his contributions to the ASEG at both State and Federal levels since 1995.

Lifetime **Honorary Membership** recognises distinguished contributions to the profession of exploration geophysics and to the ASEG, and has been awarded this year to **Lindsay Thomas**, current editor of Exploration Geophysics, for his involvement at both State and Federal levels over the last 36 years.

The **Grahame Sands Award** for innovation in applied geophysics has been awarded to **Duncan Massie** and **James Cull** of Monash Geoscope, for development of the TerraTEM time-domain electromagnetic instrument.

Congratulations also go to the following ASEG members, who received awards for their presentations or exhibits at AESC2006.

The **Laric Hawkins** Award for the most innovative use of a geophysical technique from a paper presented at the conference went to **Rune Tenghamn** of PGS, for his paper 'An electrical marine vibrator with a flextensional shell'.

The award for Best Paper Presentation went jointly to **Michael Roach** of the University of Tasmania/CODES ('Optimised Gravity Survey Design') and **Roger Clifton** of the Northern Territory Geological Survey ('Visualising Magnetic Depths').

Michael Hallett of the Geological Survey of NSW received the Best Poster Presentation award for his poster entitled 'Geophysical Interpretation of the Murray Basin Region, Southwestern NSW'.

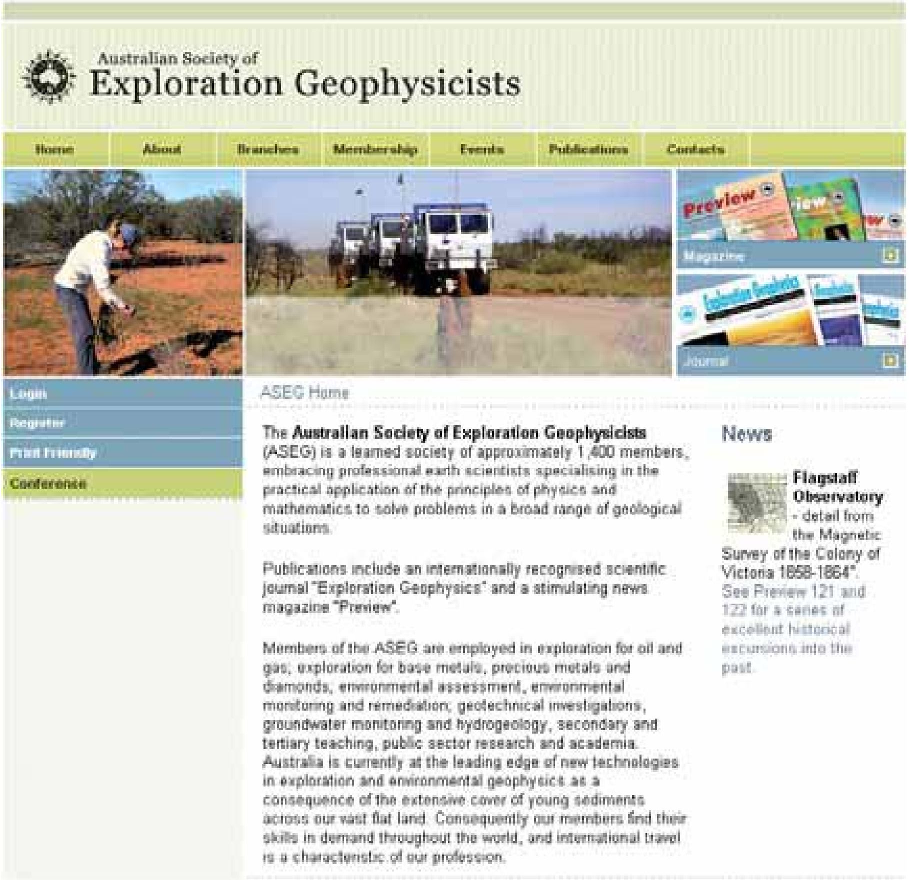
The Best Exhibit Award was won by **Veritas**.

Agreement between ASEG and the Society of Petroleum Geophysicists, India

An Association Agreement between ASEG and SPG was signed at the Inter-Society Luncheon held during AESC2006. I thank Koya Suto for his efforts in negotiating the agreement on behalf of ASEG. ASEG has association agreements with six other geophysical societies, namely the Society of Exploration Geophysicists (SEG), European Association of Geoscientists and Engineers, SEG Japan, Korean SEG, South African Geophysical Association, and the Environmental and Engineering Geophysical Society. Association Agreements foster collaboration between societies, through mutual activities such as representation at annual general, board and council meetings, promotion of and representation at technical meetings, and exchange and joint publication of journals.

James Reid

ASEG's new website



The ASEG's new website is now open. It has been developed specifically for the ASEG by The Regional Institute and has the following characteristics:

Features

The website has the following features:

- Moving the society database to a live online environment - members can update their details and renew membership in real time.
- Database can be downloaded and managed offline if required.
- Members able to join interest and/or membership groups and be emailed by State or group.
- Connection of the membership database to the E-Matters payment gateway.
- Capacity to set up and manage event registration.
- Abstract database for EG and Preview (missing recent issues).
- Flexible and scalable framework for incorporating new features.

How it works

The details of all ASEG members have been loaded into the database on the website. Each member has been assigned a unique user ID and password to enable them to login and view their membership status and access the member-only features. The different levels of membership have been programmed into the system so it differentiates between renewing and new members.

How to login

- Go to http://www.aseg.org.au
- Click the login link in the menu on the left hand side of the page.
- Go to the bottom of the form that appears, enter your email address and click the Submit button **(do not enter a username yet)**.
- You will receive a username and password in your email browser.
- Go back to the login page and enter your username and password to login to the website.

What happens then?

When you login you will be taken to a Welcome Page - the central navigation hub. There is a menu on the right hand side of the page in Site Tools and some guidelines outlining the various features. Please note that the CV module is not yet active as it is being upgraded, but will be available shortly.

Feedback

Feedback is welcome in relation to:

1. The content on the website - some of which we know needs updating by the yet to be formed ASEG web committee!
2. Your membership details - accessible when you login to the site.

Please submit feedback through the Help/ Feedback link so it can be logged in the system.

Future

In the next few months we are planning on introducing fully downloadable articles from past Exploration Geophysics issues and an Author Gateway to expedite submission, reviewing and editing of manuscripts. By the end of the year we hope the website will be developed enough to allow abstracts and papers to be handled on-line for the Perth Convention.

Phil Schmidt
ASEG Publications Chairman

ASEG Membership: can we reverse declining numbers?

Emma Brand presented some interesting numbers on membership levels at the ASEG Council meeting in Melbourne.

Figure 1 is very revealing. It shows that there has been a gradual decline in membership numbers from the last exploration boom in 1996. This decline has been punctuated by boosts to numbers after some of our recent conferences. For example, the Adelaide Conference of February 2003 and the Perth Conference of February 2000 appeared to have been very successful in attracting new members, but the Brisbane Conference of August 2001 and the Sydney Conference of August 2004 failed to arrest the declining trend. The analysis from the Melbourne meeting has still to be done, but maybe we should only hold conventions in February!

The first good news is that the decline in ASEG membership is not as great as in some other Australian professional societies, but in the US, membership numbers of the large societies like the AGU, the GSA and the SEG appear to be growing. For example the membership of the Geological Society of America has continued to increase from 1996 to 2006. In that period the total membership numbers increased steadily from 15,000 to 19,000. Over the same period the SEG has increased its membership from about 14,000 to 24,000, taken from the SEG website.

For both these societies, overseas memberships have counted for most of the increases.

The second good news is that the ASEG has a much larger percentage of active members than does the SEG. Figures 3a and 3b show the pie charts for the ASEG and the SEG and are self-explanatory.

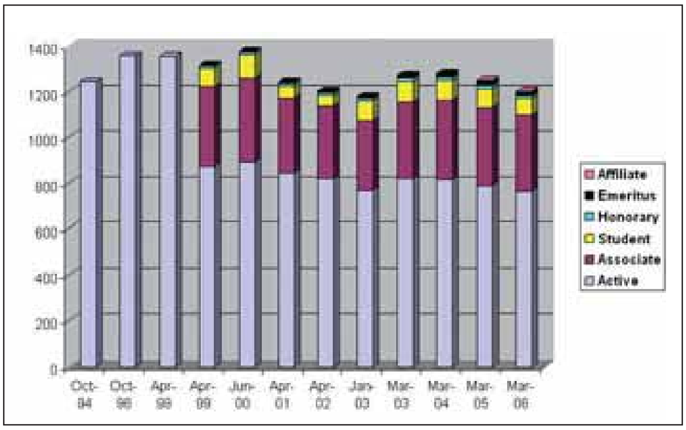


Fig. 1. Bar chart of ASEG membership from 1996-2006. Notice how the February Conventions in Perth (2000) and Adelaide (2003) resulted in significant increases in membership numbers.

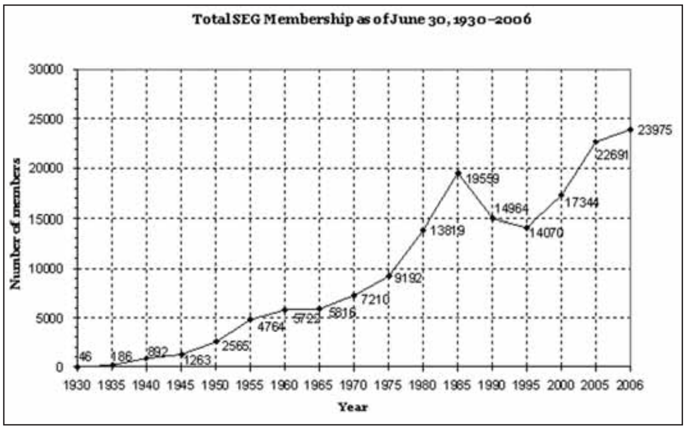
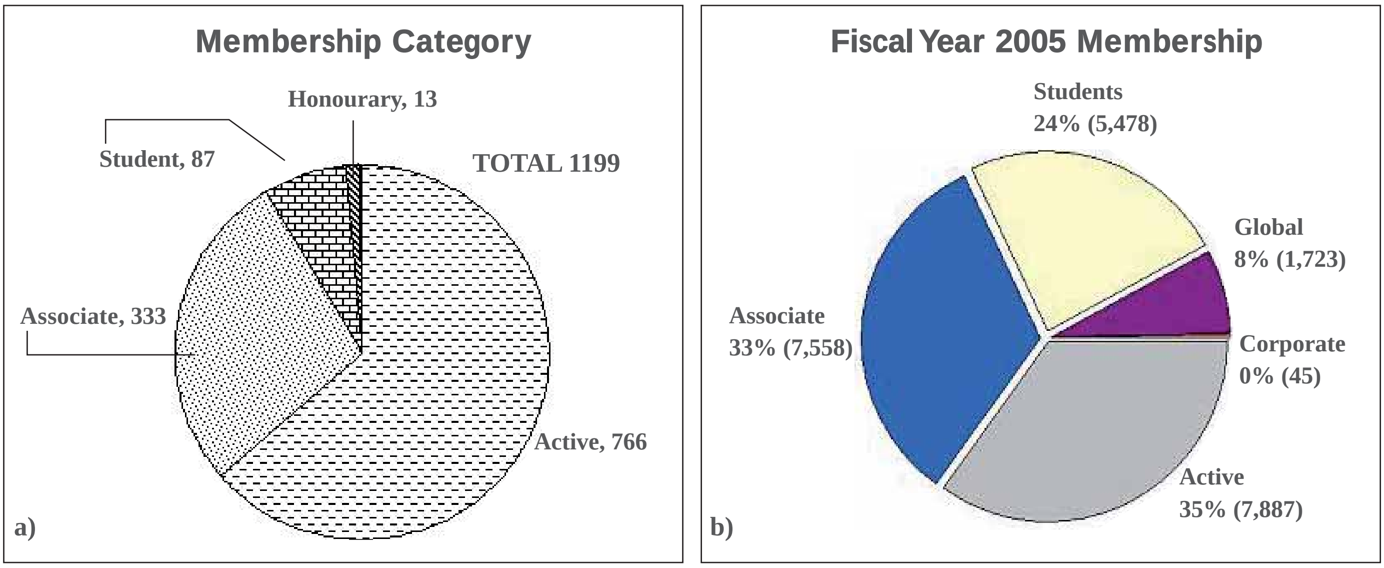


Fig. 2. Total membership numbers for the SEG from 1930-2006, taken from the SEG website.



Figs. 3a and 3b. Pie charts of membership numbers for the ASEG and the SEG, respectively. Notice how the percentage of active members is much larger for the ASEG than for the SEG.

2006

26-28 September
The Broken Hill Exploration Initiative Conference 2006
Venue: Broken Hill
Sponsored by: NSW Geological Survey, PIRSA and GA
Website: http://www.minerals.nsw.gov.au/__data/page/1267/008_2006_GS_News.htm
Contact: rob.barnes@dpi.nsw.gov.au

1-6 October
SEG International Exposition & 76th Annual Meeting
Venue: New Orleans, Louisiana, U.S.
Contact: http://seg.org/meetings/calendar

5-8 November
2006 AAPG International Conference and Exhibition
Theme: Reunite Gondwana – realise the potential
Host: PESA
Venue: Perth Conference and Exhibition Centre
Contact: www.aapg.org/perth/

2006

16-28 November
8th International Symposium on Imaging and Interpretation
Sponsored by SEGJ
Co-sponsored by ASEG, KSEG, SEG, EAGE and EEGS.
Venue: Kyoto University, Kyoto, Japan
Abstract deadline: 12 May 2006
Website: http://www.segj.org/is8/
Email: segj8th@segj.org

11-15 December, 2006
American Geophysical Union Fall Meeting
Moscone Center West, San Francisco
Website: http://www.agu.org/meetings/fm06/

2007

15-18 April
2007 APPEA Conference & Exhibition
Adelaide Convention Centre, South Australia
Website: http://www.appea.com.au/Events/AppeaEvents.asp#2007
Contact: Julie Hood at jhood@appea.com.au.

2007

21-25 May
American Geophysical Union Joint Assembly
Acapulco, Mexico
Website: http://www.agu.org/meetings/ja07/

11-14 June
69th EAGE Conference & Exhibition incorporating SPE Europec 2007
Venue: ExCel London, UK
Website: http://www.eage.org/events/

23-28 September
SEG International Exposition & 77th Annual Meeting
Venue: San Antonio, Texas, U.S.
Contact: http://seg.org/meetings/calendar

18-22 November
ASEG's 19th International Conference and Exhibition
Perth, WA
Contacts: Brian Evans
Email: brian.evans@geophy.curtin.edu.au
http://www.promaco.com.au/2007/aseg
Email: promaco@promaco.com.au

ASEG and PESA invite you to register for the 19th International Geophysical Conference and Exhibition from 18 - 22 November 2007 at the Perth Convention and Exhibition Centre Western Australia

CONFERENCE SECRETARIAT:
PROMACO CONVENTIONS PTY LTD
ABN 68 008 784 585
PO Box 890, Canning Bridge
WESTERN AUSTRALIA 6153
Tel: +61 8 9332 2900
Fax: + 61 8 9332 2911
Email: promaco@promaco.com.au

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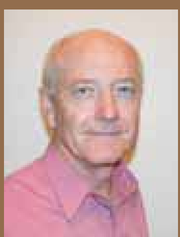
19TH INTERNATIONAL GEOPHYSICAL CONFERENCE & EXHIBITION

exploration & beyond

18 - 22 NOVEMBER 2007
Perth Convention & Exhibition Centre
WESTERN AUSTRALIA

50th ANNIVERSARY INTERNATIONAL GEOPHYSICAL YEAR

ASEG and PESA welcome you to Perth, 'heart of Australia's resources industry'



ASEG and PESA welcome you to Perth, 'heart of Australia's resources industry'. We are proud to extend an invitation to you to join us at the premier event of the year to explore technical aspects of exploration ... and beyond.

Perth is the centre of the oil and gas industry of Australia and is the exploration base for the majority of mining companies in Australia. It is Australia's sunniest capital city, sitting on the banks of the sparkling Swan River.

Perth hosts the newest convention centre in Australia, where we will hold the 19th International Geophysical Conference and Exhibition from 18 - 22 November 2007. We also invite you to come and join us to celebrate the 50th Anniversary of the International Geophysical Year in this outstanding venue.

We hope that in addition to the technical papers and state-of-the-art technologies, you will have time to visit the beaches, wineries and the myriad of other attractions which the city offers.

Come and help us examine today's state-of-the-art in exploration and tomorrow's technology at '**exploration** & beyond'.

Brian Evans and Howard Golden
Co-Chairs

www.promaco.com.au/2007/ASEG

ASEG Awards in Melbourne

ASEG Gold Medal, for exceptional and highly significant distinguished contributions to the science and practice of geophysics by a member, resulting in wide recognition within the geoscientific community

Art Raiche responding to his award of the ASEG Gold Medal, with President James Reid looking on

Art Raiche

Art is well known to virtually all of us in the mineral exploration industry for his crucial research work over 35 years in the field of electromagnetic modelling for exploration geophysics. The results of this work are the foundations for much of the EM interpretation methodology in use today.

Art commenced his career as a physicist in the US defence industry in the 1960's and completed his PhD at night. He migrated to Australia in 1970 and joined the CSIRO Division of Mineral Physics where he has remained to this day and is now the Chief Research Scientist.

He has established and worked on eight AMIRA projects involving 45 different sponsors over a 26 year period. This represents the longest running exploration project series in AMIRA's history and is the best indicator of the very high quality of his research work and its value to industry sponsors.

Art has co-authored two books, and has been either the lead author or co-author for over 100 scientific papers. He was the first to establish the theory of controlled source 3D EM modelling applicable to geophysics and he was the first to publish on time-domain EM inversion. His work on joint EM and DC resistivity inversion had a major industry impact on discovering targets that were largely invisible to either technique alone.

Art has held honorary appointments with four universities. He has been the Assistant Director of the Centre for Geophysical Exploration Research at Macquarie University has led the Mathematical Geophysics Program of the CRC for Australian Mineral Exploration Technologies. He also served on the Technical Committee of the Australian Continental Reflection Project. He has been the supervisor and mentor of numerous postgraduate students and junior scientists. He has presented invited lectures at conferences, universities, government agencies and companies in over twelve counties.

Art has made significant contributions to the exploration geophysics industry whilst simultaneously establishing and maintaining Australia's reputation in the world of mathematical geophysics. He has also contributed as an educator through his close interaction with industry geophysicists and as a result, has deservedly won and maintained industry support worldwide that is without peer in the global mineral exploration industry. As a long standing member of the ASEG, it is fitting that Art now be recognised with the ASEG Gold Medal for exceptionally and highly significant distinguished contributions to the science and practice of exploration geophysics.

Art Raiche's response

It is very kind for the ASEG to give me a medal for something that I have enjoyed doing for the past - 70 or 80 years or so. One aim of the work was to develop modelling and inversion tools to help industry extract more information from EM survey data. Of course, you can't extract what isn't there so another aim of our software was to enable users to plan surveys with increased information content. Sometimes that information is that EM won't be able to detect targets of interest in a certain type of terrane.

Software isn't useful unless it is used. Thus the third aim was to encapsulate our methods in software that could be easily used by geophysicists who were not EM experts. This of course becomes increasingly difficult due to the complexity associated with advanced 3D modelling capability, especially considering the other demands upon the industry geophysicist.

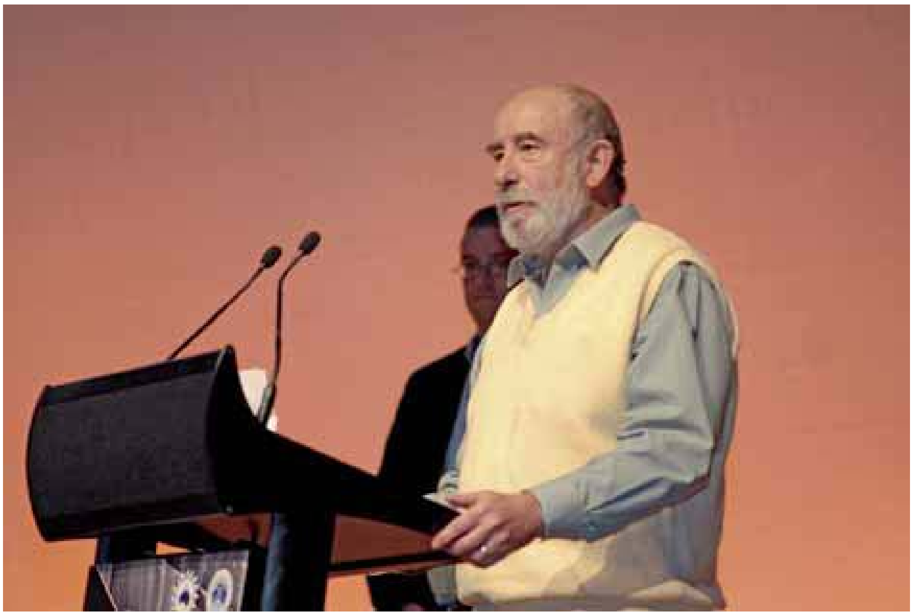
A lot has been achieved because of the contributions of so many people. Most obviously, I pay tribute to the efforts of my CSIRO colleagues both present and past. A lot of the ideas upon which our software is based have come from discussions with other researchers both in Australia and overseas.

You can't get anywhere with 2.5D or 3D modelling and inversion without an excellent graphical user environment. EMIT has done a wonderful job in the last 4 years by modifying Maxwell to allow our software to operate from within that environment. Much of our earlier work was facilitated by EMGui, developed by Encom, which also took some of our software to market through their products, EM Vision and Siroex.

Designing software is one thing. Using it to solve problems in what some industry geophysicists quixotically refer to as the "real world" is quite another. When we released software to the geophysicists of sponsoring companies, some were not at all hesitant in telling us what to do with it. We chose to concentrate on the more constructive suggestions. My industry colleagues played a large role in shaping what we produced. It was much more of a partnership rather than a researcher- client relationship which is what made it all so mentally stimulating and fun.

AMIRA has contributed substantially to technological progress in the mineral industry through their role as a broker and link between research providers and mining companies. I thank them for all the help they have given me over the past 26 years.

Having had my thirty seconds of fame, I now conclude by expressing my appreciation to the ASEG for all they have done in being a forum for the advancement of mining geophysics in Australia.



Lindsay Thomas after receiving Honorary Membership of the ASEG, with President James Reid, looking on

Honorary Membership, for distinguished contributions by a member to the profession of exploration geophysics and to the ASEG over many years

Lindsay Thomas

Lindsay Thomas is well known to almost every geophysicist in Australia, through his academic and teaching career spanning almost 40 years, and through his on-going involvement with the ASEG since its inception in 1970.

After completing his PhD research in 1968 at the University of Adelaide, Lindsay joined The University of Melbourne as lecturer in Geophysics in the Department of Geology. He continued in that role until retiring at the end of 2001. During that period he supervised numerous higher degree and honours degree students, engaged in projects in almost all areas of geophysics. Lindsay has been an icon to a generation of students, many of whom joined the ASEG and have been integral members of the society and the geophysical profession.

His research interests have included a broad range of geophysical disciplines, primarily gravity, seismic, and electromagnetic studies.

Upon retirement from teaching in 2001 he continued to maintain his interest in geophysics, through his appointment as Managing Editor of Exploration Geophysics. Since that time, he has overseen the production of almost 5 years of Exploration Geophysics journals. Lindsay's personal involvement has enhanced the academic reputation of the journal, as well as its relevance to all sectors of the geophysical community. Lindsay's efforts have also helped launch the society into new areas of collaboration with other geophysical organisations in the region, resulting in the publication each year since 2004 of the special combined Australian, Japanese and Korean geophysical journal, a publication that is regarded as a benchmark in international scientific collaboration.

Apart from his recent role as Managing Editor of Exploration Geophysics, his overall contributions to the ASEG have been outstanding. Lindsay has been involved with the ASEG since inception, and has been a member of both State and Federal committees over many years. In particular, he served as Treasurer at both the local and Federal committee levels, and has also served as Company Secretary for the ASEG, a role for which, we are told, he nearly went to jail in service to the Society, because of the tardiness of some state branches in submitting annual accounts.

The award of Honorary Membership of the ASEG is well justified for Lindsay's outstanding contributions over four decades to the teaching of geophysics and geophysical research, and for the substantial time and work Lindsay has put in, and continues to put in, to the ASEG.

Lindsay Thomas's response

I am thrilled, of course, honoured and humbled to realise that my colleagues have moved to make this gesture of appreciation. It is not though as if it has been a hard task. Since I came into Geophysics over 40 years ago, I have continuously come into contact with optimistic, innovative, pragmatic and professional people with initiative and generosity – geophysicists. Working with people like you has been a central part of my life, so I thank you for that, as well as for this honour.

Grahame Sands Award, for innovation in applied geophysics through a significant practical development of benefit to Australian exploration geophysics in the field of instrumentation, data acquisition, interpretation or theory

Duncan Massie and James Cull of Monash Geoscope, for TerraTEM

The terraTEM Time Domain EM System complies fully with this award for its innovation in instrumentation and data acquisition. It is all Australian made, having been developed in Melbourne by Duncan and Jim over the last three years. It fills the gap left by the SIROTEM Mark 3 System in providing a portable TEM system which includes a transmitter and receiver in the same package.

Using the latest advances in electronics, terraTEM employs very high speed sampling with up to three simultaneous channels for maximum survey efficiency and high data resolution. Combined with its fast transmitter

Duncan Massie, who was awarded the Grahame Sands Award with James Cull, for their work on TerraTEM

James Cull responding on behalf of Duncan Massie and himself after receiving the Graham Sands Award

Tim Pippett after receiving his ASEG Service Medal, with President James Reid still looking on

turn-off, this provides attractive new options for geotechnical and environmental surveys as well as conventional surveys for mineral exploration. Data is stored in essentially unlimited solid-state memory (as much as 500,000 soundings), making the terraTEM system ideal for rapid, near-surface surveys.

Innovations include a colour touch screen for operation and display, an intuitive graphical user interface, digital signal processing including spectrum analysis and conductivity plots in the field. An incorporated GPS receiver allows location information to be automatically recorded with the measurements. Options include use of multi-turn receiver coils, synchronisation to separate transmitters and continuous recording for moving platforms.

Data are transferred using a USB memory stick. Images can be saved and inserted directly into reports. Upgrades can be installed through the USB port from emailed files. The operational parameters are easily changed and can readily accommodate the users own requirements.

Congratulations to Jim and Duncan for another great Australian product.

Jim Cull's response on behalf of Duncan and himself

Firstly, many thanks for the nomination and the panel responsible for the award.

I am happy to accept on behalf of my colleague Duncan Massie who is unable to be present today.

As is the case with complex projects of this type, there are many others who have contributed to the development of terraTEM over many years. The basic momentum was established during an AMIRA program focused on the development of a down-hole three-component TEM probe broadly supported by the exploration industry.

The operational protocols and survey conventions developed for the resulting VECTEM probe have now been widely adopted as world standards. Our current terraTEM unit benefits from that experience and provides a world-class instrument for high definition TEM surveys. We have made a particular effort to improve the resolution at early times providing data suitable for engineering and environmental surveys. Hopefully this instrument will become a standard tool in those applications providing an imaging capacity supplementing the GPR technique.

Finally it gives me particular pleasure to accept this award in view of the fact that I was for a very short time (thanks to Norm Uren) the nominal supervisor of Grahame Sands, while he was enrolled in a PhD program at Curtin

John Watt displaying his ASEG Service Certificate with a very happy President

University (then WAIT). His personal example, energy, and enthusiasm remain an inspiration.

ASEG Service Medal, for outstanding and distinguished service by a member in making major contributions to the shaping and the sustaining of the Society and the conduct of its affairs over many years

Timothy Pippett

Tim Pippett is a very worthy addition to the illustrious list of Service Medal winners.

He has been active in the affairs of the ASEG throughout his entire 28 years of membership by serving on many committees, often at the highest level. Whenever the Federal Executive was based in Sydney or a Conference was held in Sydney, Tim was involved in some way.

As one of his fortes is in commerce, he was an excellent Exhibition Coordinator for the 1985 Sydney Conference. On the next return of the Conference to Sydney in 1991, he increased the commitment to effort by volunteering to be Conference Co-Chairman. This conference was jointly held with GSA which requires extra effort, not to mention some degree of diplomacy from the Chair in dealing with the different requirements of another society. He also worked on the committee for the next conference in Sydney in 1997.

When the Federal Executive moved away from Sydney, Tim didn't rest and served on the NSW branch committee, ultimately becoming President in 1997-99. This was followed immediately by being elected to the Federal Executive again, first as 2nd Vice-President in 1999, then 1st V-P in 2000 and President in 2001, a continuous period of 3 years at the top level.

Yet again, when the Conference was next in Sydney in 2004, Tim volunteered as Co-Chairman for another time and again it was a joint conference, this time with PESA. This conference was highly successful in all aspects and resulted in a record financial surplus.

Tim is well deserving of the ASEG Service Medal.

Timothy Pippett's response

It is a great honour to receive the ASEG Service Medal. The ASEG is a great society to belong to and it has been my pleasure to service the membership over the last 20 years in various capacities as noted. It has been very encouraging seeing the growth in the society over this time and in particular the conferences, which is where I have served on a number of Committees. The ASEG Conferences have been the premier conference in Australia for the earth scientists and have attracted a large number of international guests over the years.

I would also like to take this opportunity to add my political comments to the discussion that has been circulating regarding the possibility of merging the ASEG with another like society. I am very much against this proposal as we do have a unique society which serves our members well. What we should be considering is collaboration with other societies in a much larger way. I think the ASEG has been at the forefront of this in the past and we should continue to be so. This would include, but not limited to, conferences with like societies (such as this conference), technical meetings, Distinguished Lectures and the like. It is my believe that the society will serve its members better by continuing to be the ASEG and not to merge with another society, which will tend to dilute geophysics into the other disciplines.

Thank you once again for giving me this honour of the ASEG Medal and I hope I can continue to serve the society in the future.

ASEG Service Certificate, for distinguished service by a member to the ASEG, through involvement in and contribution to State Branch committees, Federal Committees, Publications, and Conferences

John Watt

John first joined the WA Branch as a committee member in 1995, and later served as the State Treasurer for three years. He then became the Federal Treasurer, a position he still holds after four years in the job.

He has overseen the introduction of GST in the WA Branch and the financial aspects of the transfer of the Federal Executive and Secretariat from the East Coast to the West Coast. He has also managed the finances for various ASEG courses.

In between serving the ASEG John works for the GSWA where he is always ready and willing to help those of us in the exploration industry.

John has quietly and diligently served the ASEG at the sharp end for the last eleven years and well deserves this recognition.

John Watt's response

Thank you very much for considering me for this award, I feel honoured. I have enjoyed working with the ASEG committees. Commitment, humour and great people have made it easy for me to be aligned with them.

AESC 2006, Conference Report

On behalf of the Conference Organising Committee, the ASEG and the GSA, we hope that those of you who attended the Australian Earth Sciences Convention 2006 had an enjoyable and rewarding time in Melbourne.

Over four days the convention hosted more than 1200 registered participants from 33 countries. More than 550 speakers presented their papers in 159 sessions, with up to 12 sessions running concurrently. 44 presentations were nominated for the Western Geco Best Convention Paper Award. And 100 posters were on display for the duration of the convention.

The exhibition booths were on display for three of the four days and were attended by 71 different exhibitors.

The convention dinner was held at Crown Palladium. 500 guests enjoyed a delicious meal and were entertained by our traditional Master of Ceremonies Barry Long, "Laser Lady" and "The Three Chinese Tenors".

We would like to acknowledge the people and organisations that have made the convention a success. It is the result of 2 years of hard work by a small group of volunteers on the Conference Organising Committee.

Co-Convenors – Suzanne Haydon, GeoScience Victoria and Ray Cas, Monash University;
Co-Chairs, Scientific Program – James Macnae, RMIT University and Rick Squire, Monash University;
Co-Treasurers – Ron Palmer, Diamond Geophysics Consulting and Fons VandenBerg, GeoScience Victoria;
Sponsorship – Michael Asten, Flagstaff GeoConsultants Pty Ltd Exhibition – Paul McDonald, GeoScience Victoria;
Publications and Publicity Liaison – Shanti Rajagopalan, Earth Bytes Pty Ltd;
Workshops – Bob Smith, Greenfields Geophysics;
Fieldtrips – Ray Cas, Monash University;
Industry in Action Symposium Convenor – Geof Fethers, Reedy Lagoon Corporation Ltd Convention Handbook Editor – David Denham; and
Colleen Wenn, Karine Bulger and their team from The Meeting Planners who assisted us in this task.

Of course none of this would be possible without the generous support of companies like our Platinum Sponsor, Inco and all of the other companies and organisations that have assisted us by backing the various aspects of the convention.

Platinum Sponsor – Inco
Gold Sponsors – BHPBilliton, Department of Primary Industries, Victoria and Geoscience Australia
Silver Sponsor – Veritas
Bronze Sponsors – Fugro, Geosoft, Newmont, ORE, Velseis, Western Geco, Encom, CRC-LEME and the Bureau of Meteorology
Morning/afternoon tea – ExxonMobil,
Workshop – Newcrest Mining Ltd,
Keynote Speaker – BHPBilliton,
Best Paper – Western Geco,
Farewell Drinks – Beach Petroleum.

And finally, a big thank you to the many people who helped us by agreeing to be theme convenors, session chairs and award judges, to the oral and poster presenters, and especially to the delegates.

The convention awards were presented at the closing ceremony by ASEG President James Reid and GSA President Professor Andrew Gleadow. Due to the particularly high standard of paper presentations nominated for the Western Geco Best Paper Award, six papers received an honourable mention, and the award was jointly presented to: Roger Clifton for "Visualising Magnetic Depths" and Michael Roach for "Optimised Gravity Survey Design".

The Honourable Mentions go to:
Dave Hatch, Gresley Wakelin-King, Jon Huntington, Bruce Goleby, Nick Oliver and Andrew Maddever.
The ASEG's Memorial Laric Hawkins Award for the paper presenting the most innovative use of a geophysical technique was awarded to Rune Tenghamn for "An electrical marine vibrator with a flextensional shell"

The award for Best Student Presentation went to Joanne Whelan for "The relationship between gabbros and granites in the Lachlan Fold Belt; an example from Arte River, East Gippsland". Best Poster was awarded to Michael Hallet for "Geophysical interpretation of the Murray Basin region, Southwestern NSW".

Best Poster by a Student was awarded to Anna Petts for "Nature's drillers and regional geochemical samplers; Termites and their implications for regolith geochemistry in Northern Australia". The award for Best Convention Exhibit went to **Veritas**.

We look forward to seeing you all in Perth in 2007 for the 19th International Geophysical Conference & Exhibition hosted by ASEG and PESA.

Suzanne Haydon and Ray Cas,
AESC2006 Co-Convenors

Some thoughts from the WA Scholarship awardee

As the winner of the 2006 WA scholarship, I was given the opportunity to attend my first ASEG conference. Throughout my studies at Curtin, I had been aware of the mass exodus of geophysicists from my department once a year to a place where new technology, dimensions to theories, and projects were presented and discussed. I was quite excited to participate in this event for the first time.

The 2006 Australian Earth Sciences Convention began for me with a fantastic talk by Tim Flannery regarding the Earth's climate situation. His lecture set the precedent of what would be some outstanding presentations over the next few days.

My interests lie predominately within the oil/gas sector, so I became entrenched in the Bellarine 4&5 rooms for hours listening to talks ranging from shallow gas deposits to new filtration methods and more. It was amazing to see the work being done by many in this area and the variations of results.

Aware that there was much to see in the other divisions of our field, I attended some of the talks for mineral exploration. The ever increasing role of land seismic as an exploration tool for minerals was a topic I found extremely well presented by all speakers.

Finally, the dinner on Wednesday night introduced me to the humour of Barry Long, laser-woman, opera and a bevy of geophysicists socializing until the wee hours of the night.

On my return home, I took with me a new outlook on the possibilities of geophysics, great memories, a cute little orange bag, and a great deal of exhaustion. Thank you ASEG for the opportunity to attend and I will see you all again in Perth next year.

Jennie Powell

Megan Evans joins ASEG Executive

Megan Evans is the WA Branch President and was elected as the Federal State Branch representative for 2006. Megan is currently employed as a geophysicist at the consulting company Total Depth Pty Ltd, which she joined in 2001. She obtained her BSc and Honours (1st) degrees at Curtin University, with her thesis on Time Reversal Acoustics Modelling.

Since joining Total Depth, Megan has been involved in interpretation, model based inversion, seismic consistent inversion, spectral analysis, database analysis, well log prediction, post-stack spectral enhancement and waveform classification projects on 2D/3D seismic datasets from Australia, Africa, New Zealand, Indonesia and the Gulf of Mexico.

We welcome her to Team Exec.

New Members

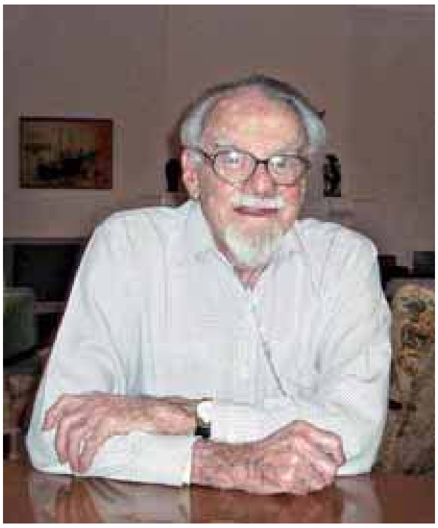
The ASEG welcomes the following new members to the society. Their membership was approved at the Federal Executive meetings on 31st May and 2nd July 2006.

Name	Affiliation	State
Christopher Bishop	Geosoft Australia	WA
Andrew James Bray	University of Sydney	NSW
Lachlan William Brown	University of Tasmania	Tas
Maxine Claprood	Monash University	Vic
Russell John Eade	Curtin University of Technology	WA
Antonia Gamboa Rocha	University of Melbourne	Vic
Lachlan Henry Gibbins	Heathgate Resources	SA
Stephen James Jestico	Resource Full Enterprises	Qld
Glyn Thomas Jones	University of Sydney	NSW
William Robert Lodwick	Fletchwick International Pty Ltd	Vic
Keith Blair McKenzie	Encom Technology Pty Ltd	NSW
Kathleen Louise McMahon	Macquarie University	NSW
Alan Michael Meulenbroek	University of Queensland	Qld
Adam O'Neill	Downunder Geosolutions	WA
Stephen Petrie	PIRSA Minerals	SA
Angela Sawiak	Chevron	WA
Jacob Adam Smith	Curtin University of Technology	WA
Ockert Terblanche	Anglo American Exploration	Africa
Troy Thompson	Downunder Geosolutions	WA
Marion Walls	BHP Billiton Petroleum	WA
Rebecca Anne Williams	University of Queensland	Qld
Putri Sari Wisman	Curtin University of Technology	WA

Jennie Powell joins *Preview* Team

I would like to welcome Jennie Powell to the *Preview* Team. Jennie will be writing Webwaves and also contributing the occasional article.

Originally from Canada, she says that she has been enjoying the Australian weather and sporting activities since immigrating three years ago. Jennie is currently completing her final year at Curtin University towards a Bachelor of Science in Geophysics with Honours. She is the Social Chair for the ASEG WA Branch for 2006 and the Student President of the PESA WA Branch. After graduation, she will be commencing her new career via the graduate program at Chevron Australia in Perth.



Obituary

Edward Burnside

Born Toronto, Ontario, Canada, 29 May 1919
Died Adelaide, Australia, 28 April, 2006

Ed Burnside was one of the unsung heroes of the Australian mineral exploration industry from early 1960's through to mid 70's, whose professionalism and management established many of the basic practices and databases still used today. Over that period, Ed was the Managing Director of McPhar Geophysics (Australia) Pty Ltd, a Canadian company which was then at the forefront of electrical geophysical exploration methods, especially induced polarisation (IP). Activities in Australia involved geophysical consulting and contracting field surveys and a range of allied geoscientific services developed locally to meet the demands of that time. From 1975 to 1983, Ed was CEO at Geoex, involved mostly in airborne geophysics, wireline logging and research.

McPhar IP crews started in Australia at the instigation of Basil Lewis, Chief Geologist of Broken Hill South Ltd around 1959. During a visit to Canada, Basil was impressed with the potential of McPhar's new age geophysical technology, in particular its application to BHS's ambitious program to reassess the Broken Hill area and other historical mining fields, seeking major sulphide ore deposits. The initial time scale was to be three years – creating a head start with this new technology before others followed, and a grid surveyed from Broken Hill into South Australia remains as one of the most extensive ever completed.

After an early career in the exploration industry in Canada, Ed, accompanied by his wife Bina, was appointed in 1961 to manage McPhar's Australian geophysical activities, then based in Melbourne. An early project in the eastern states was at Kanmantoo, based partly on proximity to good infrastructure, where a strong IP anomaly was defined over the old Kanmantoo Copper Mines, with extensions for up to 9 km. The potential of this project to develop into a mine resulted in the formation of Mines Exploration Pty Ltd (BHS 90%, McPhar 10%), and the move of Ed and Bina to Adelaide in 1964. Ed's outstanding professional expertise, management skills and personality quickly began a long list of Australian friendships within this major mining group.

By the mid-60's, mineral exploration was gathering pace nationwide at an unprecendented rate, culminating as the "Poseidon Nickel Boom". Ed, together with his Canadian management, notably the renowned geophysicist Phil Hallof, keenly sensed the opportunity to expand their geophysical services. And expand they did, not only in geophysics with the addition of several experienced geophysicists and numerous field crews, but also into allied geoscientific areas, including Exploration Geochemistry consulting and contracting, Chemical Assay and Mineralogical Laboratories, Geological and Hydrological Services, together with the necessary administration, drafting and workshop support.

The McPhar central offices and laboratories were officially opened at 50-52 Mary Street, Unley, December 4th, 1970, by Premier Don Dunstan with 85 attending guests. A major branch office in Kalgoorlie was a 'shop front' and operational base for all of these services, right in the epicentre of the unparalleled WA nickel exploration activity. Offices in Sydney included an assay laboratory, and an operational base to Eastern Australia. Offices were also established in Singapore and Manila. Staff numbers throughout Australia including professionals, field crews and support staff, were in excess of 150, and this basic structure was maintained until mid-1972, with Ed very much pivotal to the entire operation. One interesting and different venture was Ed's contribution of a magnetic survey crew to an expedition in 1972 which successfully recovered an anchor and cannons jettisoned from Captain Cook's "Endeavour" on the Great Barrier Reef.

Ed's enormous compatability and support, together with his personal interest in his staff and a wide-ranging clientel, earned him great personal and professional respect and lasting friends, one of whom recently quoted : "What a lovely guy……….one of nature's gentlemen. A mature, polished professional and yet, in a sense, a 'friendly uncle' to all who worked with him. He had a knack of "keeping his cool" under all circumstances. A first rate and, yes, jovial colleague. A good man to have at a party – a fine raconteur, with a finely honed dry wit."

Exploration activity suffered a significant down-turn around 1972 and work for the team that had been McPhar Geophysics in Australia for the previous six years correspondingly diminished. Ed however, forever the entrepreneur and optimist, resolutely regrouped the original core business of geophysics, together with several senior staff, to form Geoex Pty Ltd in 1975, where he was Managing Director until 1983. This new group concentrated on airborne geophysics, eventually owning four aircraft and flying more than one million line kilometres of survey. Geoex also became a significant manufacturer and contractor of wireline borehole logging equipment for application in the minerals and oil industries and a number of these units were sold to mining interests in Thailand and China. In addition, Geoex developed a number of electrical geophysical exploration technologies in liaison with CSIRO. After eight years Geoex succumbed to market forces, resulting in the closure of Ed's professional career, when he then retired with Bina in Adelaide.

Above all the demands of his corporate responsibilities, Ed was forever the loving and dedicated family man to Bina and their children Michael, Gillian, Kim and Margaret, always keenly interested in their many involvements, and later a great friend and mentor to his nine grandchildren. Ed will be remembered for his kindness, modest and endearing personality and for his early key contribution to the establishment of contract geophysical and related geoservices which remain very much an integral part of the current mineral exploration scene.

by Ian Pontifex FAusIMM, Keith Yates FAusIMM and Chris Haslam FAusIMM

New South Wales – by Glenn Wilson

At a well attended June meeting, Phil Schmidt presented an overview of CSIRO's OceanMAG project in the context of marine controlled source EM for oil and gas exploration, seafloor mineral exploration and maritime defence. So recent were the results Phil presented, he showed analyses from the initial marine survey data acquired from within Sydney Harbour only two days prior to the meeting.

Following the Australian Earth Science Convention in July, a technical hiatus was agreed and the NSW Branch held a social dinner at Zia Pina's Pizzeria at The Rocks. During July, Carina Simmat relocated to the WA Branch, and so resigned as NSW Branch President. Until the next AGM in February, Glenn Wilson has assumed the role of Acting President in addition to his role as Secretary.

An invitation to attend NSW Branch meetings is extended to all interstate and international visitors travelling via Sydney. Meetings are held on the third Wednesday of each month from 5:30 pm at The Rugby Club in the Sydney CBD.

Queensland – by Emma Brand

The Queensland Branch has continued with its resurgence, with a June Technical Meeting held shortly after the highly successful May Meeting. The Branch was delighted to welcome Mal Cattach, Managing Director of Gap Geophysics to present a talk entitled Sub-Audio Magnetics–Conception to Commercialisation.

Mal and John Stanley have twice been the recipients of the ASEG Grahame Sands Award. The inaugural award in 1988 was for the development of one of the first rapid sampling magnetometers, the TM-3 "Image Processing Magnetometer". A second award in 1995 was for the development of the Sub-Audio Magnetics (SAM) survey technique. It was a great pleasure to spend an hour listening to the history of SAM, from initial conception, through its development and to recent commercialization. Whilst attendance was down from the May Meeting, those who attended were treated to an excellent presentation.

South Australia – by Selina Donnelley

On June 1st, we were very pleased to have new committee member David McInnes present to us a talk entitled *Application of Geophysical Techniques for Uranium Exploration*. We had an excellent crowd of interested people – some who had not come to a meeting for years! David gave an enthusiastic and interesting talk and there were lots of questions and discussions around the bar after the meeting.

A smaller group came to listen to Dom Calandro's talk *New data and information – unearthing prospects hidden by cover: update on the SA Government's Plan for Accelerating Exploration (PACE) project… new data over key prospective regions of South Australia!*.

Wine samples have been building up ready for tasting by the SA Branch Committee. We hope to again choose two excellent wines for onselling to all Australian members – last year was a record year for this non-profit venture, and we hope this year will continue this trend! The wine tasting dinner will be held in mid-August and it is sure to be an enjoyable evening, based on previous year's experience!

The SA ASEG Branch is joining PESA and SPE in organising a fund-raising quiz night on Saturday 28th October. We hope to raise a substantial amount of money for the Royal Flying Doctor Service by holding a Quiz Night with Xavier Minnecon as MC. If you or your loved ones ever work or travel in remote parts of Australia - this is a fun way to show your support for the charity responsible for personal safety out there and remember RFDS not only provide this rural and remote service but also many Adelaide residents are flown interstate by the RFDS to a higher level of care, or to receive an organ transplant. We hope that ASEG members show their support for this excellent cause and get a few tables together. There is more information on the PESA website: http://events.pesa.com.au/ or contact Peter Boult (peter@saugov.sa.gov.au) for more information.

We thank our sponsors (especially new sponsors) for technical meetings in 2006: PIRSA, BHP, Santos, Cooper Energy, Australian School of Petroleum, Minotaur Resources, Petrosys, Zonge Engineering, Beach Petroleum, & Stuart Petroleum. We have appreciated the continued support of the South Australian Meetings.

We welcome new members and interested persons to come along to our technical meetings, usually held on a Thursday night at the Duke of York Hotel at 5:30pm. Please contact Selina Donnelley (selina.donnelley@santos.com) for details.

Websites of the Majors and how they recruit

Company websites are an integral method for a business to communicate information to its investors, employees and future employees. This month I am looking at six company websites to assess their design formats and accessibilities.

All six websites offered specialized links for their investors to all recent and archived media releases, as well as their mission statements, company values, share prices, and employment standards. Development and exploration projects were another standard module, which explained the global and regional involvement of each firm. Though the layout varied, each site had great colour schemes, graphics and fonts which allowed navigation within each page an easy task. All sites were immaculately maintained with no 'dead' links and recent postings.

(www.alcoa.com)

Alcoa is a large international company and their website accommodates its dynamic role in world economics. The main page allows you connect to any of the countries where Alcoa operates. The Australian page-link details the bauxite and refinery ventures that operate in Kwinana, Pinjarra, and Wagerup. Certain links from country specific sites return back to the main US site (e.g. the recruitment events are all in American cities).

Alcoa's environmental commitment is well documented with conservation and community investing links available. Another interesting facet is the 'Earthwatch Diaries' where staff and contractors can participate in conservation expeditions around the world and document their experiences.

(www.coalandallied.com.au)

Coal and Allied's development has been solely within the Hunter Valley, NSW. Consequently the site's focus is on a community scale with their local investments being the Rescue Service, Community Trust and the Newcastle Knights. A map of Coal & Allied's developed mine/refinery sites is the centre piece of their main page with links detailing their history in New South Wales.

Coal and Allied is a member of the Rio Tinto Group, as a result, some of the menu options are linked to Rio Tinto Coal Australia (e.g. the graduate program is run by Rio Tinto). The flow of links works well with the Rio Tinto site and is very functional.

(www.santos.com)

Santos' website incorporates an up-to-date format of business and exploration activities with the innovation of extending glossary and calculator links. The menu options extend the opportunity for investors and the general public to fully comprehend press releases and reports. The calculator can derive the value of a barrel of oil/LNG/condensate/other into other standard units (e.g. kilolitres, tonnes, KBOE) whilst the glossary clarifies oil/gas slang and abbreviations.

Another feature of interest was the career job posting where you can post an interest in a specific field on their database which remains valid for one month. Any job postings from the company that suit your selection will result in notification via email.

(www.bhpbilliton.com)

BHP has used their website to clearly explain all of their interests in the minerals and petroleum industry. They have also included a link to what BHP can offer their customers as a supplier of primary materials, which was a different element from the other websites.

An extremely useful component was the 'Job Interest' link, which allows those seeking employment the opportunity to register a job search account with the company in more of a 'Seek.com' format. When a vacancy fits the area of specialization you have listed, you are notified via email and given the option to apply.

For up and coming graduates, BHP Billiton has documented a detailed timeline of what a new recruit could expect if they were to participate in their graduate program. BHP offers both a local and international recruitment program connection.

The main page of this site was particularly functional. It is possible to register your email address for up and coming news from BHP Billion via the front page of the site. As well as, log-on via a business portal for registered suppliers.

(www.riotinto.com)

This site was superbly designed with detailed links that offered no confusion and many clear and complimentary avenues to explore. The graphics applied to this page contributed to the balance of the page's overall appearance.

As Rio Tinto functions in many primary industry fields, the Group Operations were broken into eight sectors with minimal overlap of information. The 'Library' link with multimedia files and recent articles correlated well with the Investor Information for a better overall comprehension of where Rio Tinto is going.

Rio Tinto runs an Indigenous Cadet Program where students are given vacation work, support and an opportunity for long-term employment upon the completion of studies. The intake to this program and the graduate program occurs annually via their online process.

(www.woodside.com.au)

Woodside's main page centre piece is an interactive map that allows you to learn more about any region of development/exploration for the company. Though there are clear links, the information provided is to the point and brief.

Students looking for vacation and graduate positions can register their interests via an online form and they will be notified when the company will begin accepting applications.

The website also showcases Woodside's involvement in the Indigenous Capacity Building program with a focus on studies in engineering and science. The company has also been a participant since 2002 of the Corporate Leaders for Indigenous Employment program sponsored by the Government of Australia with a focal point on employment retention.

NEUMAYER: pioneer exploration geophysicist (Part III)

Neumayer's magnetic survey of Victoria continues

To the Alps

On the 18th October 1862, two days out of Melbourne, Neumayer, on his horse Tommy with his dog Hector at his side, and his assistant Edward Brinkmann and the artist Eugene von Guérard in the "American" wagon, arrived at the foot of Mount Disappointment.

Neumayer climbed to the summit to observe and on reaching the top he was to discover that an old acquaintance, the government geodesist Mr. Petty, was already camped there. Together they observed, with Neumayer (as he had done once before) borrowing Petty's chronometer to accurately time some absolute magnetic intensity oscillations. Von Guérard sketched that day, and has left us with a historic image of Neumayer's wagon, see Figure 1.

On the 23rd October they reached Benalla, where Neumayer wrote of seeing auroral lights in the evening (he was very aware of the effects of the aurora on his observations). The following day he wrote:

"Fine pleasant morning on the 24th Station Benalla, about a mile from the bridge across the Broken River, on the road towards Wangaratta, the only available place on account of the forest. The instrument put up and adjusted. Engaged in magnetical and astronomical observations. Dense forest all round. The geological formation is Silurian. The magnetic theodolite was put up close to three large trees, one of which was marked in my usual manner."

This was a somewhat typical description from his narrative, but what Neumayer did not mention was that von Guérard was nearby sketching; leaving us with a great, almost animated, record of the moment, see Figure 2.

Geophysicist tastes some wine

On reaching Albury, Neumayer visited Mr.Thomas Twynham, the district surveyor, to firstly compare his barometers but also to obtain maps and the best routes to the high country and Mount Kosciusko. Thomas Twynham's brother, John, volunteered to assist and was accepted as Neumayer's guide.

Neumayer, at this time, took the opportunity to visit some local German winegrowers, the Frauenfelder family, and he was so impressed with what he saw and tasted, he was to again make some visionary comments:

"I paid a visit also to their cellars and was delighted with the taste and flavour of their contents which were certainly of a most promising character. It is now many years since they commenced the cultivation of the vine and in so doing I am convinced that they have opened up one of the greatest sources of the future wealth of this country."

Maybe the ASEG, with our history of wine promotion, should at some time consider labelling a nice red from the region.

There were rough mountain tracks ahead of them so the wagon was left at the Wodonga police station; travel from then on was to be by horseback or by foot. Travelling east via Tallangatta and the Mitta Mitta, Neumayer commented he was somewhat uneasy about travelling through this region, he had been warned the locals were lawless. On one evening he wrote they were *"visited"* by some men on horseback *"whom from their dress and equipment, I took to be bushrangers"* – this may have been the case, for they were suddenly to disappear into the dense timber when they noticed Neumayer was suspicious of them. We will never know.

Snakes, drunks and "celestials"

Neumayer complained of the numerous brown snakes and of the drunks who disrupted him when observing near habitations on this trip – there were active gold diggings everywhere.

On the 9th November 1862 he was to spend some time studying the geology of Little Wombat and Granite Flat diggings, which had been reached after difficult travelling through heavily timbered and steep gorges; Neumayer described it as beautiful country and von Guérard must have agreed for he avidly sketched.

"As soon as the magnetic instruments were mounted, I examined specimens of basaltic rock with a view to determine their magnetic properties. Found that they greatly attracted the magnet, while the slate lying about in no way attracted the needle."

Neumayer wrote that he twice visited the site making detailed inspections of the local outcrops. He then astronomically positioned it – the goldminer in him obviously wanted to keep a record of this place. Continuing on through the remote trackless mountains towards Benambra, Neumayer was to record *"at [a] lonely spot some celestials had fixed their tents, who were rather astounded when they saw us approaching"*; the "celestials" being Chinese[1].

The well grassed high country around Benambra impressed Neumayer and he commented that the whole region looked like gold-bearing country to him; he was also to note Lake Omeo was empty. Heading north towards Mount Kosciusko Mr. Twynham got lost trying to locate the track to [Tom] Groggin's but with some back-tracking and local help they were to eventually find it. Enroute they were to meet a lone rider, a Mr.Weston, who just happened to be the manager of Groggin's and he readily agreed to return there with them and to then guide the party up Mount Kosciusko.

On top of Kossie

On the 18th November 1862 they left three horses at Groggin's and packed Tommy with all the blankets and rations (von Guérard sketching him all loaded up) but following a long climb it was found Tommy was struggling and would not be able to make it all the way to the summit; Neumayer unloaded him and then had him well secured to a tree. The party travelled on with backpacks, reaching the peak

[1] China was colloquially known as the Celestial Empire.

the following day. Von Guérard immediately began sketching the scene from which, on his return to Melbourne, he was to paint one of Australia's finest and iconic works (Figure 3). Neumayer and Brinkmann measured no magnetic components near the summit, only barometric pressure - the wind was at such strength that they needed to climb down and observe in a sheltered spot some 40 feet below the peak and to stop the maps from blowing away Brinkmann placed them under some rocks. Neumayer determined their altitude to be 7176 feet (Figure 4).

Von Guérard, at that time sketching profusely, warned the others of a severe storm approaching from the northwest, a warning that was heeded with everyone having no hesitation in vacating the peak and heading down.

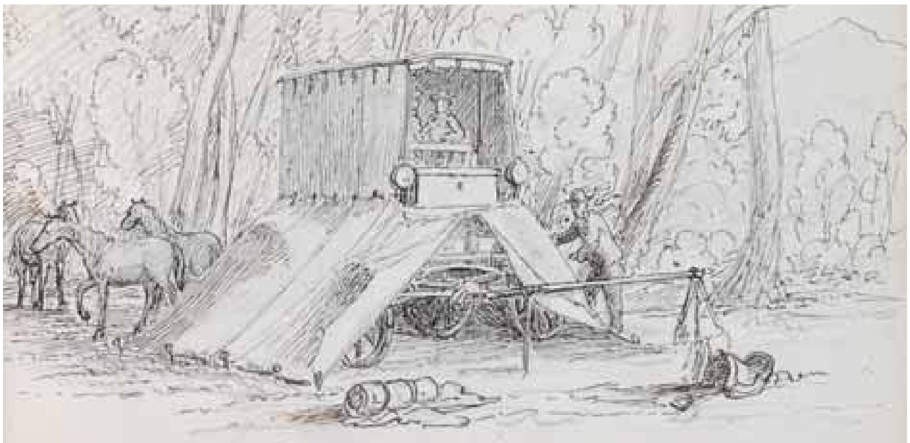


Fig. 1. By Eugene von Guérard' (1811-1901). Sketch of Neumayer's "American" wagon, 18-19th October 1862 near Mount Disappointment by Eugene von Guerard (1811-1901). For travel, some of the survey instruments were hung from the springs. Collection Dixson Galleries, State Library of New South Wales (DGB16 Vol.12 f.24).

Fig. 2. Von Guérard's sketches of Neumayer observing at Benalla 24th October 1862. Neumayer's distinctive peaked cap and three-quarter coat has lead to his identification in other sketches and paintings. Von Guérard was fascinated by the sight and span of the giant river gums. Collection Dixson Galleries, State Library of New South Wales (DGB16 Vol.12 f.27-28).

The storm and big trouble

Brinkmann, in the climb down, realised that the maps had been left near the top and, with Hector, backtracked to recover them, but within five minutes the storm hit with extraordinary force – Hector returned to Neumayer's calling but Brinkmann didn't.

Everything was by then in dense fog with temperatures freezing and in the rush to get down from the mountain and to find and release Tommy, Mr. Weston could not continue and halted, and then Mr. Twynham collapsed. Amazingly, Neumayer and von Guérard were to stumble upon Tommy in the fog, finding him terrified and appallingly tangled. They were at the time dragging Mr. Twynham between them and when they reached their camp they found it had been totally destroyed – nothing had been left standing from the initial storm front. They were in very serious trouble at this time and both Brinkmann and Weston were missing! Anxious to start a fire they, at first, were hampered as Brinkmann had the match box with him, however they were able to get a good fire going. At about 11pm Hector's barking announced the arrival of Mr. Weston – he had luckily seen the fire.

Brinkmann lost

In the morning (20th Nov 1862), Neumayer and von Guérard went looking for Brinkmann but he could not be found – Neumayer however found the maps, so Brinkmann had not even reached the summit in the storm – Neumayer seriously considered that Brinkmann may have already perished. The following day, 21st November, Neumayer diligently made his only magnetic observations on Mount Kosciusko;

"There was no chance for making any astronomical observations, the weather being too unfavourable, and only one set of observations on the horizontal force could be obtained. Horizontal Force: (2.4576). . . . . 5.3300." [cgs and British Units]

Neumayer left some provisions and directions for Brinkmann before heading down[2] – the weather was still appalling – they reached Tom Groggin's where they were to spend a day mending torn clothes, tents and damaged harnesses before then saying goodbye to Mr. Weston and travelling in teeming rain to Benambra. Neumayer tried unsuccessfully to organise a search for Brinkmann at Benambra - nobody would accompany him back – and on reaching Omeo, after officially reporting Brinkmann's demise to the police, he then offered a £20 reward for anyone to accompany him on an extended search, again no one accepted.

[2] The provisions were some time later found and used by the geologist A. R. C. Selwyn.

Fig. 3. The wind is blowing, the storm is about to hit and Neumayer is observing in Von Guérard's iconic painting: North-east view from the northern top of Mount Kosciusko. All five members of the party are shown. Inscribed "Mt. Kosciusko 19th Nov.1862 Eug. Von Guérard" but painted in 1863. Collection National Gallery of Australia.

Fig. 4. Detail from von Guérard's painting showing Edward Brinkmann, Georg Neumayer (and Hector the dog) observing the barometric pressure on Mount Kosciusko. Collection National Gallery of Australia.

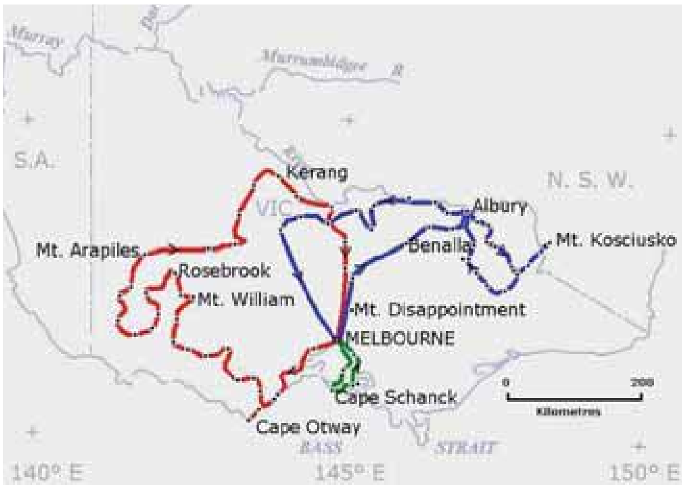


Fig. 5. Neumayer's 1862 routes to Cape Otway, the Victorian western districts and his later route to and from Mount Kosciusko. Dots represent observation locations.

On the way out of the mountains and despite his remorse, Neumayer continued with his observations and descriptions of the geology. When he crossed the numerous quartz reefs in the Flour Bag Plains area, near Mt. Hotham – he was intrigued enough to set up his theodolite magnetometer and measure both intensity and inclination across some of them.He then climbed and observed on the top of Mt. Hotham before travelling on to Bright via the many Chinese diggings;

"The industrious character of these Celestials has given quite a cheerful and homely aspect to the country, every little house having a nice garden attached to it."

A surprise – no breakages!

At every point of his journey home, Neumayer enquired on Brinkmann and on reaching the Adam's Flat diggings (near Yackandandah) on the 6th December 1862, and after further enquiries that day, he was sitting down to dinner when Brinkmann suddenly appeared, he was in *"a most deplorable condition"* having been without food for some time. Amazingly Brinkmann had come down via Thredbo, Kiandra and Albury – a completely different route. During the entire time he had been lost and then on his great walk back he carried the glass barometers on his back – and they were undamaged. Neumayer, ecstatic, and Brinkmann then travelled to Albury and calibrated these barometers. Brinkmann must have been an exceptional bushman to initially survive the storm and then get back like he did (on foot).

The wagon was collected from Wodonga and on the 8th December they continued with the survey, travelling west to Chiltern and Rutherglen, passing the *"corn fields"* to Yarrawonga and Shepparton. The travel was at this time on poor tracks that was, again, very difficult for the horses pulling the wagon. Neumayer never failed to observe and comment as he went but he was not particularly happy with his magnetic observations at this time, for he wrote in his narrative that observations were probably *"disturbed by the effect of Auroral light"*. Neumayer continued west for a while before then heading south to Sandhurst (Bendigo), Castlemaine and Melbourne, an end to a historic trip with travel of about 1400 kilometres and 30 observed mag stations (Figure 5).

The legacy

In addition to Neumayer's observations and narrative[3], the great surviving record from this trip is Eugene von Guérard's sketchbook and his later inspired paintings – a wonderful legacy. Von Guérard's sketchbook with over seventy pencilled scenes is held at the Dixson Galleries, State Library of New South Wales and his historic paintings are spread and treasured at various Australian galleries. They are important colonial records.

(to be continued)

[3] Portions of Neumayer's narrative describing the Kosciusko events are included in Tim Flannery's 1998 annotated anthology The Explorers.

Does integrated exploration add value? Dispelling popular myths[1]

Nick Sheard answering questions after his keynote address

Nick Sheard
VP Inco Exploration
nsheard@inco.com

1 This article is an edited version of Nick Sheard's keynote address at AESC 2006.

Exploring the Myths

Unfortunately, today's mineral industry suffers from past pessimism. This pessimism is largely based on flawed myths. I am going to explore some of these myths, dispel them and show that investment in integrated exploration adds real value.

Myth 1

"Investment in mineral exploration has declined principally because the returns have been so poor, and that we can only expect investors to return when performance improves."

Consider two types of investment:
- Exploration budgets – an investment in discovery and organic growth, and
- The Share Market – a direct investment in companies.

Exploration Budgets

In the past four years exploration budgets have not declined but have increased across most of the mineral commodities. Figures 1 and 2 show the increases in both exploration investment and commodity prices globally for copper, nickel and gold. Notice how responsive the exploration investment is to commodity prices, particularly for copper and nickel. The numbers indicate a dynamic industry that is not lagging behind market forces.

Clearly the global exploration expenditure on gold tracks the price of gold.

Share Markets

I need go no further than the Australian Stock Exchange and a speech by Tony D'Aloisio, in October 2005. He made a number of key points:

"The ASX and the mining industry have a long and rich history working together. The ASX owes its existence to Australia's mining heritage."

"Miners are a resilient lot. Over the last two financial years there has been only eight delistings of junior mining and resource companies. In fact mining represented only 8% of all delistings, yet mining companies represented 40% of all IPOs over the same period."

For the 2004/2005 financial year the Bell Potter Survey reported that the average earnings for industrials gained 13.3% while resource companies increased by a massive 71.4%. Investors have returned in droves (see Figure 3). In fact from July 2003 to July 2006 the market capital of the resource companies in the top 150 companies in the ASX has more than doubled to over $225 billion. Not a bad result at all.

Clearly, investment in mineral exploration has returned, exploration budgets have expanded and listings of new companies have increased dramatically. This increased investment is tied to metal prices not performance.

So the key question becomes: ***Will this bring success?***

Myth 2

"A number of studies of mining companies have concluded that mineral exploration has been a consistent destroyer of shareholder value fro the last 15 – 20 years."

The facts are that:
- Many companies have profited from exploration success,
- All mines are built on discovery (at some time),
- Many companies have failed or gone bust – not just mining companies,
- Small discoveries can lead to continuing wealth through exploration
  - Continued addition to reserves/resources
  - e.g. discovery of new mining camps
- There have been significant discoveries in the last 15 years.

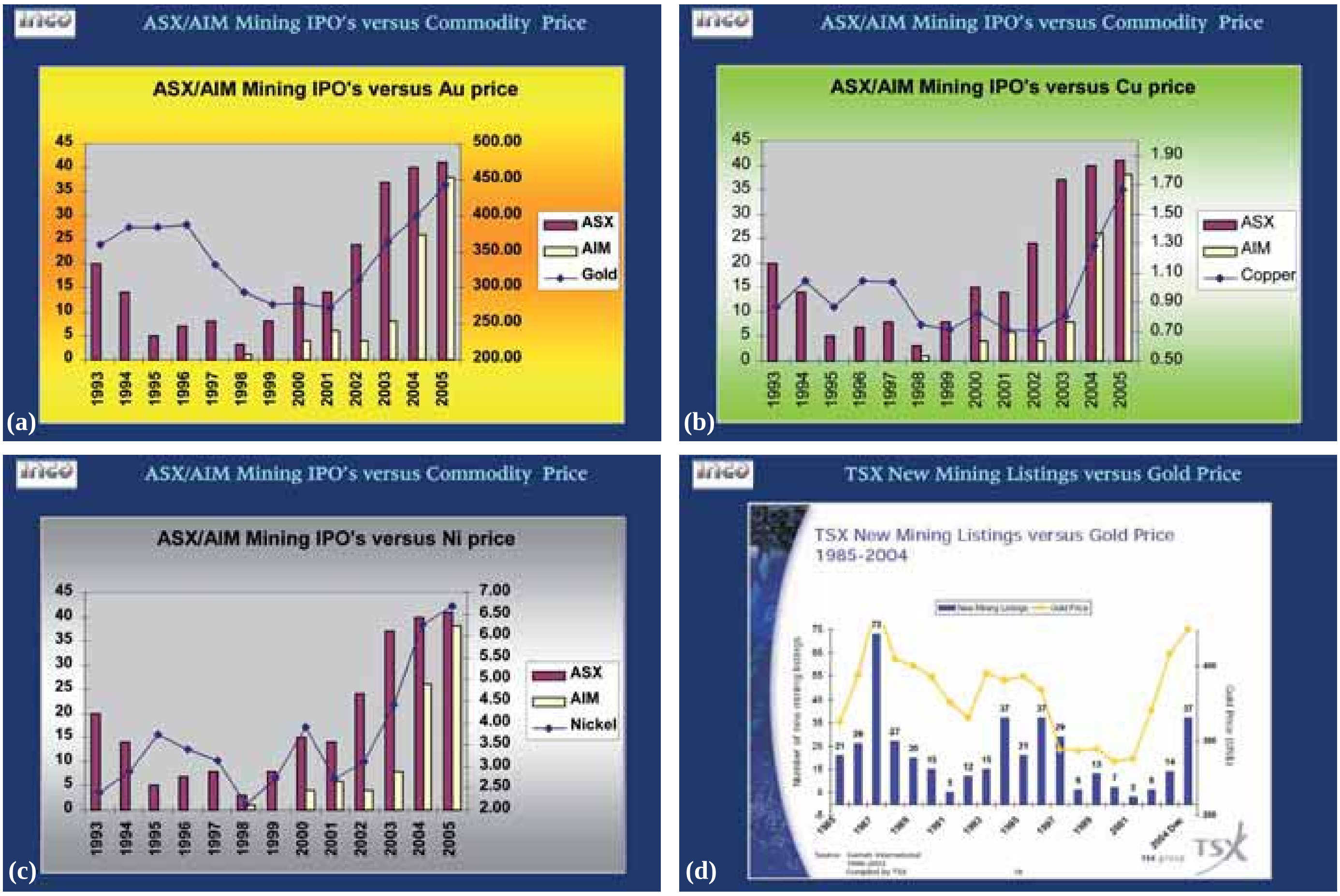
Let me give you a Canadian example of generating profit through exploration success at the Thompson Nickel Mine in Manitoba

Thompson Mine was discovered in 1956 by drilling an airborne EM anomaly. The historical resource was listed in 1956 as 25 million tons at a combined copper-nickel grade of 3.0%. The first production was in 1959 and commercial production started in 1961.

After 45 years of mining the following were listed in the 2005 Inco Annual Report:
- Reserves
  - Proven and probable 25 Mt @1.94% Ni and 0.13% Cu
- Resources
  - Measured and indicated 4 Mt @ 2.4% Ni and 0.14% Cu
  - Inferred 30 Mt @1.0% Ni and 0.1% Cu

Fig. 1. Copper and nickel prices and global exploration expenditure for 1996-2005.

Fig.2. Gold exploration expenditure and the price of gold from 1996-2005.



Figs. 3a-3d. ASX/AIM Mining IPO's (Initial Public Offerings) versus commodity price for gold, copper and nickel, and the story from Canada

In other words, exploration in the vicinity of the mine has maintained the reserves and increased the resources while about 100 Mt of ore has been mined (from 1959-2005) and 2.3 Mt of nickel has been produced. Figure 5 shows a current longitudinal section at Thompson Mine where the grey area is mined out and the potential new resources and recent intersections are noted.

Put another way, from 1959-2005 US$20 billion in value has been produced (using an average price for the last 10 years of US$3.84/lb in today's $s and the cost of discovery in today's dollars was ~C$0.93/t.

Elsewhere in the district, by 2006, continued exploration has discovered an additional 100 to 200 Mt in what we would call a historical resource category at 0.6 -1.0% Ni in separate deposits. Figure 6 shows the current model for the Thompson Mine with the location of these ultramafic hosted deposits.

We therefore have a situation where there are more reserves/resources now than there were at the start of the mine, and the mine life has been extended considerably. Of course Thompson Mine is not unique; Roxby Downs, Broken Hill and the Super Pit at Kalgoorlie are Australian examples of where brownfields exploration has been very cost effective.

Mineral exploration is considered the equivalent of R&D in the Pharmaceutical Industry; both are undertaken with the aim of continuing growth.

The table below gives a simple indication of some similarities in these industries:

The analogies do not stop here. The most successful pharmaceutical companies are those that invest heavily in R&D and similarly the mining companies that invest the most in exploration are, in the main the most successful (see Figures 7 and 8).

Obviously R&D is seen as a creator of wealth in the pharmaceutical industry. Perhaps we should be more serious in the mining industry to increase our investment in exploration – particularly in the unexplored greenfields areas.

It is good to know, however that the world's biggest miner BHP Billiton together with many other major – mid-tier mining houses clearly focus on exploration. The BHP Billiton 2005 annual report states:

"Our exploration programme is integral to our growth strategy and is focused on identifying and capturing new world-class projects for future development, thereby securing options fro the long term – value creation."

Myth 2 implies that there have been very few discoveries in the last 15-20 years.

Is this true? Well for Nickel it most certainly is not, and Figure 9 indicates where the recent successes have occurred.

Unfortunately we are threatened by Doomsday Merchants and have all heard the statements like "Exploration destroys share holder value" emanating from the financial analysts. These words lead frequently self fulfilling prophesies. So we get:

- Reduction in exploration budgets
  - Particularly greenfields budgets
- Reduction in explorers, loss of skills and experience
- Reduction in university geoscience entry

Importantly this results in reducing the chance of discovery

Furthermore, the chances of success must be diminishing. The large easy ones at or near the surface have been found. We have to look deeper and we have to look under cover, so the cost of success is increasing. Fortunately the exploration technologies are improving and the current commodity prices are able to support these cost increases.

Mineral Exploration	Pharmaceutical R & D
Project generation – find project	Decide what disease to cure
Ensure it would be profitable	Confirm it would be profitable to do so
Analyse previous work	Analyse previous work
Explore the ground	Design and make new drug
Drill – nothing found	New drug does not work
Start again	Start again
Drill successfully - start feasibility	New drug works – clinical trials
Time frame 7-10 years	Time frame 7-10 years

However to be successful we need steady exploration budgets that reflect the long term requirements of our industry. This will allow not only consistent near mine exploration but feed Greenfield exploration programs, which produce the successes and "camp makers" of the future. Without Greenfield exploration our resources will diminish too rapidly.

To succeed at a technical level we need an integrated geoscientific approach that does not rely on one method or system. We need new or different approaches in mature terranes if we are going to discover the deposits that have eluded us before.

Companies need to use their strengths to flourish. For example the major explorers with good cash flows have the luxury of a longer timeline and the use of in-house technical resources. They should define new technologies or new genesis models to establish new terranes. They need to explore in their own right, but also to work closely with Juniors to maximise their zones of influence and take early advantage of Junior discoveries.

Juniors, on the other hand, only have a short time frame. They are living for the here and now. They have to be able to mine small deposits and also to strike alliances with other explorers. Their exploration strength is their speed but they should use the support of Majors to tap into their financial, data bases, and technical strengths.

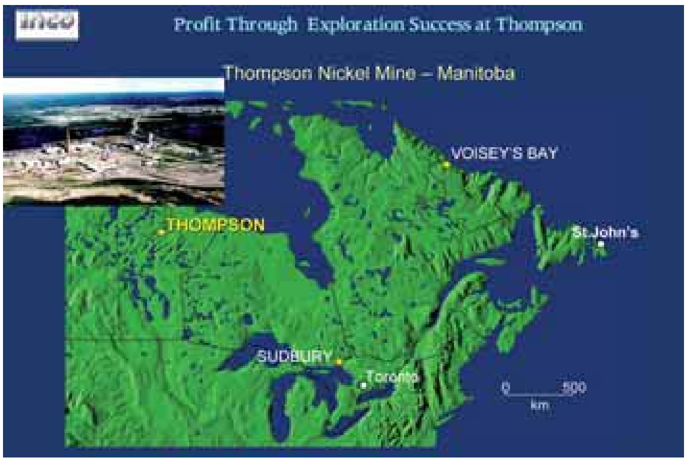


Fig. 4. Location of the Thompson Nickel Mine.

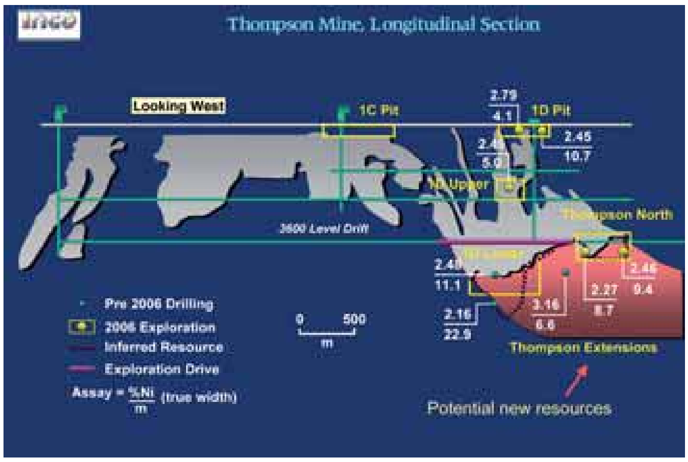


Fig. 5. Longitudinal section at the Thompson Mine, looking west. The grey area is

Exploration success

Exploration success will come through a persistent integrated approach. One has to be bold and take some risks to have any chance of substantial rewards. I would therefore like to conclude with a case history of the Reid Brook Zone at the Voisey's Bay deposits. It provides another excellent example of how exploration in the vicinity of a known deposit can lead to further significant discoveries.

Figure 10 shows where the Reid Brook Zone is located with respect to the other deposits.

Figure 11 shows the interpretation of the Reid Brook Zone in 2003. The initial interpretation was based on wide spaced drilling and the sulphide was interpreted as trending parallel to the dyke. Figures 12-16 show the result of more recent drilling. The results indicate a more complex structure and of course, a more extensive and valuable resource.

The exploration work at Reid Brook has shown that both persistence and importantly the challenge of old ideas and the willingness to embrace new thoughts using the same data have provided Inco with a major new discovery that importantly will add many years of mine life to Voisey's Bay.

Conclusions

The two myths:

1. We can only expect investors to return when performance improves, and
2. Exploration destroys shareholder value

Both are flawed.

Investment, in exploration and companies, has increased largely due to commodity price improvements.

Deliberately focused integrated brownfields work is where the fast gains are to be realised.

Greenfields successes have occurred and will continue, if we provide the appropriate investment. Both the risks and the potential rewards are higher in these terranes.

And remember the explorer's prayer:

Dear God
Let there be another minerals boom –
I promise not to blow it away this time
We are here now
Lets not stuff up this one!

Acknowledgements

In preparing this article I would like to thank my co-workers at Inco Exploration – who make me look good through their continuing successful exploration exploits.

Special thanks to Cameron Bowie, Charlene McCooeye and Barry Satchelle.

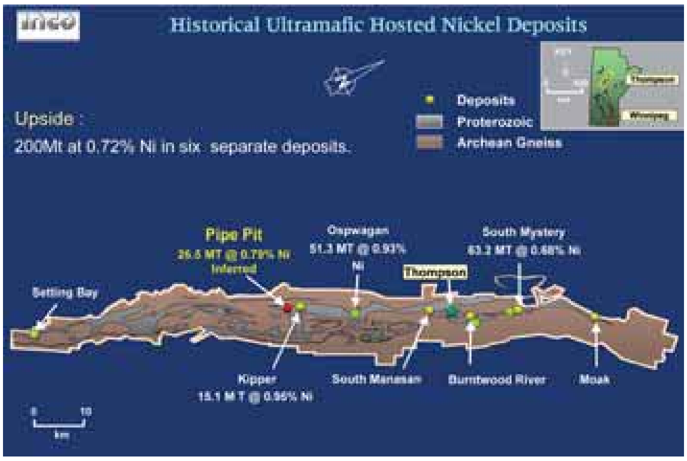


Fig. 6. Location of ultramafic-hosted historic resources.

Fig. 7. Exploration budgets in 2004/05 for the top 25 mineral companies.

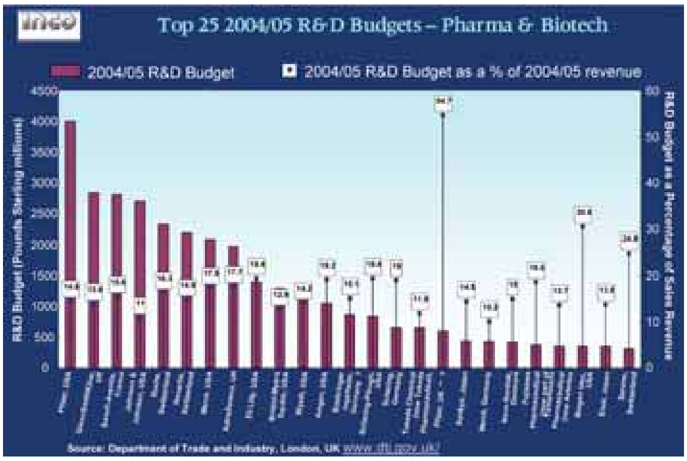


Fig. 8. R&D budgets for the top 25 pharmaceutical and biotech companies.

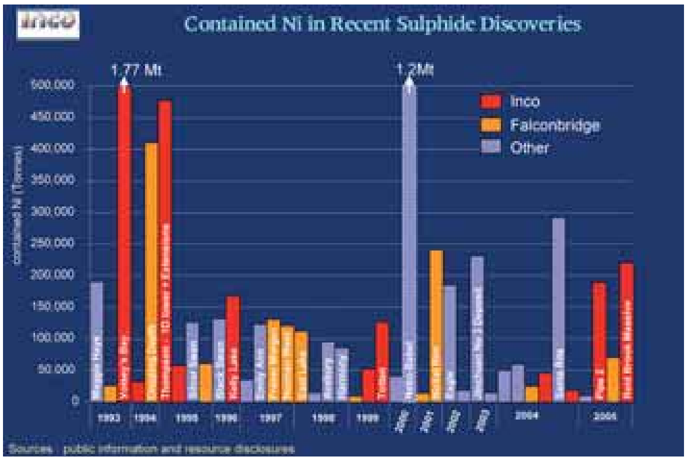


Fig. 9. Contained nickel in recent sulphide discoveries.

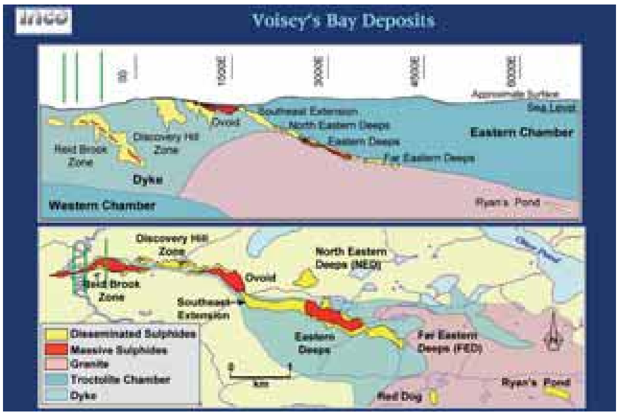


Fig. 10. Voisey's Bay deposits in section at the top and in plan at the bottom.

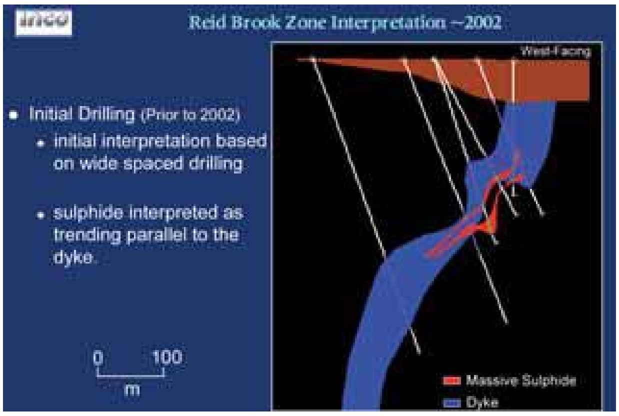


Fig. 11. Interpretation of the Red Brook Zone in 2002.

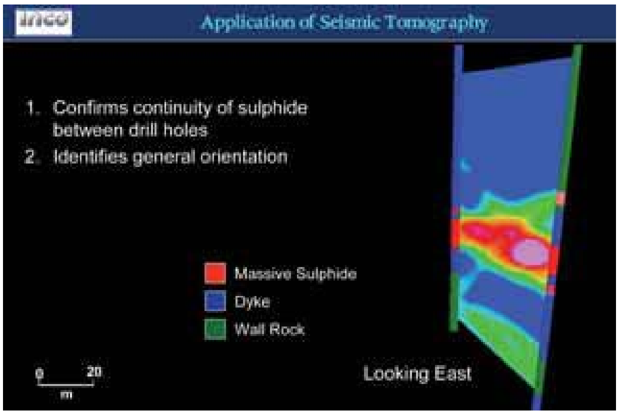


Fig. 12. Initial cross-hole seismic tomography between two holes at Reid Brook. The hotter colours are lower velocities which represent massive sulphides.

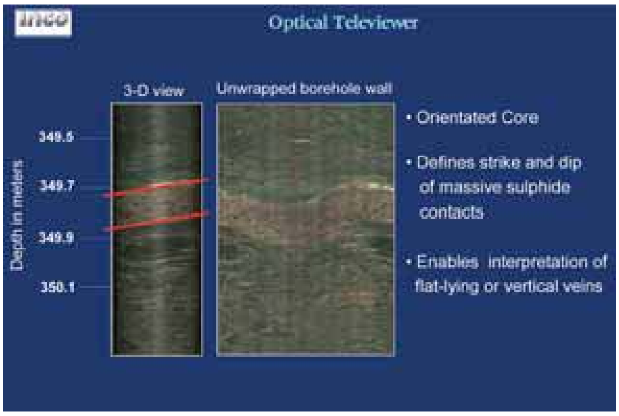


Fig. 13. Results from a downhole televiewer at Reid Brook. Note that the 3D view is a computer generated core.

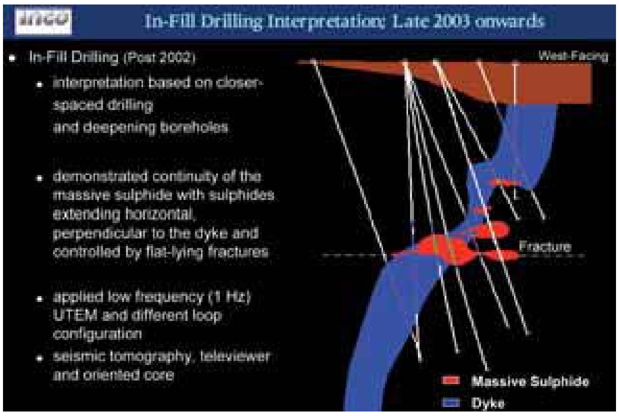


Fig. 14. In-fill drilling results at Reid Brook which confirmed the potential of this discovery.

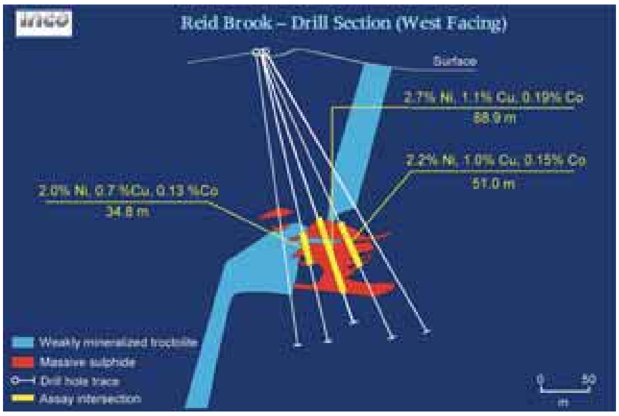


Fig. 15. Drilling results at Reid Brook showing true thickness and grade from the new drilling.

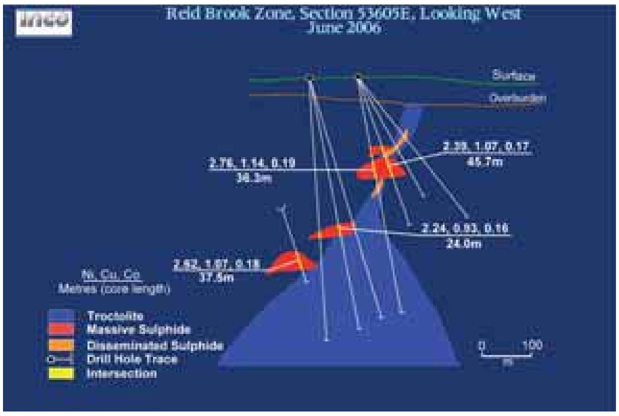


Fig. 16. Results and interpretation from the 2006 drilling showing the potential duplication of the shallower mineralisation at depth.

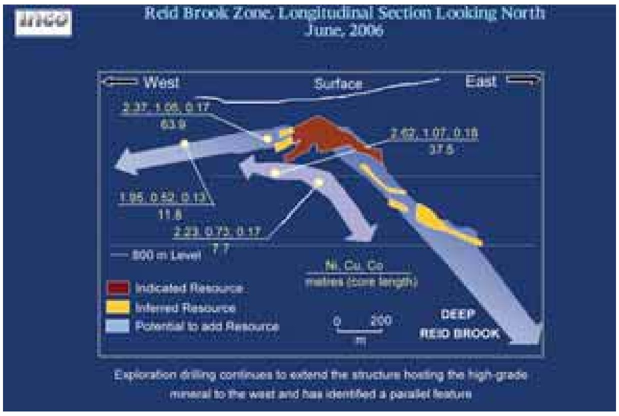


Fig. 17. Longitudinal section at Reid Brook, indicating the potential to add resources with continued exploration

Michael Hatch
michael.hatch@adelaide.edu.au

[1] *CRCLEME/ University of Adelaide*

[2] *Australian Water Environments*

[3] *CRCLEME/CSIRO*

[4] *SA DWLBC*

Fast-sampling surface EM in the Riverland of South Australia[1]

by Michael Hatch[1], Andrew Telfer[2], Graham Heinson[1], Tim Munday[3] and Volmer Berens[4]

Summary

To date, our ability to measure and locate saline groundwater entering the Murray River has been limited to near-surface, low-resolution techniques. Current methods include the combined use of Run-of-River Surveys and fixed salinity pontoons that directly measure river salinity from which the location of salinity hotspots are inferred. Fast-sampling TEM techniques offer a rapid, accurate way of increasing data density in the river environment, providing information on river sediment salt load. This information then informs catchment managers directly about saline hotspots, and importantly, geological variation that can influence the discharge of saline ground water into the river. In this paper we show examples of data from in-river, fast sampling, TEM surveys linked to similar data acquired from adjacent floodplains and highland areas in the Riverland of South Australia and discuss their role in monitoring salinity along the River Murray.

Introduction

While the amount of saline ground water presently entering the Murray River has lessened over time due to the introduction and adoption of improved irrigation practices and the construction of Salt Interception Schemes (SIS), there is still a large amount of this salt water still "in the system" that has not reached the river yet. Ultimately this will affect both irrigation and drinking water quality over the next ten to twenty years . The Murray Darling Basin Commission (MDBC), South Australian Department of Water, Land and Biodiversity Conservation (SA DWLBC) and the Mallee Catchment Board, among many others, are working to locate areas of significant salt accession in the river and nearby floodplains. The aim is then to mitigate the entry of this water into the River Murray system and manage floodplains for improved environmental health.

Recognition of areas that contribute salt to the river and floodplain and the subsequent design of programs to mitigate these sources before they have a chance to affect the river ecosystem require the integration of a large amount of hydrogeological information from a variety of sources (Telfer *et al*., 2004). The most effective methods for measuring instream salt loads have included South Australia's combined use of Run-of-River surveys and stationary salinity pontoons along the river. These pontoons are placed at nominally 10 to 20 kilometre intervals along the river and allow the monitoring of day-to-day salinity variations. Run-of-river surveys (ROR) have provided arguably the best in-stream information about salt flux into the river. In 1985 the SA Department of Water Land and Biodiversity Conservation (DWLBC) ran the first of approximately forty ROR surveys . ROR surveys measure river-surface salt variation at approximately one kilometre intervals from specially equipped boats during low flow conditions and extrapolate back to source locations . The resolution achieved with ROR surveys (i.e. approximately every kilometre) has been detailed enough to locate and help design the existing larger salt interception schemes. However, the method does not provide resolution at the sub-kilometre scale, which is becoming more important because the remaining salt sources tend to be smaller and more localised (but still quantitatively important). In addition, the existing methods lack resolution when reviewing the performance of individual wells in an existing SIS.

Electrically based geophysical techniques have the potential to provide higher resolution information that can fill in some of the gaps left by traditional salinity detection techniques. In the river systems of the Murray Basin low salinity river water and much of the background geology is relatively resistive, and saline groundwater, and clay units are generally quite conductive.

Zonge Engineering ran its first line of fast-sampling transient electromagnetics (known as NanoTEM) for Australian Water Environments in 2001 at the Bookpurnong Irrigation Area, near Loxton SA. The ground-based NanoTEM was then adapted for in-stream work (Barrett *et al*., 2005), initially to review the performance of the Waikerie SIS borefield. The successful implementation of the land and in-stream NanoTEM systems brought these techniques to the attention of the hydrogeological community as potent new tools to help characterise the river and floodplains. This has led to the system being used to collect at least 200 line kilometres of ground based NanoTEM and well over 1000 "line" kilometres of in-stream NanoTEM in the Murray Basin. An additional 900 line kilometres is planned.

Figure 1 is a mosaic of Landsat TM satellite images of part of the Murray Basin, between Lake Alexandrina in South Australia to the Mallee Cliffs region in Victoria (MDBC's Basin-in-a-Box, 2002), with much of the NanoTEM data collected since 2001 overlain on the image. The data have been inverted to resistivity-depth sections and depth slices of the inverted data at particular depths prepared. For the instream NanoTEM a pseudocoloured "ribbon" depth slice of the complete data section that corresponds to the resistivity of the sediments directly under the base of the river is shown. This is the area of at least first interest when looking for conductive hot spots under the river. For the land based NanoTEM the displayed data is the 10-metre depth slice.

[1] *Extended Abstract of paper presented at the AESC 2006 in Melbourne.*

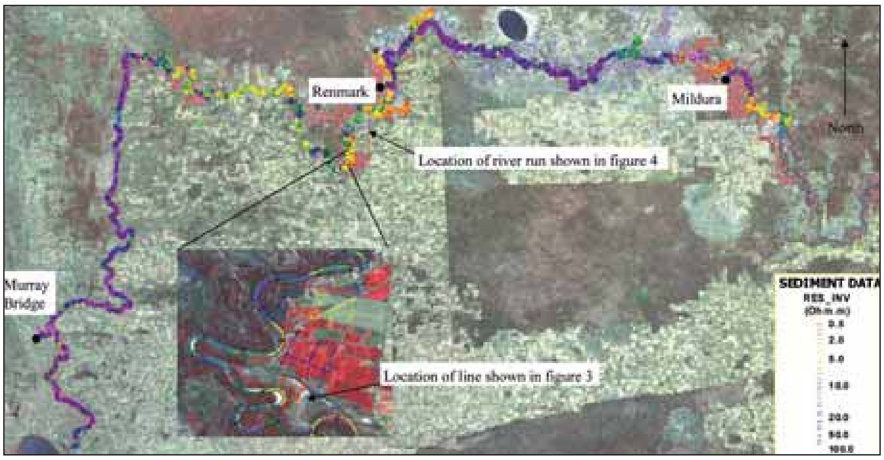


Fig. 1. Overview of fast sampling TEM data collected in the Murray Basin. All instream data are contoured EM resistivities at the bottom-of-the-river / sediment interface. All land-based data are contoured at a depth of 10 metres. Inset shows detailed view of land data collected in Bookpurnong area since 2001. These data are presented courtesy of MDBC, Mid Murray LAP, SA DWLBC, CSIRO, NSW DIPNR, and the Mallee Catchment Board.

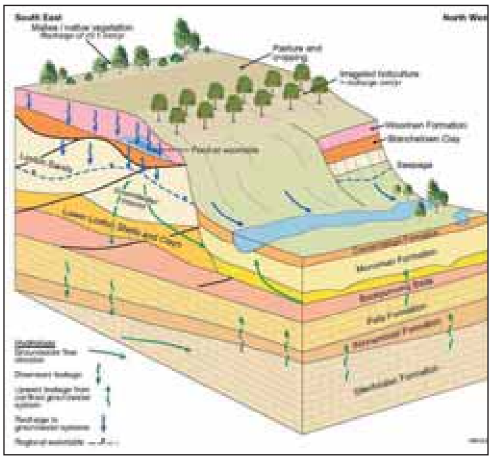


Fig. 2. Schematic outline of the geology of the Murray Basin at Loxton, (Munday, et al., 2005).

Hydrogeology of the Murray River

The overall hydrogeology and hydrostratigraphy of the Murray River Basin is well documented, so will not be described in great detail here. Lukasik and James , Telfer *et al*. and Munday *et al*. all provide more detailed overviews of the underlying hydrogeology.

Figure 2 is a schematic representation of the stratigraphy of the Basin near Loxton, SA. For the purposes of this paper (and much of the ongoing salinity research in the Murray Basin) the units of major interest are the near-surface Coonambidgal and Monoman Formations on the floodplain and the Blanchetown Clay, and the various units making up the underlying Loxton Formation on the highlands. On the floodplain, the Monoman is for much of the river the main "aquifer" unit immediately adjacent to the river. The overlying Coonambidgal is a clay unit that exerts a significant influence on the rate of evapotranspiration across the floodplain. On the highland the Loxton Sands is the major aquifer adjacent to the river system. In the highland areas, the Blanchetown clay plays an important role as an aquitard, influencing the rate of groundwater recharge from irrigation and rainfall across the region.

Methods and results

Transient electromagnetic techniques were originally developed for use in the mining industry to image electrical contrasts to depths of 100's of metres. These techniques provide excellent information about the location of conductive units (ore bodies) beneath the surface of the earth, albeit with limited near-surface resolution. Recent improvements in transmitter turn-off time and sampling rate have vastly improved resolution of the top 20 metres below the Earth's surface making fast-sampling TEM a very useful tool for characterising the earth for salinity surveys.

TEM techniques generally use an ungrounded loop on the surface of the Earth to induce a rotating electric current in the earth (and an associated vertical magnetic field). On turn-off of the electric current in the wire these primary fields collapse and drive a set of secondary fields in the earth that can be measured in the centre of the loop with a magnetic antenna. The secondary electric field starts near the loop at the surface; then rapidly travels away from the surface into the earth. The "receiving antenna" is set to measure the strength of the resulting magnetic field at discrete intervals after turn-off (i.e. the decay of the magnetic field with time). The rate of decay changes depending on how the field interacts with materials in the earth. Generally, faster decay is related to resistive earth, slower decay is related to conductive earth. A more complete explanation of this type of system may be found in many geophysical textbooks; see, for example, Parasnis .

Zonge Engineering's NanoTEM system is a variation on the original mineral exploration application that increases the resolution of the system by using much smaller loops than the mining systems and measuring the decay very quickly after turnoff of the transmitter and then sampling much faster. The system is designed to take data from within one to two metres of the surface down to a depth of 20 to 50 metres . Note that all of the TEM data shown in this paper have been inverted using Zonge's STEMINV program . Depth sections have been contoured using either Geosoft or Surfer. In all cases reds indicate conductive ground while blues indicate resistive ground.

The standard ground configuration for a NanoTEM survey uses a 20m x 20m transmitting loop with a 5m x 5m centred loop as the receiving antenna. Most of the ground data shown in this paper were taken using this configuration. Where greater resolution is desired, 10m x 10m transmitting loops with 2.5m x 2.5m receiving loops have been used. A typical depth section is shown in Figure 3. These data were collected on the line highlighted in Figure 1 with an arrow.

The instream data were collected using a floating version of Zonge's land-based NanoTEM system. The 7.5m x 7.5m transmitting antenna and 2.5m x 2.5m receiving antenna are mounted on a stiff PVC framework and four floating pontoons. Data are acquired in a nearly continuous mode every 4 seconds (stacking data for two seconds and a 32 hertz repetition rate). The moving platform travels at speeds less than 7 km/h, resulting in data being collected approximately every eight metres along the river. The vessel is fitted with a GPS logger that records both position and water depth approximately every ten metres. All three data sets are time stamped and synchronised, accurately locating every TEM sounding and associated water depth. A typical depth section of this type of data is shown in Figure 4.

This part of the river is highlighted on Figure 1 with a red box. See Telfer *et al*. and Berens (2006) for a review of the instream NanoTEM technique and results.

Conclusions

In the process of monitoring salinity changes in the River Murray system, whether it is in the river to monitor Salt Interception Scheme effectiveness, or on the floodplain to image salinity distribution, geophysics, especially fast sampling TEM methods have become an important and effective tool. These surface techniques provide high resolution, repeatable data which are critical in determining spatio-temporal variations in aquifer and river water quality; critical information in the preservation of social, economic and environmental values along the River Murray Corridor.

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The authors wish to acknowledge a number of companies and people without whom this work could not have happened. These include but are not limited to Zonge Engineering, Brian Barrett (originally at University of Adelaide, presently at University of Leeds), and Barry Porter of SA DWLBC. And we thank the following groups for funding and support: Murray Darling Basin Commission, Mid Murray LAP, Mallee Catchment, SA DWLBC, NSW DIPNR Australian Water Environments and CRC LEME. Data presented here are courtesy of the MDBC, Mid Murray LAP, SA DWLBC, CSIRO, NSW DIPNR, and the Mallee Catchment Board.

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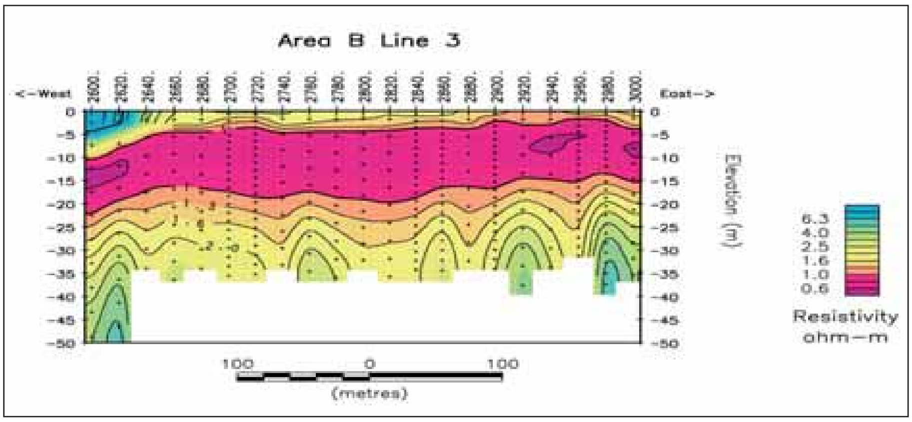

Fig. 3. Example of ground NanoTEM data inverted to give depth vs. resistivity section for 21 stations. Data collected near Bookpurnong, SA. See Fig. 1 – this line is highlighted with an arrow (SA DWLBC report, in prep.).

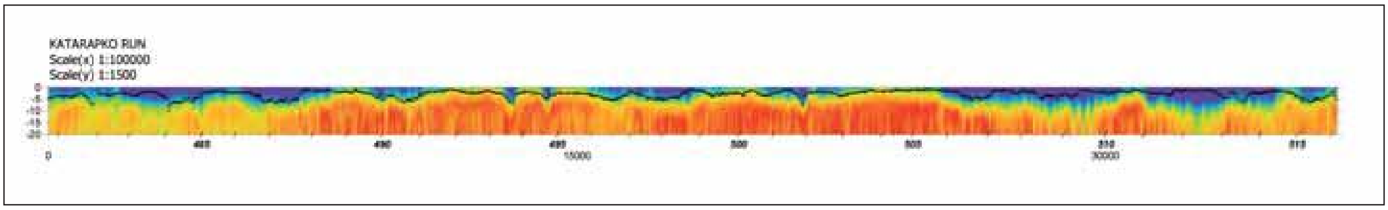

Fig. 4. Example of instream NanoTEM taken near Loxton, SA. See Fig. 1 – this section of the river is boxed. Black line at approximately 5 m shows water depth. Colour scale is same as for Fig. 1.

SkyTEM – status and development[1]

Max Halkjær
SkytEM Aps
Finlandsgade 6-8
8200 Aarhus N,
Denmark
max.halkjaer@skytem.com
http://skytem.dk

Kurt I Sorensen
Department of Earth Sciences
University of Aarhus,
Finlandsgade 8
8200 Århus N,
Denmark
Kurt.sorensen@geo.au.dk
http://www.hgg.au.dk

Niels Bøie Christensen
EMmodel
63/46 East Street,
East Fremantle
WA 6158, Australia
nbc@geo.au.dk

Esben Auken
Department of Earth Sciences
University of Aarhus,
Finlandsgade 8
8200 Århus N,
Denmark
Esben.auken@geo.au.dk
http://www.hgg.au.dk

Summary

The SkyTEM system was originally designed for hydrogeological purposes. The system has now been adapted to suit the demands for mineral exploration. Since 2003, the system has been used on a commercial basis.

The low internal noise and the fact that no levelling, bias corrections or other corrections are involved, results in very reliable and high resolution data. As a result, data can be inverted to produce quantitative cross sectional imagery can be over depth ranges of less than 20 m up to in excess of 250 m in some environments.

Key applications which benefit from such a capability would include mapping salinity, salt water intrusions, paleo-channels (e.g. uranium), geology, nickel laterites and channel iron deposits (CID's). For the first time, it may be possible to define some mineral deposits with the accuracy required to progress directly from airborne mapping to drilling.

Since the system is relatively light, self contained, mounted on an external sling and does not use the helicopter power, it is easy and safe to deploy.

Ongoing developments are in progress. The new transmitter and motor generator can produce just above 400.000 Am^2 and the goal is to reach 1.000.000 Am^2. There is also a focus on horizontal magnetic gradient measurements which are expected to be tested and ready for production in the 2nd half of 2006.

Introduction

In the development and design of the SkyTEM system shown in Figure 1 & 2, it has been a key objective that the data quality should be equal to or better than the data quality of ground-based systems (Figure 3). This ambitious goal has been reached, hence the fact that employment of ground based TEM soundings can be justified, only if the survey area is very small.

The reason for focusing on very high quality is due to the fact that the method has been developed for ground water mapping where even subtle resistivity contrasts can be significant.

More than 50 SkyTEM surveys have been performed to date. The system has now been adapted for mineral exploration and several such surveys have been flown during 2005/2006.

Fig.1. The SkyTEM system in operation, Utah, October 2005.

Method

The entire TEM system is carried as an external sling load, suspended from the helicopter (Figure 1). The transmitter, mounted on a lightweight wooden lattice frame, is a multi-turn loop with variable moment to optimize resolution (Figure 2).

The shielded, over-damped, multi-turn receiver loop is rigidly mounted on the side of the transmitter loop in a near-null position of the primary field, which minimizes distortions from the transmitter. The Z component receiver coil has a 2 m vertical offset, and the X component receiver coil is placed in the same plan as the transmitter coil.

The configuration is equivalent to a central-loop configuration and the data are processed and inverted as such.

The X component receiver coil has been implemented to improve the resolution of the upper layers in sedimentary environment and to improve the description of dipping conductors.

1 This Extended Abstract was not included in the Conference CD.

SkyTEM (Figure 2) is a stand-alone system; no personnel other than the pilot are required on board the helicopter to operate the equipment. The transmitter and receiver coils, power supplies, laser altimeters, GPS, electronics, and data logger are carried as a sling load from the cargo hook of the helicopter. Key parameters and selected data can be transmitted online to a geophysicist on the ground.

The transmitter current has a square waveform with a variable on and off-time to suit the given geology in the present survey area.

The time gates are programmable and can cover the range from 10 µsec to 10 ms.

The total weight of the system varies from less than 300 kg to 400 kg, depending on the set-up. The relatively low weight allows the use of a smaller helicopter, which will reduce the cost. Typical flying speeds are 40 – 80 km/h.

In Denmark, a low flying speed is mandated. In Australia a nominal speed of 80 km/h would be typical unless low speed high resolution surveys were sought.

Fig. 2. The SkyTEM system configuration.

Examples

SkyTEM for ground water and salinity exploration

Ground water mapping in Denmark calls for a high resolution of the formation throughout in the entire depth interval from surface down to 200 - 250 m (Figure 4).

No water is derived from aquifers in the upper parts of the formation, as they are often polluted by agricultural or industrial activities. However, the composition of the near-surface layers plays an important role for the vulnerability of the deeper lying aquifers. A clay cap of a thickness more than 20 – 30 m provides a natural protection due to its hydraulic properties and its ion exchange capacity.

Hence, it is important that the TEM data sets provide information of the near-surface layers. This implies that early times must be measured from 10 µs from start of turn-off. The delineation of buried valleys requires late time measurements in order to achieve information about depths up to 250 m. It is therefore demanded that the TEM data sets have delay times up to 10 ms.

Applying the SkyTEM method, mainly by public authorities in Denmark, Germany, Norway, US and Ecuador, has provided reliable 3D characterization of the extent of aquifers and their environmental vulnerabilities.

The TEM method has also proven suitable to determine the depths of the saltwater/freshwater interfaces, as required for characterizing saltwater intrusion into aquifers.

In principle, SkyTEM would be readily applicable to characterizing paleo channels in Australia and ground water salinity as affecting areas in Australia. The approach can also be considered for undertaking shallow water bathymetry, where other approaches are not applicable.

SkyTEM for characterisation of mineral deposits:

The precision acquired in the data targeted for environmental mapping has also proven

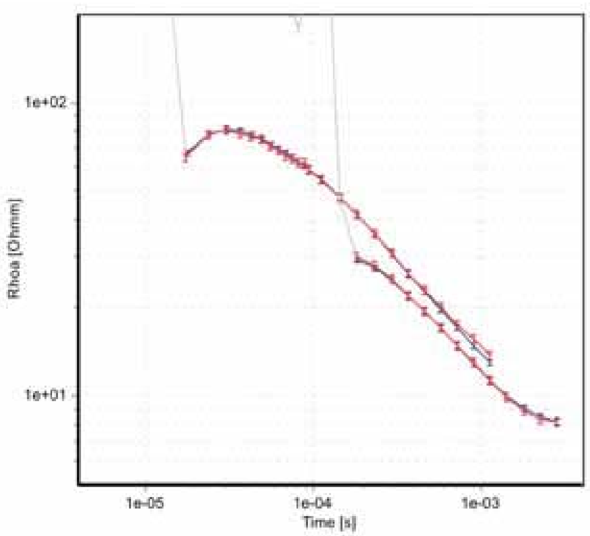

Fig. 3. Example of verification check of the SkyTEM system versus ground based TEM data. The blue curve represents ground based data upward continued to 10 m height. The red curve indicates actual SkyTEM data acquired at a height of 10 m. The error between the data sets ranges from 2% - 3%. The SkyTEM data has not had drift or system response corrections applied.

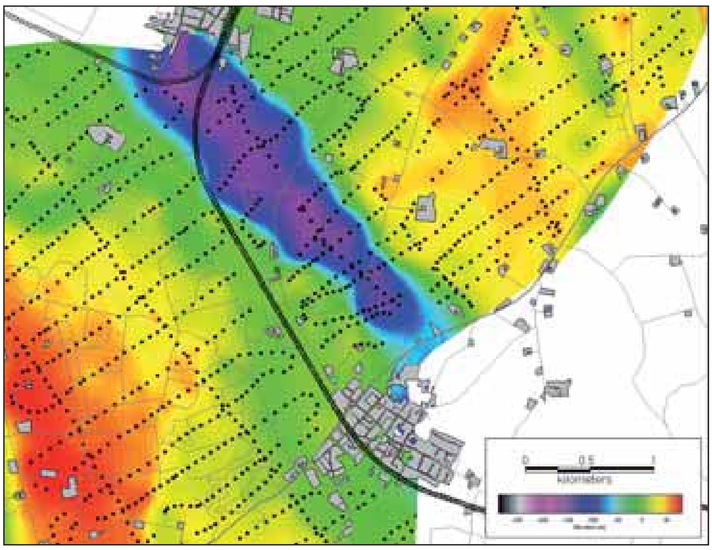

Fig. 4. An example of a contoured map showing the elevation to a good conductor, - in this case tertiary clay. Striking NW-SE we have defined a 150 m deep paleo valley. The valley is 500-1000 m wide, and has a significant potential as a water resource. The valley is filled with sand and gravel, and the aquifer is protected by a till cap/overburden.

most beneficial in the surveying of mineral deposits.

Characterisation of mineral deposits has become an increasingly important part of survey activities. The SkyTEM approach is particularly relevant for mapping targets where subtle responses across shallow and deep depth ranges require quantitative cross sectional imaging of relatively small resistivity variations.

Apart from the usual application of mapping massive sulphides, key applications which benefit from such a capability would include mapping geology, paleo channels (e.g. uranium), nickel laterites and channel iron deposits (CID's).

Ongoing developments

The method is subject to ongoing improvements. Increasing the moment to achieve deeper exploration/penetration depth is one of the main objectives of ongoing development.

The new transmitter and motor generator can produce just above 400.000 Am^2 and the goal is to reach 1.000.000 Am^2. There is also a focus on horizontal magnetic gradient measurements, which are expected to be tested and ready for production in the 2nd half of 2006.

A transmitter system has been developed which sustains the low noise and the quick turn off moments, a development which will prove advantageous.

Furthermore, SkyTEM ApS is working on the implementation of horizontal magnetic gradient measurements, again to enhance the quality of the data, and as such the level of processing.

SkyTEM ApS is also building additional systems. Presently, we have six frames and by September this year, we hope to extend the scope of our equipment with three more operational frames.

Acknowledgments

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C Nind

[1] **Scintrex Ltd**
222 Snidercroft Rd
Concord (Toronto)
Ontario, Canada
L4K 2K1
hseigel@rogers.com
cnind@scintrexltd.com

[2] **École Polytechnique de Montréal**
Campus de l'Université de Montréal
P.O. Box 6079, station Centre-ville
Montréal, Québec, Canada
H3C 3A7
chouteau@geo.polymtl.ca
giroux@geo.polymtl.ca

[3] **Chris Nind**, made the presentation at the Convention.

Development of a borehole gravimeter for mining applications

by H O Seigel[1], M Chouteau[2], B Giroux[2] and C J M Nind[1,3]

Introduction

Variations in the gravitational field of the Earth reflect the distribution of geological materials of different densities. These variations are currently observed through precise measurements by means of gravimeters, on the surface and, more recently, from aircraft. In mining applications such measurements play an important role in the exploration, evaluation and development of mineral resources, including both metallics and non-metallics.

Currently, state-of-the-art surface gravimeters can achieve sensitivities of the order of a few parts per thousand million (μGals) of the normal Earth's gravitational acceleration. Even with this sensitivity, gravity measurements made at surface are of limited help to exploration and mining operations at depths of 1-2 km below the surface.

Borehole gravity measurements reflect the distribution of rock densities at depth with greater target sensitivity and resolution than surface measurements. In conjunction with geological information and other geophysical parameters, borehole gravity data logs are input for 3D quantitative modelling of subsurface environments. Borehole gravity measurements also provide unique quantitative, bulk density data about the formations being traversed by the hole.

The borehole gravimeter being developed by Scintrex is based on its well proven quartz element sensor technology, which is small enough in diameter to enter the exploratory boreholes commonly drilled in mining programs, while retaining the same sensitivity as current surface gravimeters (see Figure 1).

The gravimeter has a sensitivity better than 5 μGal, for use in BQ holes and NQ drill rods, from 30° to 90° inclination. Its development for the mining industry is being supported by an industry group and the Canadian government. Software to interpret logging results is being developed by École Polytechnique in Montreal. This will be used to interpret logging results and to predict the subsurface gravity from modelled geology.

Potential applications of borehole gravity measurements in mining

There are two basic types of information that can be obtained from borehole gravity measurements. Information concerning the distribution of densities, both in the vicinity of the hole and remote from it, allows the explorationist to construct a 3D representation of the subsurface geology with improved spatial resolution and sensitivity for deeply buried structures. "Bulk density determination" of the rocks traversed by the borehole is a feature that is unique to borehole gravity. The difference between gravity measurements at two different levels in a borehole is proportional to the average bulk density of the formations between the two levels to a radial distance of about 5 times the spacing of the gravity measurements (Li and Chouteau, 1999).

Fig. 1. Scintrex BH gravity sensor ball. It is about the size of a ping pong ball.

Specific potential applications for borehole gravity measurements in each of the two broad categories above include:

Remote Detection

Massive Sulphide Deposits

In many mature mining camps the returns from surface exploration methods have largely been exhausted, and additional reserves are being sought by drilling to greater depths, sometimes in excess of 2 km (e.g. Sullivan body extensions and Sudbury nickel deposits). Borehole gravity measurements allow for an accurate calculation of excess mass, and, when a suite of boreholes has been logged, a 3D inversion of the deposit can be generated. These data can be used as a valuable adjunct to EM logging.

Modelled borehole gravity logs from four hypothetical boreholes into Inco's Kelly Lake Ni/Cu deposit in the Sudbury Basin are shown below (Figures 2, 3, 4 and 5)

Other Types of Metallic Deposits

A borehole gravity signal will exist whenever there is a significant difference in densities between the host rocks and the deposits. Non-conductive lead-zinc deposits in carbonate rocks, such as Pine Point, have higher densities than the host (Seigel *et al*., 1968). Other targets may include skarn and other types of Cu and Au deposits associated with zones of high iron oxides, and Au in high silica or carbonate alteration zones.

Non-Metallic Deposits

The exploration for non-metallic deposits will likewise be assisted by borehole gravity. For example, kimberlite intrusives are often variably magnetic, whereas their density is usually lower than that of their host rocks (Power *et al*., 2004). Subtle density variations in kimberlite facies may be revealed by a high sensitivity borehole gravity log.

Verification of Surface and Airborne Gravity Anomalies

Multiple gravity anomalies often arise from a land or airborne gravity survey for mining exploration. Some may be drilled primarily on the basis of their provocative gravity responses. An initial exploratory drill hole may fail to adequately reveal the source of the gravity anomaly, particularly if it is due to subtle bulk density changes in the subsurface rocks or if the anomaly has been mispositioned. In such cases, borehole gravity logging will assist decisions to be made about the need for additional drilling.

Bulk Density Determination

Grade Control and Rock Quality

Borehole gravity logging provides mining engineers for the first time with the ability to determine, in situ, the bulk density of formations traversed by the hole. Knowledge of the bulk density of the ore will allow a more accurate estimate of the tonnage of rock in a particular volume of ore, helping to improve the grade control in the mining of many types of deposits. In the case of iron deposits, there may be a direct relationship between the bulk density and the iron grade.

Other possible uses of bulk density information from borehole gravity measurements include assessing rock quality during quarrying operations and monitoring the integrity of dams and tailing ponds.

Corrections applied to borehole gravity measurements

It is necessary to make several corrections to borehole gravity measurements to derive the desired geological signal. Bulk density determination will normally require more stringent corrections than remote detection. To achieve a signal sensitivity of better than 5 μGal, the difference between two gravity values measured at adjacent locations must have a precision better than 7 μGal. This sets the cumulative target for errors in the corrections.

Depth:

Accurate bulk density calculations require accurate relative depths. The increment of gravity, Δg, between two stations separated vertically by a distance Δz is given by:

$$\Delta g = (0.3086 - 0.0838d)\ \Delta z \text{ in mGal/m} \quad (1)$$

Where d = density in g/cm^3.

In igneous rock (d=2.87 g/cm^3), an error of 1cm in Δz will introduce an error of about 0.7 μGal in Δg. The vertical depth precision required for stations separated vertically by >5m is, therefore, ~5cm (relative, between stations).

If the inclination of the mining boreholes is Φ degrees, then:

$$\Delta z = \Delta L \sin \Phi \quad (2)$$

where ΔL is the slant distance (along the hole) between the two stations.

The relative vertical depth precision may be achieved using a gamma tool (open holes) or CCL tool (drill rods) in combination with a sheave wheel counter, and/or a pressure gauge (open hole). Inclination is measured with a clinometer and/or fluxgate sensor. If an accurate orientation log of the hole is available, it can be used.

Latitude:

As in surface gravity measurements, borehole gravity measurements will be subject to variations with the Earth's latitude θ. These variations are given by:

$$\Delta g = 0.813 \sin 2\theta - 1.78\text{x}10^{-3} \sin 4\theta \text{ in μGal/m} \quad (3)$$

This correction peaks at 0.8 μGal/m N/S at mid-latitudes, and decreases progressively to zero at the poles and the equator. The same suite of tools employed to determine depth will provide the data needed to calculate the latitude correction for each station.

Atmospheric Pressure:

An increase of atmospheric pressure will decrease the observed gravity values because of the increased mass of the column of air above the hole. The effect is given by:

$$\Delta g = -3.6 \text{ μGal/kPa} \quad (4)$$

Correction for this possible error may be achieved through the use of a microbarometer at the collar of the hole

In addition, when a pressure gauge is employed to measure depth, the increased atmospheric pressure will be interpreted as an increase in the depth of the station and give rise to an overcorrection for depth. These effects are additive and the total effect is given by:

$$\Delta g = -12.2 \text{ μGal/kPa} \quad (5)$$

Gravimeter Drift:

Correction for linear drift of the gravimeter will be made by tying back to base, normally at the collar of the hole, at the beginning and end of the logging process

Earth Tides:

Tidal gravity effects will be removed using standard software-based formulae based on time and longitude.

Surface Topography and Underground Workings:

Borehole gravity readings will be affected by surface topography and underground mine workings in the vicinity. Corrections may be calculated using forward modeling routines included in the École Polytechnique software, local digital topographic models and three dimensional digital representations of the mine workings.

Regional Gradient:

In some circumstances there may be substantial regional gravity gradients due to large scale geologic features. Their effects may be removed either by reference to available regional gravity maps, or by running orthogonal, wide spaced gravity traverses on surface, centred on the hole. These corrections will require knowledge of the dip and azimuth of the borehole, in the same manner as for the latitude correction.

The Scintrex borehole mining gravity meter: system specifications

The Scintrex "Gravilog" borehole mining gravity system is comprised of:

- an uphole section including a 3 km winch with 4 wire cable, encoder, power supply and ruggedised PC;
- and the downhole tool

Development of the Gravilog system at Scintrex began in the fourth quarter of 2005 and the system target specifications are summarized in Table 1:

Parameter	Target specification
Sensitivity	better than 5 µGal with a one minute reading time (1 µGal is 10-9 of the Earth's gravity field)
Operating range	7000 mGal
Max sonde diameter	48 mm
Max sonde length	2 m
Max. operating depth	2000 m (water filled hole)
Minimum hole diameter	BQ (60 mm) and NQ drill rods (57.2 mm)
Max. hole deviation from the vertical	60 degrees
Operating temperature range	0C - +70C (downhole section) -40C - +50C (uphole section excluding PC)
Vertical position determination in borehole	+/- 5 cm (depth and trajectory will be determine with a combination of pressure sensor, winch encoder and fluxgate magnetometer

Table 1: Gravilog Target Specifications

Kelly Lake orebody model: a case study for borehole gravity

There are three main techniques to compute the gravity response of 3D structures (Li and Chouteau, 1998). The so-called "right rectangular prism" model computes the response of a body by summing the effects of a set of right rectangular prisms that approximate the volume of the body. The "right polygonal prism" model computes the gravity response by summing the effects of a set of thick polygons (slices) that approximate the geometry and volume of the body with depth. The "polyhedron" model approximates the body with a set of polyhedrons and computes the gravity response using a surface integral computed over the facets delimiting the body. Each method has its advantages and disadvantages. In general, the first and the third methods are the most practical to compute the gravity effect of 3D bodies with complex geometry. Here we have modelled the borehole gravity response of a known orebody using a code based on the right rectangular prism that was specially designed to remove any singularity caused by the holes passing through the prisms (Li and Chouteau, 1998). A new version is presently being developed based on the polyhedron model; the structures will be discretized using tetrahedrons and the response will be computed using the analytical response given by Singh and Guptasarma (2001).

The borehole gravity response of Inco's well documented Kelly Lake Ni/Cu sulphide orebody, located in the Sudbury mining camp has been modelled. The orebody consists of three distinct zones. The two smaller zones are between depth between 100 and 600 m depth. The main zone is 700 to 1600 m deep. Depths are measured from the surface, which is between 200 to 300 m ASL. The bodies have been delineated by intensive drilling and densities within the zones have been estimated for blocks of 5m x 5m x 5m from cores and density (gamma-gamma) logging. The igneous host rock density is about 2.8 g/cm^3, and the density contrast of the orebody zones with the host rock varies from zero to about 1.3 g/cm^3.

The structural complexity of the Kelly Lake orebody is evident in the figures below. The borehole gravity response will be complex, with anomalies indicating pockets of excess mass (high density) within the zones. We have used this real-world orebody to model four distinct scenarios that could occur in borehole gravity surveys. The vertical component of the gravity response, g_z, and its vertical gradient, $\Delta g_z/\Delta z$, are modelled for the effect of the excess mass, assuming that all corrections summarized above have been applied.

Figure 2 shows the case of a vertical hole that would have missed the Kelly Lake bodies. The vertical gravity anomaly, g_z, and the vertical gravity gradient anomaly, $\Delta g_z/\Delta z$, are represented on the right side of Figure 2 by solid and dashed lines respectively. The vertical gravity anomaly, g_z, will be positive when the gravity meter is above a high density pocket and negative below, with a cross-over opposite the pocket, due to excess mass at this location in the orebody. There are two recognizable g_z anomalies on this profile. The shallower anomaly shows a peak to peak response of about 200 μGal with a cross-over at about 300 m depth (surface at 250 m ASL) and a separation between peaks of about 250 m. The vertical gravity gradient anomaly, $\Delta g_z/\Delta z$, has a positive peak at about 310m depth, coincident with the g_z cross-over. These results indicate the presence of excess mass at a distance of about 150 m from the borehole at a depth of about 300 m. The borehole passes between the two shallower zones of the orebody at this location, as indicated in Figure 2. A second g_z anomaly is evident on Figure 2, with a cross-over at about 900 m depth, a peak-to-peak response of about 150 μGal and a peak-to-peak separation of about 250 m. There is a $\Delta g_z/\Delta z$ peak at about 850 m depth. These results indicate the presence of excess mass at a distance of about 400m from the borehole at a depth of 850-900 m. Referring to Figure 2, the borehole gravity response is indicating a pocket of high density near the top of the deeper zone of the Kelly Lake orebody. This is consistent with the density model of the orebody. The borehole gravity data in Figure 2 clearly indicate the presence of shallow and deep zones of excess mass remote from the borehole.

Figure 3 shows the case of a dipping hole that intersects one of the shallow zones of the orebody. The g_z cross-over in the vicinity of the intersection at a depth of 375 m shows a peak-to-peak response of about 150 μGal. The $\Delta g_z/\Delta z$ peak coincides with the g_z cross-over. The responses from 375 m to 500 m depth are complex, indicating that the intersection is not a simple one and may actually be a number of

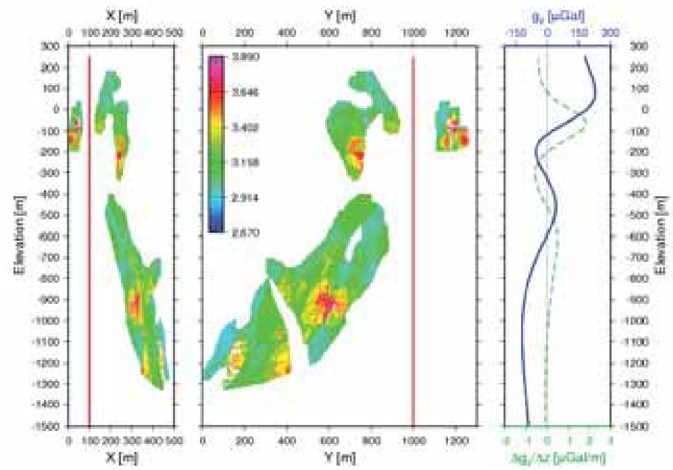

Fig. 2. The borehole has missed the Kelly Lake orebody. The density model of the three zones in the orebody is shown projected into the xz (left) and yz (middle) planes along with the trace of the borehole. The panel on the right displays computed profiles of the vertical component of gravity, g_z, (solid line) and the vertical gradient of gravity, $\Delta g_z/\Delta z$, (dashed line). The colour bar shows the density distribution in gm/cm³. The host rock density is 2.8 g/cm³. The borehole gravity profiles show g_z cross-overs and $\Delta g_z/\Delta z$ peaks corresponding to off-hole excess masses, indicating both shallow and deep zones remote from the borehole.

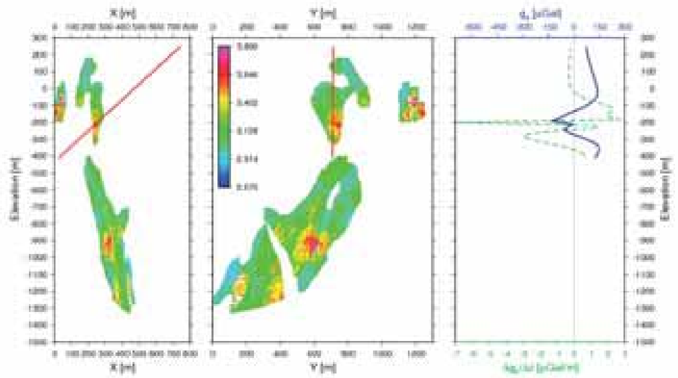

Fig. 3. The borehole has intersected one of the shallow zones in the Kelly Lake orebody. The panel of the right displays computed profiles of the vertical component of gravity, g_z, (solid line) and the vertical gradient of gravity $\Delta g_z/\Delta z$, (dashed line). The colour bar shows the density distribution in gm/cm³. The host rock density is 2.8 g/cm³. The gravity responses display abrupt and complex changes in the vicinity of the intersection. There is evidence of a deeper zone below the bottom of the borehole.

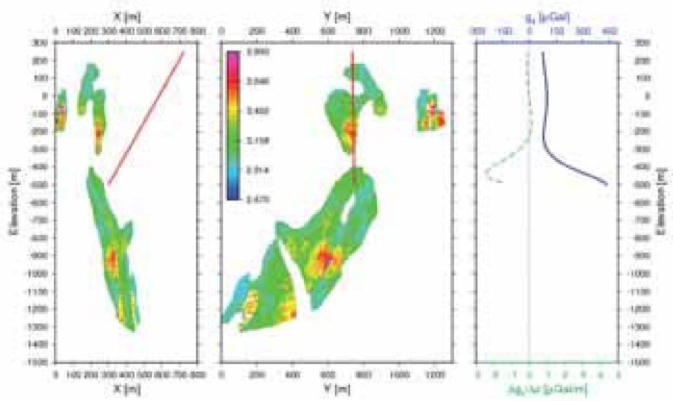

Fig. 4. The borehole has missed the shallow zones and does not extend to the deep zone. The panel of the right displays computed profiles of the vertical component of gravity, g_z, (solid line) and the vertical gradient of gravity $\Delta g_z/\Delta z$, (dashed line). The colour bar shows the density distribution in gm/cm³. The host rock density is 2.8 g/cm³. We observe a small, broad response indicating excess mass in the shallow zones several hundred metres remote from the borehole. There is a clear response from the deep zone below the borehole.

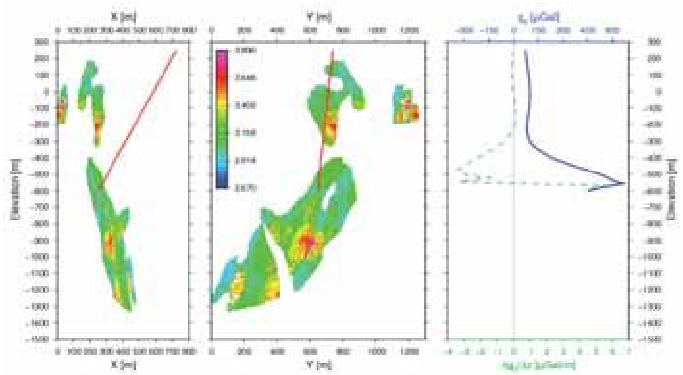

Fig. 5. The borehole in Figure 4 has been extended until it reaches the deeper zone. The panel of the right displays computed profiles of the vertical component of gravity, g_z, (solid line) and the vertical gradient of gravity $\Delta g_z/\Delta z$, (dashed line). The colour bar shows the density distribution in gm/cm³. The host rock density is 2.8 g/cm³. The borehole gravity responses indicate that the hole is quickly approaching a zone of higher densities but that the hole has not yet reached the centre of the excess mass.

individual lenses of varying densities within this depth range. There is a clear indication of another massive body at depth at the bottom of both g_z and $\Delta g_z/\Delta z$ logs, suggesting that the hole should be extended.

Figure 4 illustrates the case of a hole that missed the two shallower zones and stopped short of the main deeper zone. The g_z and $\Delta g_z/\Delta z$ logs show a low amplitude effect of a distant body of excess mass at about 400 m depth. The main feature indicated by these logs is the presence of excess mass below the bottom of the borehole, clearly indicating that the hole should be extended.

In Figure 5 the borehole from the previous case has been extended by 100 m to stop at the upper contact between the lower zone and the host rock. The g_z and $\Delta g_z/\Delta z$ logs indicate that the hole is quickly approaching a zone of higher densities but that the hole has not yet intersected the centre of the excess mass.

Conclusions

Borehole gravimetry will provide useful information for mining, both in exploration and existing operations. Scintrex is developing a borehole gravimeter that can be used in open BQ holes and in NQ drill rods, to a depth of 2 km. The processing steps required to borehole gravity data are understood and the corrections must be carefully applied to achieve a signal sensitivity of better than 5 µGal. École Polytechnique is developing software to interpret the processed borehole gravity data.

The modelling exercise based on a density model of Inco's Kelly Lake orebody shows that borehole gravity anomalies can be large (>100 µGal) for typical exploration targets located 100 m and further from a borehole. The gravity response and its vertical gradient are complementary. g_z shows a cross-over anomaly associated with massive bodies, with the separation between the peaks roughly indicating the distance to the excess mass. $\Delta g_z/\Delta z$ displays a maximum opposite the centre of excess mass, coincident with the g_z cross-over. Borehole gravity data that provides evidence of excess mass located below the hole will assist an informed decision about extending the hole.

Acknowledgments

The authors would like to thank Alan King of Inco, Inc. for supplying the density model of the Kelly Lake orebody.

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Geological Surveys of Queensland, Western Australia, Northern Territory, Tasmania and Geoscience Australia

Update on Geophysical Survey Progress

Paterson Province WA – Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of WA (GSWA) with project management by Geoscience Australia. UTS Geophysics commenced data acquisition on the Paterson Central and Paterson South-East surveys on 24 June 2005. Approximately 123,000 line-km of magnetic and radiometric data were acquired over an area of approximately 42,000 square kilometres. See *Preview* 115 (April 2005 – Page 33) for a locality diagram of this survey. Flying was completed on 30 June 2006. Raw data were supplied to GA on 18 July for assessment and the final data are expected to be supplied in August.

Gascoyne WA – Airborne Magnetic and Radiometric Survey

This survey is being flown for the Geological Survey of WA (GSWA) with project management by Geoscience Australia (GA). Approximately 105,000 line-km of magnetic and radiometric data were acquired over an area of approximately 35,900 square kilometres. Data acquisition was completed on 26 March. See *Preview* 117 (August 2005 – Page 34, Figure 4) for a locality diagram of this survey. Final data were released via GADDS on 7 June along with final data from the East Yilgarn airborne magnetic and radiometric survey.

Bowen – Surat North Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. UTS Geophysics commenced data acquisition on the survey on 25 January 2006. Approximately 169,800 line-km of magnetic and radiometric data will be acquired over an area of approximately 53,800 square kilometres. At the end of July UTS had completed 95% of this survey. See *Preview* 118 (October 2005 – Page 41) for a locality diagram of this survey.

Bowen – Surat South Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. Fugro commenced data acquisition on the survey on 26 January 2006. Approximately 170,000 line-km of magnetic and radiometric data were acquired over an area of approximately 60,550 square kilometres. Data acquisition was completed on 9 April. See *Preview* 118 (October 2005 – Page 41) for a locality diagram of this survey. Raw data were supplied to GA on 5 May for assessment. Final data were supplied to GA on 13 July for assessment.

Isa West Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. Fugro commenced data acquisition on the survey on 4 February 2006. Approximately 63,533 line-km of magnetic and radiometric data were acquired over an area of approximately 22,030 square kilometres. Data acquisition was completed on 2 April. See *Preview* 118 (October 2005 – Page 41) for a locality diagram of this survey. Raw data was supplied to GA on 5 May for assessment. Final magnetic and elevation data were supplied to GA on 30 June for assessment.

Bowen – Surat Gravity Survey

This survey is being carried out for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. Daishsat commenced data acquisition on 17 November 2005. Approximately 5,263 new gravity stations were acquired over an area of approximately 85,000 square kilometres. Data acquisition was completed on 7 April. See *Preview* 118 (October 2005 – Page 41) for a locality diagram of this survey. Final data were released via GADDS on 7 June.

Ashburton Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of WA (GSWA) with project management by Geoscience Australia. UTS expect to commence data acquisition on the survey at the completion of flying on the Bowen – Surat North survey. Approximately 100,000 line-km of magnetic and radiometric data will be acquired over an area of approximately 34,920 square kilometres. See *Preview* 121 (April 2006 – Page 35) for a locality diagram of this survey.

Southern Officer Basin (Trainor) Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of WA (GSWA) with project management by Geoscience Australia. WorleyParsons GPX expect to commence data acquisition on the survey in August 2006. Approximately 105,000 line-km of magnetic and radiometric data will be acquired over an area of approximately 37,330 square kilometres. See *Preview* 121 (April 2006 – Page 35) for a locality diagram of this survey.

Musgrave Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of WA (GSWA) with project management by Geoscience Australia. Fugro commenced data acquisition on 15 June 2006. Approximately 82,000 line-km of magnetic and radiometric data will be acquired over an area of approximately 27,920 square kilometres. See *Preview* 121 (April 2006 – Page 35) for a locality diagram of this survey. At the end of July Fugro had completed 38% of this survey.

Isa Area A Gravity Survey

This survey is being carried out for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. Daishsat commenced data acquisition on 10 April 2006. Approximately 6,719 new gravity stations were acquired over an area of approximately 26,000 square kilometres. See *Preview* 118 (October 2005 – Page 41) for a locality diagram of this survey. Data acquisition was completed on 14 June. Final data were supplied to GA on 7 July for assessment.

Isa Area B Gravity Survey

This survey is being carried out for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. Fugro commenced data acquisition on 4 July 2006. Approximately 9,898 new gravity stations will be acquired over an area of approximately 78,000 square kilometres. See *Preview* 118 (October 2005 – Page 41) for a locality diagram of this survey. At the end of 15 July, Fugro had completed 11% of this survey

Isa South West Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. Fugro commenced data acquisition on 3 April 2006. Approximately 140,000 line-km of magnetic and radiometric data will be acquired over an area of approximately 50,100 square kilometres. At the end of July Fugro had completed 90% of this survey. See *Preview* 118 (October 2005 – Page 41) for a locality diagram of this survey.

Isa South East Airborne Magnetic and Radiometric Surveys

This survey is being flown for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. Fugro will commence data acquisition upon completion of flying on the Isa South West survey. Approximately 100,000 line-km of magnetic and radiometric data will be acquired over an area of approximately 35,800 square kilometres. See *Preview* 118 (October 2005 – Page 41) for a locality diagram of this survey.

Jervois Gravity Survey

This survey is being carried out for the Northern Territory Geological Survey (NTGS) with project management by Geoscience Australia. Daishsat commenced data acquisition on 6 June 2006. Following successful land access negotiations the survey area increased in size to contain approximately 5,500 new gravity stations over an area of approximately 20,600 square kilometres. See Figure 1 for a locality diagram of the complete survey. Data acquisition was completed on 10 July.

Webb Gravity Survey

This survey is being carried out for the Geological Survey of WA (GSWA) with project management by Geoscience Australia. Daishsat were expected to commence data acquisition on the survey by no later than 1 August 2006. Approximately 4,100 new gravity stations will be acquired on a 2.5 km station spacing over an area of approximately 24,800 square kilometres. See Figure 2 for a locality diagram of the survey.

Murchison Gravity Survey

This survey is being carried out for the Geological Survey of WA (GSWA) with project management by Geoscience Australia. Fugro Ground Geophysics is expected to commence data acquisition on the survey by no later than 2 October 2006. Approximately 3,600 new gravity stations will be acquired on a 2.5 km station spacing over an area of approximately 24,800 square kilometres. See Figure 3 for a locality diagram of the survey.

Because such a high percentage of the data acquisition program is being carried out in Western Australia a summary of the surveys in progress in Western Australia is shown below in Figure 4 and the table.

GSWA Regional Geophysics Survey Program: July 2006 update

Final data releases are available by download from the GA Data Delivery System at www.ga.gov.au/gadds

Preliminary data releases are made periodically on the GSWA website on the Maps and Images page. Subscribe to the GSWA newsletter to keep informed of preliminary and final data release dates.

New Geophysical Surveys

Northern Territory

Requests for quotation have been released for provision of magnetic and radiometric coverage over the Tiwi Islands. Approximately 29,300 line-km of magnetic and radiometric data will be acquired over an area of approximately 10,200 square kilometres. New data will be acquired on north-south flight lines spaced

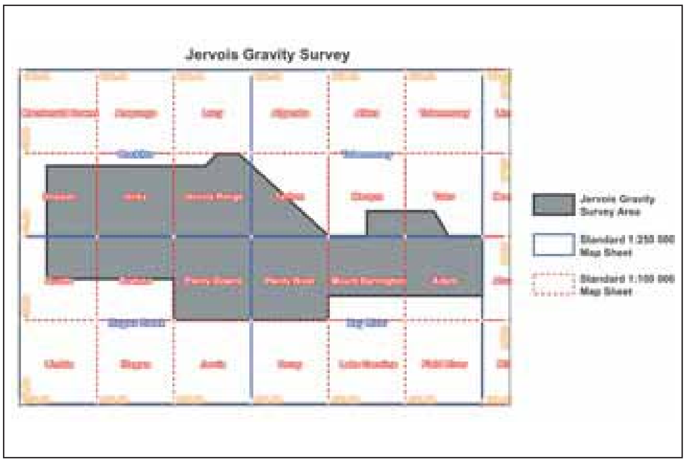


Fig. 1 Location of the Jervois Gravity Survey

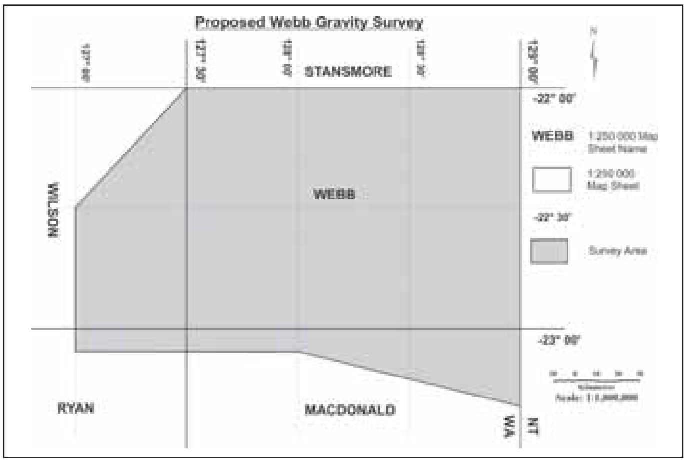


Fig. 2. Location of the proposed Webb Gravity Survey

400 metres apart with a ground clearance of 80 metres. See Figure 5 for a locality diagram of the survey.

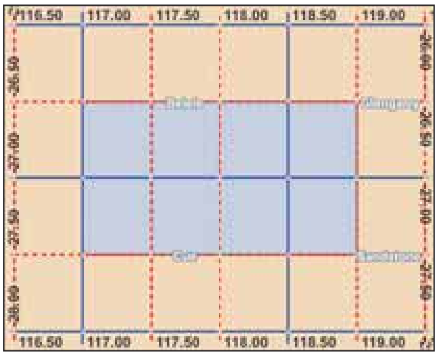
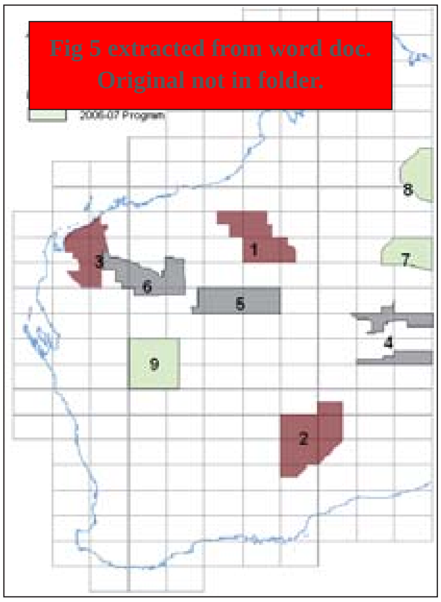


Fig. 3. Murchison Gravity Survey location map



The quotation period closed on Wednesday 16 August 2006. Geoscience Australia will be managing the flying program for the Tiwi Island survey.

For further details, contact Roger Clifton by telephone on 08 8999 3853 or by e-mail at roger.clifton@nt.gov.au or Murray Richardson by telephone on 02 6249 9229 or by e-mail at murray.richardson@ga.gov.au.

Tasmania

Requests for quotation have been released for provision of magnetic and radiometric coverage in three regions of Tasmania:
8,600 km2 over North-East Tasmania;
2,900 km2 over Flinders Island;
27,260 km2 west of King Island offshore.

When completed, the projects will release a total of more than 108 000 line km of magnetic and radiometric data to the public domain.

In the North-East Tasmania and Flinders Island surveys the new data will be acquired on east–west flight lines spaced 200 metres apart with a ground clearance of 90 metres

For the offshore King Island survey the new data will be acquired on east–west flight lines spaced 800 metres apart with a ground clearance of 130 metres

The quotation period closed on Wednesday 16 August 2006. Geoscience Australia will be managing the flying program in all three areas of Tasmania.

For further details, contact Robert Richardson by telephone on 03 6233 3824 or by e-mail at rrichard_pc@mrt.tas.gov.au or Murray Richardson by telephone on 02 6249 9229 or by e-mail at murray.richardson@ga.gov.au.

See below for a locality diagram of the surveys.

ID	Name	Specifications	Status	Start	End	Release
Airborne Mag/Rad Surveys						
1	Paterson South 2005	400m x 60m; E/W; N/S	Processing	Oct-05	Jun-06	Sep-06
2	East Yilgarn 2005	400m x 60m; E/W	Released			07-Jun-06
3	Gascoyne 2005	400m x 60m; E/W	Released			07-Jun-06
4	Musgrave 2006	400m x 60m; E/W; N/S	Flying	Jun-06	Oct-06	Dec-06
5	Officer (Trainor) 2006	400m x 60m; N/S	Contract	Aug-06	Nov-06	Feb-07
6	Ashburton 2006	400m x 60m; N/S	Contract	Aug-06	Nov-06	Feb-07
Gravity Surveys						
7	Webb	2.5 km regular	Contract	Aug-06	Oct-06	Dec-06
8	West Tanami	2.5 km regular	Planning	Dependant on Land Access		
9	Murchison	2.5 km regular	Contract	Sep-06	Nov-06	Jan-07

Fig. 4 and summary table for WA; information current at 21 Jul 2006

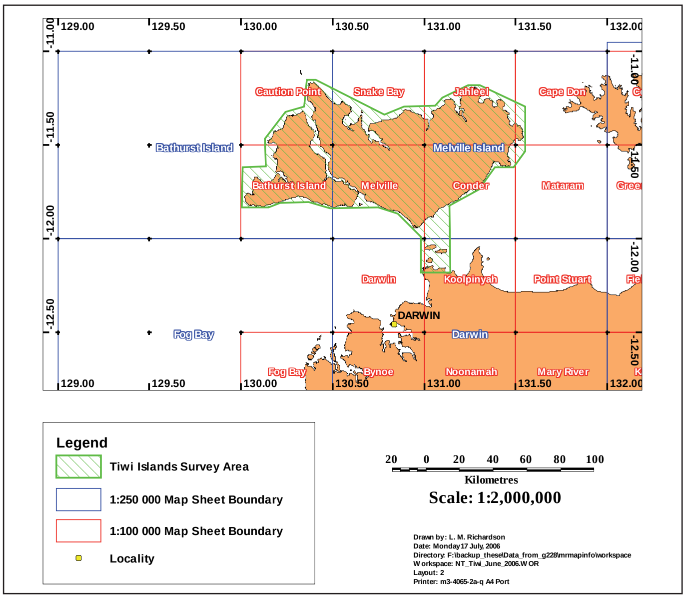


Fig. 5. Location of Tiwi Island airborne geophysical survey

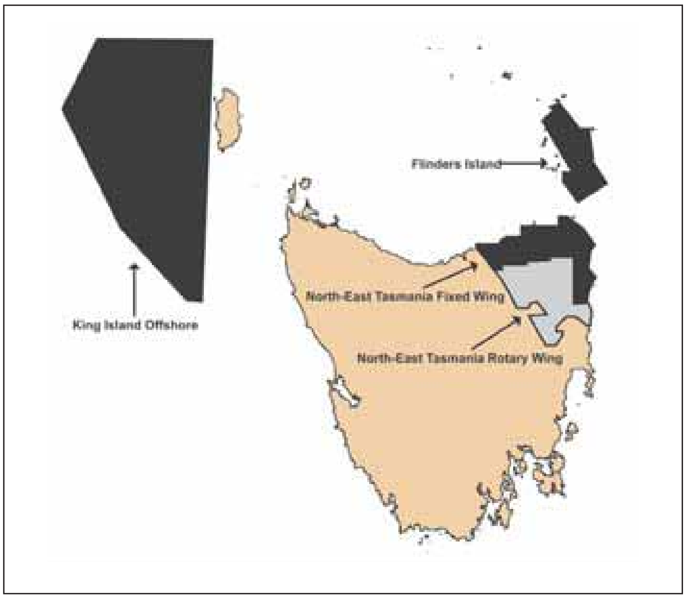


Fig. 6. Location of 2006 Tasmanian airborne geophysical survey

Geoscience Australia

Seismic Reflection Surveys

The 2006 Central Victorian Seismic Transect was recently completed with a total of 398 km of deep seismic reflection data acquired. The projects collaborators, Geoscience Australia, GeoScience Victoria, *pmd**CRC, Leviathan Resources, GoldFields, Ballarat Goldfields have been impressed with the initial field results. GeoScience Victoria representatives at the recent Australian Earth Sciences Convention were espousing the virtues of deep seismic reflection surveys within their state and how it will improve their level of understanding of the geological makeup of Victoria. ANSIR, the National Research Facility for Earth Sounding acquired the seismic data. The transect commenced north of Stawell and ran eastwards, running north of Bendigo and on into the Melbourne Trough. The survey has already provided valuable information on the nature of the crust architecture in the Stawell, Bendigo and Melbourne structural zones and, after processing, will provide a better understanding of the relationship of gold mineralisation to structure in the upper few kilometres of crust in this part of the Lachlan Fold Belt.

Preparations for the 2006 Mt Isa Seismic Transect Project are progressing. The project collaborators are the Geological Survey of Queensland - Queensland Department of Natural Resources and Mines, Geoscience Australia, Zinifex Limited, the *pmd**CRC and ANSIR. The Mt Isa Project involves the acquisition of approximately 600 km of shallow and deep seismic reflection, which is aimed to improve the understanding of crustal architecture which will assist in the discovery of further mineral resources.

The results of the 2005 Tanami Seismic Collaborative Research Project were presented at the recent North Australia Project wrap-up conference, titled the *Evolution and Metallogenesis of the North Australian Craton.* The conference abstracts were published as Geoscience Australia Record 2006/16 and are available via the GA website. The seismic results have provided valuable constraints on the crustal structure within the Tanami Region and indicate a mineral deposit – structure correlation.

ANSIR and BHP Billiton Illawarra Coal completed a big Vibe (Hemi 60) and small high frequency MiniVib comparison project. Results will have implications for exploration of deeper coal seams and therefore benefit coal exploration and mine seam delineation.

For further information please contact Bruce Goleby +61 2 6249 9404 or bruce.goleby@ga.gov.au

Oil price rises drive exploration and production

Huge increase in demand forecast -

In early July the International Energy Agency forecast that the world will consume 115.4 million barrels per day by 2040, up from 82.1 million barrels per day two years ago. The agency estimated that world oil demand will increase by 1.2 million barrels per day this year, growing at an average annual growth of 1.5 percent. This demand is likely to continue expanding as countries such as China and India increase the energy requirements of their economies.

This demand will increase current pressure on companies to find more oil and increase refining capacities. The whole energy supply infrastructure will require additional spending on facilities like, power stations, oil fields and natural gas wells and pipelines and particularly, exploration.

Whether production levels can reach these targets remains to be seen.

- but it's getting harder to find

As we all know oil exploration is getting more difficult as production from the larger easy-to-access fields declines. Last month for example, BP announced a discovery in the Urano well, which was drilled offshore Angola some 345 kilometres northwest of Luanda. By itself, that is nothing new, but the fact that the well was drilled in a water depth of 1,938 m, and reached a total depth of 4,578 metres below sea level makes it something special.

What's more it produced nearly 2000 barrels a day in a drill-stem test.

The Association for the Study of Peak Oil and gas (ASPO) has been making noises about dwindling reserves for several years. The two key graphs produced by ASPO are shown opposite.

A similar graph for Australia was presented by ASPO to the Inquiry into Australia's future oil supply and alternative transport fuels by the **Senate Rural and Regional Affairs and Transport Committee.** See the following website: (http://www.aph.gov.au/senate/committee/rrat_ctte/oil_supply/index.htm).

The main problem for Australia is that the Gippsland Basin Fields, which were discovered in the 1960s, are gradually becoming depleted leading to an increased fiscal burden through the necessity of having to rely increasingly on imports.

Anyway ASPO is now predicting a global production peak between 2010 and 2015. As shown in Figure 2 opposite.

Meanwhile, petroleum exploration is increasing globally to try and meet the demand. The Baker Hughes rig numbers give an indication of changes in global rig usage and as shown in Figure 3, there has been gradual upward trend since 1995. Another point of interest in the graph is that even though the US fields are probably the most mature on earth, they are still being attacked by almost half the world's rigs.

The Baker Hughes Rotary Rig Counts are counts of the number of drilling rigs actively exploring for or developing oil or natural gas in the United States, Canada and international markets. Baker Hughes has issued the rotary rig counts as a service to the petroleum industry since 1944, when Hughes Tool Company began weekly counts of US and Canadian drilling activity. However, the data are sometimes skewed to accommodate US politics. For example, in January 2006, the company discontinued its rig count for Iran and Sudan after business activity that directly or indirectly involved or facilitated transactions in Iran, Sudan or with their governments was prohibited.

Finally, I cannot resist the temptation to include a plot of the price of oil over the last 30 years or so. I have plotted this below in Figure 4.

Continued on page 42

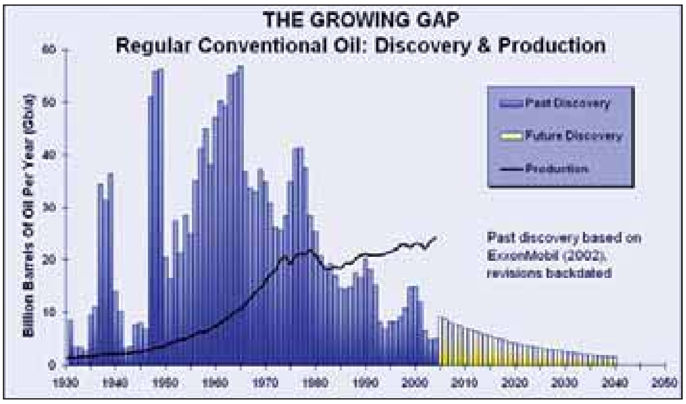


Fig. 1. From the ASPO website (www.peakoil.net), showing the widening gap between production and past discoveries.

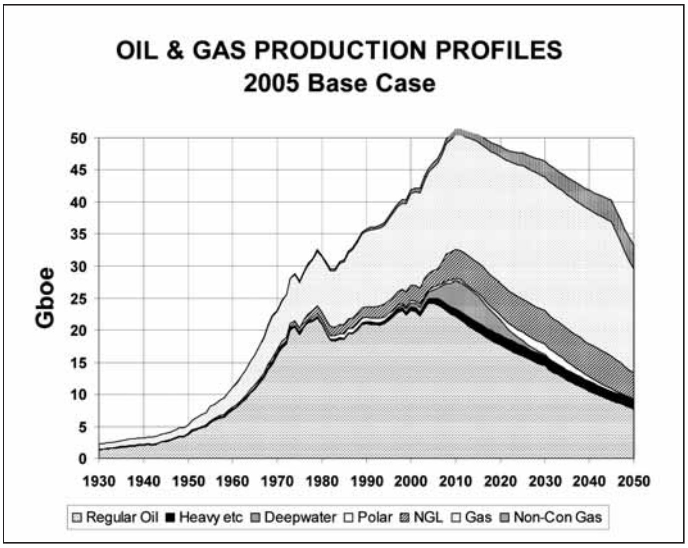


Fig. 2. General depletion of global oil and gas according to ASPO Diagram from the website: (www.peakoil.net).

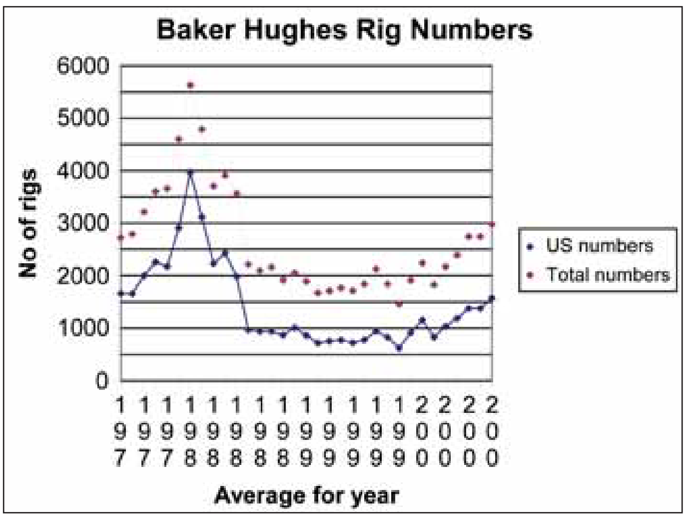


Fig. 3. Baker Hughes Rig Counts for the period 1975-2006.

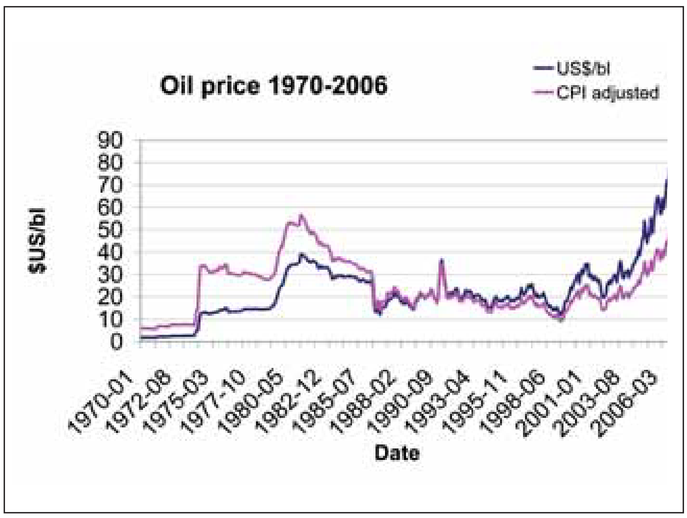


Fig. 4. NYMEX equivalent oil price in current dollars (dark blue) and CPI adjusted (purple). Notice that the CPI adjusted is creeping closer to the previous short-lived peak in 1981.

Continued from page 41

Santos and Woodside doing well

Meanwhile Santos and Woodside are both doing well in the current resource boom. At the end of July Santos reported record sales revenue of $1.3 billion for the first half of 2006, an increase of 29 percent on the corresponding period for 2005.

It also increased its first half production to 28.7 million barrels of oil equivalent (mmboe) which was a record for Santos. This is compared with 26.3 mmboe in the previous corresponding half-year.

The record first half reflects increased second quarter production, combined with continuing high prices received for all products.

Santos' total production for the second quarter was 14.9 mmboe, which represents a 9 percent increase on the corresponding quarter in 2005.

In the same quarter sales revenue increased by 25 percent from $553.2 million in 2005 to $691.5 million in 2006.

So a 9 percent increase in production has been converted into a 25 percent increase in revenue – not a bad return.

Meanwhile, production has begun from Woodside Energy Limited's Enfield oil project off North West Cape, Western Australia.

The company has completed hook-up, testing and commissioning of the floating production storage and offloading facility, Nganhurra. It is expected that production will increase steadily over the coming weeks.

Nganhurra is about 50 kilometres north-west of Exmouth. It has a maximum production rate of about 100,000 barrels per day and a storage capacity of about 900,000 barrels of oil. Water depth at the location is 390 metres.

Enfield was discovered by Woodside in 1999 and is located in production licence WA-28-L. The project has estimated reserves of about 127 million barrels of oil. This should convert to a very useful cash flow.

$112 million boost to offshore exploration

The award of five new offshore petroleum exploration permits announced on 31 May 2006 by Ian Macfarlane, the Australian Minister for Resources, will result in additional $112 million invested in offshore exploration over the next six years.

The five new permits awarded are as follows:

Two in the Bass Basin off Tasmania, situated close to southeast Australian gas markets in shallow water, to Bass Strait Oil Company Ltd;
One in the Browse Basin off Western Australia, a proven major hydrocarbon province, to Nexus Energy Australia NL; and
Two in the Bonaparte Basin, in the Territory of Ashmore and Cartier Islands off north-western Western Australia, close to areas with demonstrated commercial potential, one to Eni Australia Limited and the other to Auralandia N.L., Natural Gas Corporation Pty Ltd and Gascorp Inc.

Figures 1-4 show the locations of these permits.

In his media release the Minister stated that: "Every year the Australian Government releases a round of offshore areas for petroleum exploration as part of our commitment to ensuring the development potential of these areas is properly identified."

"This provides a steady supply of new areas for bidding in Australia's vast offshore sedimentary basins. The bidders also draw heavily on Geoscience Australia's pre-competitive data which is maintained and updated through government support."

"The annual acreage release and the recent additional $61 million put into updating Geoscience Australia's pre-competitive data underline the Government's commitment to encouraging further petroleum exploration."

For the award of exploration permits in Australia's offshore areas, applicants are required to nominate a guaranteed minimum exploration program for each of the first three years of the permit term. Permits are initially granted for six years.

The table opposite summaries the work being proposed by the successful bidders.

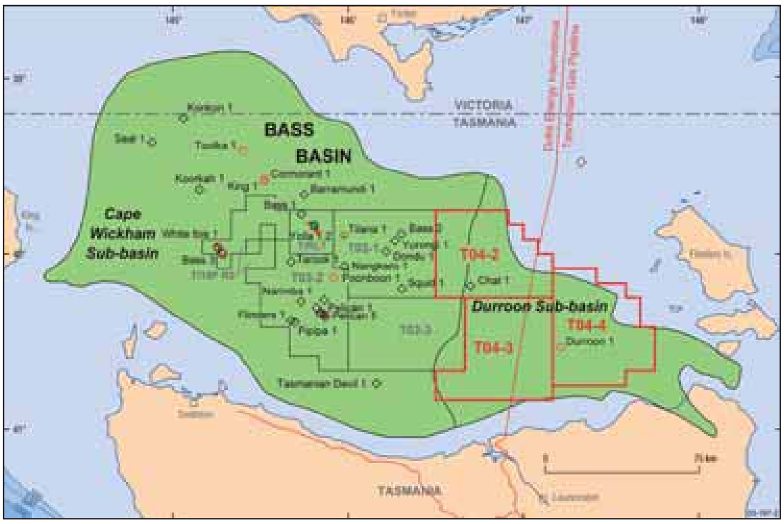


Fig. 1. Location of Permits T04-3 and T04-4, in the Bass Basin, showing the location of permits and exploration wells. The wells coloured red produced gas.

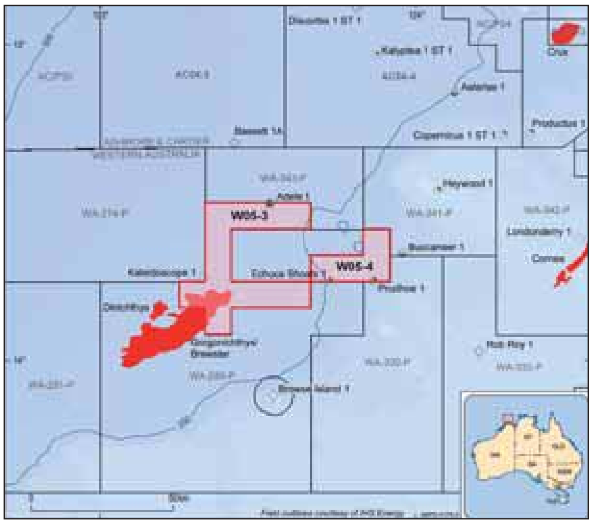


Fig. 2. Location of Permit W05-4, in the Browse Basin, showing exploration wells and gas fields (in red).

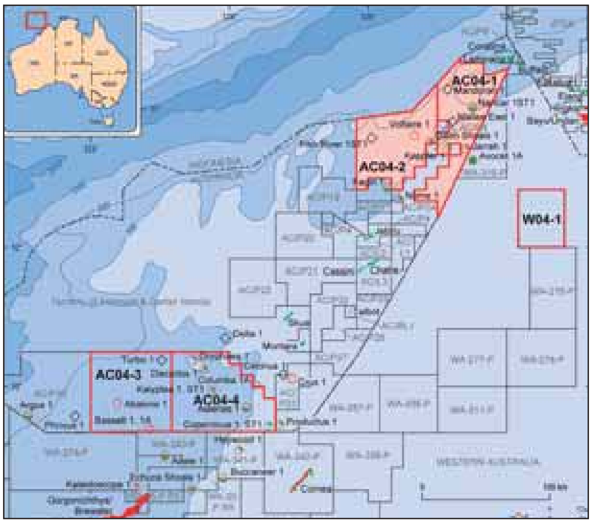


Fig. 3. Location of Permit AC04-1, in the Bonaparte Basin, showing bathymetry, exploration wells and oil and gas fields.

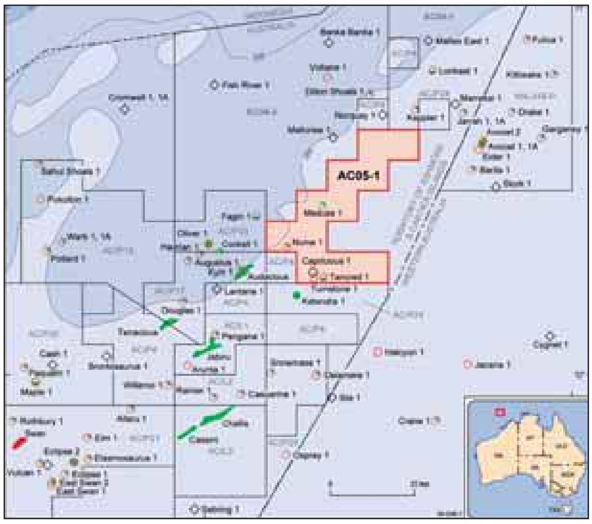


Fig. 4. Location of Permit AC05-1, in the Bonaparte Basin, showing exploration wells and oil and gas fields.

Permit Area Number of Bids	Operating Companies	Exploration Program
Bass Basin off Tasmania Permit T/42P (released as T04-3) Two bids	Bass Strait Oil Company Ltd.	A guaranteed work program of studies and 525 km of new 2D seismic surveying, at an estimated cost of $1.39 million. Secondary work program consists of studies and one exploration well, at an estimated cost of $15.6 million.
Bass Basin off Tasmania Permit T/43P (released as T04-4) Two bids	Bass Strait Oil Company Ltd.	A guaranteed work program of studies and 575 km of new 2D seismic surveying, at an estimated cost of $1.46 million. The secondary work program consists of studies and one exploration well, at an estimated cost of $15.6 million.
Browse Basin Permit WA-377-P (released as W05-4) Four bids	Nexus Energy Australia NL	A guaranteed work program of studies, the purchase of 150 sq km of 3D seismic data and one exploration well, at an estimated cost of $21.3 million. The secondary work program consists of studies and one exploration well, at an estimated cost of $20.3 million.
Bonaparte Basin Permit AC/P38 (released as AC04-1) Two bids	Eni Australia Limited	A guaranteed work program of studies and 1000 sq km of 3D seismic data reprocessing, at an estimated cost of $2.8 million. The secondary work program consists of studies and one exploration well, at an estimated cost of $20.3 million.
Bonaparte Basin Permit AC/P39 (released as AC05-1) Two bids	Auralandia N.L., National Gas Corporation Pty Ltd and Gascorp Inc.	A guaranteed work program of studies and one exploration well, at an estimated cost of $12.9 million. The secondary work program consists of studies, at an estimated cost of $0.6 million.

Weather Analysis and Forecasting: Applying Satellite Water Vapor Imagery and Potential Vorticity Analysis

by Patrick Santurette and Christo G. Georgiev

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Reviewed by Philip Riley, School of Professional Studies, Bureau of Meteorology Training Centre (p.riley@bom.gov.au)

Satellite images of the Earth have been used by meteorologists since the 1960s, and the images taken in the 10 to 12 micrometre wavelength range have become familiar to the general public through television weather news segments. These images provide a 24-hour per day picture of the movement of cloud systems but they do not provide weather information in cloud-free regions. This drawback can be overcome by using images in the 6 to 7 micrometre spectral region where water vapour is a strong absorber and emitter of radiation. Because the water vapour content (i.e. the relative humidity) of the atmosphere is variable, but tends to be related to flow patterns, these images not only reveal something of the distribution of water vapour, useful information in itself, but also give clues to what the atmosphere is doing, even in the absence of clouds. Although water vapour images have been available from European and United States geostationary satellites for over twenty-five years, and from the Japanese GMS series for over a decade, there has been relatively little available in monograph form for training weather forecasters in their interpretation. The book by Santurette and Georgiev helps to fill this gap and is to be welcomed for that reason. Its stated purpose is to provide operational meteorologists with a practical guide for interpreting water vapour channel imagery in combination with dynamical fields to enable weather analysis and forecasting.

An analyst trying to deduce the atmospheric flow field from water vapour imagery requires a conceptual model of atmospheric motions that can be related to the patterns in the images. Santurette and Georgiev use a model based on potential vorticity, a quantity related to the rotational component of the motion. Potential vorticity is conserved under conditions that are reasonably well approximated at the time and space scales of interest to weather forecasters. The first chapter of the book provides a brief review of potential vorticity and its use in monitoring the development of weather systems, following the approach of Hoskins and his co-workers (see, for example, Hoskins 19971). I found this chapter a little too brief. While it may provide a useful reminder for someone who had previously studied the topic in detail, I think that someone new to the concepts would have trouble following it.

Chapter 2 provides a basic introduction to the relationship between image grey scale value and the vertical distribution of water vapour at that location, providing a simplified treatment of atmospheric radiative transfer to do this. This should be sufficient for most readers of the book, but an appendix provides more detail for those wishing to delve further.

Chapters 3 and 4 deal with the practical use of water vapour imagery in conjunction with dynamical fields, including potential vorticity, derived from Numerical Weather Prognosis (NWP) models to analyse weather systems such as cyclones and jet streams (Chapter 3), and to assess NWP model performance and improve forecasts (Chapter 4). A large number of classes of synoptic situation are treated, each with at least one example fully illustrated in colour. All of the examples come from the North Atlantic or Europe, using Meteosat images and NWP model fields derived mainly from the Météo-France operational model. The assessment of the quality of NWP output, discussed in Chapter 4, uses three-way comparisons of actual water vapour images, synthetic images derived from the NWP output, and potential vorticity analyses. To fully use the techniques described one would also need access to such synthetic images.

The treatment of Chapters 3 and 4 presupposes a good knowledge of mid-latitude synoptic meteorology and considerable experience in interpreting meteorological analyses, particularly in the upper troposphere. The detail provided is at times overwhelming. It is not a book to be read cover to cover over a period of a few days, or even weeks, but to be used as a guide in a longer term study exploring water vapour imagery for oneself. There would be little point reading it unless one were prepared to do this, and had ready access to full resolution water vapour images, a variety of NWP model output and, ideally, the means to overlay the one on the other. In many cases the analyses that are overlaid on the satellite images may not be available to the reader. The book would still be useful in this case, though unless one could overlay at least potential vorticity, a major tool in the interpretation of the images would be missing.

In summary, this is a book for the experienced meteorologist who has the determination and patience work through it carefully, and access to water vapour imagery and NWP output to apply its lessons along the way. The reader would need a great deal of determination to work through it unaided as it is presented, though Chapters 3 and 4 do provide useful summaries to help locate particular interpretation problems. The book would be a very useful resource for a course in satellite image interpretation or mid-latitude synoptic meteorology.

Note: Low resolution water vapour images from the Japanese MTSAT-1R, whose field of view includes Australia, may be obtained from http://www.jma.go.jp/en/gms/index.html.

*Copies can be purchased directly from Elsevier Australia Customer Service on Tel: 1800 263 951 or email: service@elsevier.com.au