Preview

Australian Society of Exploration Geophysicists

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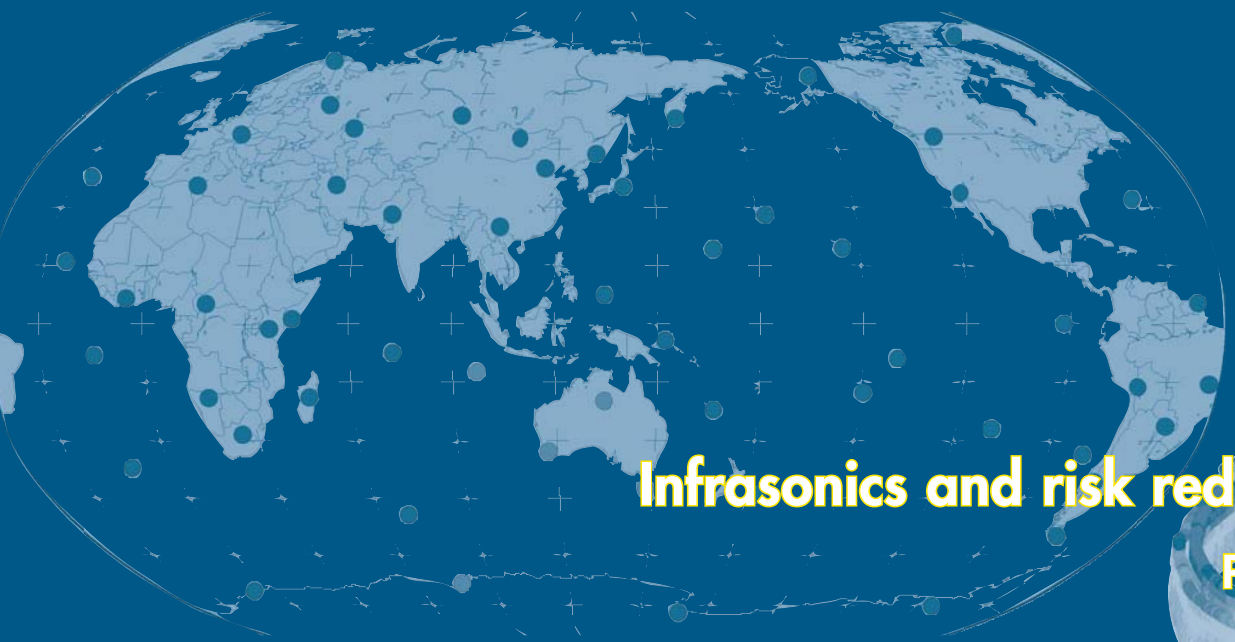

For the Record

We apologise for the delay in the publication of this issue of *Preview*. It was caused by technical problems in the publisher's office

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- Good interpersonal and communication skills.
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David Denham

Asia-Pacific Partnership fails to set targets or timetables to tackle climate change

Last year, David Letterman of CBS Late Show fame joked that as a solution to global warming George W Bush would "give the boys at Halliburton a 90-billion dollar contract to patch the hole in the ozone layer" and "convene a blue-ribbon committee to explore innovative ways of ignoring the problem".

Well so far Haliburton are still waiting for $90 billion but it can be argued that the blue-ribbon committee met for the first time in Sydney on 11/12 January this year.

It's called the Asia-Pacific Partnership on Clean Development and Climate and the member counties are America, Australia, China, India, Japan and South Korea. Together they account for roughly half of the world's population, economic output and greenhouse gases blamed for global warming. They include both the countries with the biggest total emissions (America and China) and the country with the biggest emissions per person (Australia). Only Japan has signed the Kyoto Protocol and is trying to reduce its carbon emissions.

In addition to energy and environmental ministers from the AP 6 countries, 120 senior business representatives from the electricity, mining, aluminium, cement, steel, finance and renewable sectors participated in the meeting. These included executives from Exxon Mobil, Rio Tinto, Peabody Energy and American Electric Power. It is noteworthy that no scientist was called upon to address the meeting on the likely future climatic trends.

According to the joint press statement from the Australian government "The outcomes of the Partnership's inaugural meeting have redefined the way climate change, energy security and air pollution will be addressed in order to encourage economic growth and development."

"This is the first time that industry has been afforded such an opportunity in global climate change discussions. The outcomes were unique and included:

- a recognition that clean development and lower greenhouse gas emissions requires economic growth as it is growth and investment that will deliver the new technologies to reduce emissions;
- agreement that governments and business must work together to achieve sustained economic growth and lower greenhouse gas emissions; and
- a public commitment to real actions.

The Asia-Pacific Partnership established eight government and business taskforces on (1) cleaner fossil energy; (2) renewable energy and distributed generation; (3) power generation and transmission; (4) steel; (5) aluminium; (6) cement; (7) coal mining; and (8) buildings and appliances."

However, the Partnership explicitly rejected mandatory caps or reductions as a useful way to cut emissions. Furthermore, the group's founding charter actually states several times that none of the commitments it contains is legally binding. Instead, the six will simply try to promote greener technology.

In other words, let's keep on burning coal because we will find ways to burn it cleaner and we will find ways to bury the CO_2 that we burn. So, no targets, no timetables (except to meet again in a year's time), no financial incentives to cut down on CO_2 emissions and pollution.

A solution very similar to David Letterman's.

What is really needed is a multifaceted approach. We need targets and timetables for the reduction of emissions, we need to conserve and be more efficient, we need research on the issues discussed at the AP 6 and we need governments with a real commitment to tackle the problem. If we don't take these actions, the economic and social consequences will far outweigh any short term economic gain.

However, it was good to read in the ABARE background paper that population is probably the most important factor in the climate change issue – it was a pity that no mention appears to have been made of this in the final communiqués.

I am one who believes that governments only get serious when they legislate, and I can't see too much of that in the pipeline on the impact of climate change.

David Denham

AGM Reminder

The 2006 AGM of the Australian Society of Exploration Geophysicsts will take place at 5.30 pm on 11 April 2006 at Chifley on the Terrace, St George's Terrace, Perth.

Be there to make a difference!

Contact Lisa Vella c/- ASEG Secretariat at <secretary@aseg.org.au> or 08 9479 8476 for more information.

Terry Crabb

A new year has begun, and the commodity boom appears to continue unchecked, which is good news for us all. I wish all ASEG members a healthy and very successful 2006.

2005 ended very sadly with the tragic death on December 19 of **Anita Heath**, who died as a result of a sailing accident on the Swan River. Anita was one of the most energetic and active members of the ASEG, and her passing is a very sad loss. Elsewhere in this *Preview* Craig Dempsey writes in glowing terms of Anita's very full and busy life. The accidental death of such a vibrant personality is a lesson to us all - live your life to its fullest and treasure every precious moment.

The **AGM** is scheduled for April 11 and all ASEG members have been advised in the previous edition of *Preview*.

There seems to be a move towards the Eastern States with regards membership of the Federal Executive. **James Reid**, (University of Tasmania) as current President-Elect is standing for President along with any other contenders for the position.

Phil Schmidt at CSIRO in NSW has taken over the role as Chairman of Publications, and a bio on Phil can be found elsewhere in this issue of Preview.

Koya Suto is planning to pass on the baton as Chairman of the Membership Committee to become the Australian "Country Representative" on the SEG Global Affairs Committee.

Many thanks to **Voya Kissitch** for his unheralded and long term voluntary efforts as the ASEG Web Master. Voya has been instrumental in keeping our website operational under the considerable constraints of an aged system which we have finally decided to upgrade.

One of the first tasks Phil has accepted in his new role as Chairman of Publications is to manage a contract with The Research Institute Ltd, a Gosford-based company, for the development of a new web site design. The development will include the establishment of a User and Content Management System incorporating the membership database, which will be integrated with the financial management system to provide improved web services to our members and an avenue to access our publications. I look forward with interest to the delivery of a new look website with increased functionality within the next month.

The Federal Executive has been involved with preparations for a number of forthcoming conferences.

- **Melbourne** will host the 18th ASEG Conference and Exhibition from **July 2 to 6, 2006.** In partnership with the GSA, this Australian Earth Sciences Convention looks destined to be one of the best, considering the number and quality of papers received.
- We have recently signed an agreement with the new **Perth** Convention Exhibition Centre to hold the 19th ASEG Conference and Exhibition **November 18-22, 2007**, with the Conference Organiser being Promaco Conventions and with PESA as a partner.
- The 34th International Geological Congress will be held in **Brisbane** in **2012**. We are considering signing an agreement with the AGC, the authorised organizing body, to participate financially and scientifically in this event, named AUSTRALIA 2012, the theme being "Unearthing our Past and Future".

The Federal Executive meets every last Wednesday of the month at the ASEG Secretariat's offices in Perth, with a teleconference link to participants elsewhere in the country. If you wish to have comment on any issue relating to your Society please contact myself , any other FedEx member or the Secretariat and we can discuss it at such meetings or respond directly.

If you wish to become more actively involved in your Society, then please consider proposing for a position on the Executive, to be elected at the AGM on April 11, 2006.

Calendar of Events 2006/2007

24 March 2006
BMR-AGSO-GA 60th Anniversary Dinner
Hellenic Club, Woden, ACT
An informal reunion for past and present staff, Auslig and State Geological Survey colleagues
Email: johnbain@tpg.com.au

2-6 April 2006
SAGEEP '06: 19th Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems
Organisers: Environmental and Engineering Geophysical Society
Venue: Seattle, Washington, USA
Email: staff@eegs.org
Website: www.eegs.org

19-21 April 2006
AAS Elizabeth and Frederick White Conference
Theme: Mastering the data explosion in the Earth and Environmental sciences.
Venue: Shine Dome of the Australian Academy of Science, Canberra
Website: http://rses.anu.edu.au/cadi/Whiteconference

1-7 May 2006
Australian Institute of Geoscientists 25th Anniversary Conference.
Theme: Outcrop to orebody - applied geoscience in exploration and mining.
Presentations will integrate modern theory, practice and procedure in the exploration and mining industry.
Website: http//:www.aig.asn.au/aig25.htm

7-10 May 2006
2006 APPEA Conference
Venue: Gold Coast Convention & Exhibition Centre, Qld.
Deadline for receipt of Abstracts 1 September 2005
Website: http://www.appea.com.au/conference/CallforPapers2006.pdf

12-15 June 2006
68th EAGE Conference & Exhibition
Venue: Vienna, Austria
Contact: http://www.eage.org/conferences/

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Australian Earth Science Convention Hots Up

With only five months to go before the Australian Earth Science Convention 2006, the program is filling out and top-class speakers are rolling in.

Hot speakers for hot topics

The conference has lined up an exiting group of Plenary Speakers for a daily Hot Topics session, including:

- Dr Tim Flannery (SA Museum): Environmental change
- Prof Steve Self (Open University): Volcanic eruptions and impact on climate
- Dr Nick Sheard (Inco): The mining industry and the future
- Dr Tom Whiting (BHP Billiton): Resources and innovation
- Dr Robin Batterham (RioTinto): Energy, uranium and geosequestration

Industry program: industry in action

This program is for people and companies involved in the search for and development of mineral and energy resources. Major themes will provide a framework for presentations encompassing exploration, project funding, investment opportunities, social & financial impacts and new discoveries. Seminars and poster displays will provide a networking focus for miners, explorers and resource analysts a source of information for investors, and a showcase for explorers, miners and investors, big and small.

- Early Morning sessions: Major Miners
- Late Morning sessions: Explorers,
- Miners & Energy Producers
- Early Afternoon sessions: Explorers, Miners & Energy Producers
- Late Afternoon sessions: Investing and Funding

For more information contact Geof Fethers (ghf@reedylagoon.com.au) the Program Coordinator.

Workshops and fieldtrips – integrating scientific interests in:

- Mineral resources
- Energy resources
- Environmental and engineering geosciences
- Geodynamics of Earth's evolution
- Resourcing and innovation

Hands-on workshops feature leading experts, covering topics from exploring the use of magnetic data, to seismic attribute mapping and creating complex 3D geological models. Case histories and live examples will round out the sessions, and leading research organisations will present their accomplishments.

A selection of field trips takes in world-class geological features, including the huge brown coal deposits of the Latrobe Valley, the beautifully preserved Quaternary maar volcanoes and lava flow tubes of the Newer Volcanics Province and the Waratah Bay outcrops of Cambrian greenstones and Ordovician limestones of the Lachlan Orogen.

A major workshop will present the annual showcase of Victoria's resource potential at the highly anticipated 18th VIMP Data Release (see page 5 of this *Preview*).

Full details, including costs, conditions, contacts and bookings available on the AESC website.

Remember: Early Bird registration closes 28 February 2006. $100 off the full registration price for Members and non-Members. Register now!

Visit: www.earth2006.org.au

Howard Golden

Kevin Dodds

An ASEG perspective at the SEG Convention, Houston

By Kevin Dodds and Howard Golden

Emails: golden1@iinet.com.au
kevin.dodds@csiro.au

The SEG's International Exposition and 75th Annual Meeting held in Houston was full of bustle, with over 8000 attendees, spread over a very large convention hall that took considerable time to traverse from one end to the other, even when not interrupted in the process. There was noticeable Australian representation from petroleum and mining in the booths throughout the exhibition as well as research institutions, the latter in the International Showcase, which this year had a very high profile and location. Given the breadth of topics, further detail in the technical program can be found at the SEG website: http://seg.org/meetings/past/seg2005/, although it is important to point out that this was the 'off year' for mining. The 2006 Conference, in New Orleans, will feature mining geophysics, consequently ideas for special sessions included uranium and other geophysical exploration advances and a luncheon speaker, who is not necessarily a geophysicist, but can comment on geophysicists' roles in the greater community would be greatly appreciated.

The ASEG is an affiliated society of the SEG and due to its size is granted three votes on council decisions. This year The ASEG was represented by John Hughes and the two authors, and we did our bit to keep it straight. In the Council, approval was given to a bylaw which aligns the Councils' Districts to the 12 regions of the Global Affairs Committee (GAC) of which the Pacific Region includes Australia, New Zealand, New Guinea, Malaysia and the Philippines, while Japan chose to share between Asia and the Pacific.

The GAC, represented through these Districts and which has had strong participation in the past from Norm Uren and Brian Spies, has received increased focus and importance within SEG priorities. The SEG has recognised its critical need to assume a global role in action and not just rhetoric to match the now dominant non-US proportion of members. Discussion in the GAC meeting revolved around how to engage in the transition to working with affiliate societies such as the ASEG and establishing active sections in areas that were not represented. It is recognised that many of the SEG activities were US centred and steps such as having meetings outside the US, establishing SEG secretariat support services in other countries and supporting international meetings, were all actions that needed increased emphasis. In fact Klaas Koster (ex-President ASEG) as retiring VP on the SEG Committee and GAC liaison was very active to define means to provide SEG benefits globally. These include DISC and now the Distinguished Lecturer Series, the Global Forum, and more emphasis in dispersing research grants outside the US.

International Showcase at the 2005 SEG AGM held in Houston, Texas. No prizes for spotting Howard Golden and Kevin Dodds.

The Asia-Pacific luncheon was very well attended with presentations from the Chinese geophysical company BGP International, President of the Indian Geophysical Society SPG and an excellent ASEG history presented by Norm Uren. The Global Forum featuring discussions on the effects of Peak Oil with CEOs of Schlumberger, ExxonMobil and the Chief Geophysicist from Apache brought out a clear message of the limited pool of specialists that companies draw on and that technical societies such as the SEG (and by inference ASEG) should be actively engaged in actions to increase that pool.

The Conference finished with the usually very popular technical workshops consisting of Marine Electromagnetics, Advanced Seismic Modelling, Estimation and Reliability of net-to-gross, Attenuation: What's to gain from seismic loss?", Improved Integration in petrophysics and rock physics modelling, Seismic Interferometry, daylight imaging and time-reversal, Low Frequencies and Seismic Exploration and Earthquake Seismology, in memory of Professor Keiiti Aki. Of these courses the Marine Electromagnetics and the Seismic Interferometry were oversubscribed and vibrant.

Gold gets a boost in Victoria

Opening the 3rd annual Victorian Gold Conference in Melbourne late last year, Mr Theophanous, the Minister for Energy Industries and Resources, said Victoria's gold industry was in the middle of a second boom.

"This is a very exciting time for the gold industry in Victoria. We now have more exploration activity and more development projects, which are creating more jobs and more wealth for Victorians – particularly in provincial Victoria."

He outlined some of the highlights for the minerals industry in Western Victoria including:

- The completion of new works at Leviathan Resources Stawell Gold Mine, securing its future operation.
- The construction of the $260 million Iluka Mineral Sands mine near Horsham and Mineral Separation Plant near Hamilton.
- Proposals for new multi million dollar mineral sands mines by Iluka near Ouyen, and by Astron near Donald.
- Extensive exploration and interest in gold and mineral sands throughout Western Victoria, including north of Stawell, St Arnaud, and for coal seam methane near Casterton.

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18th VIMP – Data release 30 June 2006

To coincide with the Australian Earth Sciences Convention, the 18th VIMP (Victorian Initiative for Minerals and Petroleum) data release is scheduled to take place on 30 June 2006.

Under the auspices of the State's Rediscover Victoria - new information and opportunities for the mining and exploration industry, the following products will be released:

New Products

- Geology and geophysical interpretation maps and report - Woods Point Walhalla
- Regolith geology map and report - Rupanyup
- Geophysical interpretation map and report - Bendigo
- Undercover prospectivity maps - Bendigo north
- Nickel prospectivity map - Victoria
- GIS DVD - Victoria
- Recently released digital open file exploration reports - Victoria

New Information

- Developing Gold Undercover - $9 M initiative
- Mineral seismic acquisition program
- DPI online shop
- GeoVic - on-line mapping application www.dpi.vic.gov.au/minpet/geovic
- Tour of DPI's new information centre and shop

To attend, register at
www.earth2006.org.au/registration.shtml
For more information contact
Paul McDonald on Phone: (03) 9658 4531
Email: paul.a.mcdonald@dpi.vic.gov.au

Cont'd from page 5

Victoria's earth resources and energy industries received a $27 million boost, announced as part of Moving Forward - the Bracks Government's $502 million action plan for growth in Provincial Victoria including $9 million for Developing Gold Undercover to attract greater investment for gold exploration to Victoria by investing in new pre-competitive geoscience data collected and delivered using modern technologies.

He said that "Current estimates suggest as much as 80 million ounces of gold are still left in Victoria - with a market value of about $50 billion.

Exploration is the lifeblood of the resources industry and studies show that new geoscience information acts as a major stimulus to increased exploration and discovery."

The Delivering Gold Undercover is a new Victorian Government initiative of $9 million (over 3 years) aimed at delivering the new geoscience insights and techniques required to discover the potentially large undiscovered gold resources presently concealed under cover in Victoria. It aims to stimulate the research and exploration communities in Victoria and help re-establish regional Victoria as a leading gold producer by delivering:

- A predictive mineralisation model for the state that uses 3D geology and fluid flow modelling to indicate regions of higher gold potential.
- An exploration 'toolkit' using the key characteristics of Victorian gold deposits to assist companies in targeting more highly prospective area
- A new and improved resource assessment for the existing Victorian gold endowment
- The development and population of new geoscience information systems together with improved online information delivery mechanisms

Good words from a very upbeat Minister.

ASEG officers

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Australian Society of Exploration Geophysicists - Honours and Awards

ASEG members are invited to submit nominations for the next round of ASEG Honours and Awards. Nominations that are judged to be appropriate and are then subsequently selected will be presented at the 18th ASEG conference, in Melbourne, July 2-6, 2006. Details of the available awards follow.

1. 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. The nominee must be a member of the ASEG.

2. Honorary Membership

For distinguished contributions by a member to the profession of exploration geophysics and to the ASEG over many years. Requires at least 20 years as a member of the ASEG, except where the nominee is a recipient of the ASEG Gold medal.

3. 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. The nominee does not need to be a member of the ASEG.

4. Lindsay Ingall Memorial Award

For the promotion of geophysics to the wider community. This award is intended for an Australian resident or former resident for the promotion of geophysics, (including but not necessarily limited to applications, technologies or education), within the non-geophysical community, including geologists, geochemists, engineers, managers, politicians, the media or the general public. The nominee does not need to be a geophysicist or a member of the ASEG.

5. 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. The nominee will have been a member of the ASEG for a significant and sustained period of time and will have at some stage been one of the following:

Federal President, Treasurer or Secretary,
State President, Conference Chairman or Standing Committee Chairman
Editor of Exploration Geophysics or Preview

6. ASEG Service Certificates

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

Nomination Procedure

For the first four award categories any member of the Society may nominate applicants. These nominations are to be supported by a seconder, and in the case of the Lindsay Ingall Memorial Award by at least four geoscientists who are members of an Australian geoscience body (eg GSA, AusIMM, AIG, IAH, ASEG or similar). Nominations for the ASEG Service Medal and the ASEG Service Certificates are to be proposed by the State and Federal Executives.

All aspects of the criteria should be addressed, and a nomination must be specific to a particular award. To gain some idea of the standard of nomination expected, nominees are advised to read past citations for awards published in Preview.

Nominations including digital copies of all relevant supporting documentation are to be sent electronically to:

Chairman, ASEG Honours and Awards Committee
Email: bill@sgc.com.au
Tel: 08 9316 2814
Fax: 08 9316 1624

Applications will close on May 2nd 2006

AUSTRALIAN CIVIL HONOUR AWARDS

Distinguished ASEG members may also be nominated for one of the following Australian Civil Honour Awards

Companion in the Order of Australia (AC)
Officer in the Order of Australia (AO)
Member in the Order of Australia (AM)
Medal of the Order of Australia (OAM)

Such nominations should be made directly using the following website: http://www.itsanhonour.gov.au/about/medal_descriptions/order_of_australia.html

Peter Lilly to lead Exploration and Mining in CSIRO

Professor Peter Lilly has been appointed Chief of Exploration and Mining in CSIRO. The announcement was made by Geoff Garrett on 9 January this year. Peter will be based at the Australian Resources Research Centre in Perth where he will start work on 15 May.

He is currently Professor of Mining Engineering at the Curtin University of Technology and Director of the Western Australian School of Mines. Peter's work experience covers both the private and public sectors. His private sector engagements have included Snowden Mining Industry Consultants, Dames and Moore International, Freeport McMoRan Australia, ICI Australia Operations and Hamersley Iron.

Peter's public sector experience includes his current positions, the University of Queensland (JKMRC) as well as CSIRO Exploration and Mining, where he was variously Program Manager, Acting Deputy Chief and General Manager from 1993 to 1997.

Peter is internationally known for his expertise in quantitative risk assessment, geotechnical engineering and related aspects of mine planning/design and has worked on projects in 15 countries. He has been committed to technology and industry uptake and his publications have appeared in prestigious journals such as Nature, Tectonophysics, The Journal of Geophysical Research and the International Journal of Rock Mechanics and Mining Sciences.

Peter took over the Presidency of the Australasian Institute of Mining and Metallurgy, in January 2006. He is on the Boards of Australian Prospectors & Miners Hall of Fame and the Australian Centre for Geomechanics as well as being Chairman of Kalgoorlie Consolidated Gold Mines' Community Reference Group.

Peter was educated in South Africa, and migrated to Australia over twenty five years ago after completing his PhD at the University of Witwatersrand and starting his career as a lecturer in Geological Engineering at Wits and Research Engineer at the South African Chamber of Mines' Research Organisation.

In his current role as Director of the Western Australian School of Mines Peter has brought about a significant and positive change in its academic status and research output. He will bring to the Division of Exploration and Mining wide industry experience and a strong record of strategic leadership as well as knowledge of the Division's activities. The ASEG wishes him well in his new role.

Phil Schmidt now heads ASEG Publication Committee

Phil Schmidt has recently been appointed to chair the very important ASEG Publications Committee. Phil has been a member of the ASEG since 1971. He gained his BSc (Hons.) from UNE in 1972 and a PhD in Geophysics from ANU in 1976 specialising in palaeomagnetism. After a post-doctoral position in Ottawa with the Earth Physics Branch he returned to Australia in 1978 to take up a position with CSIRO Mineral Physics. Since then he has collaborated with colleagues in research organisations and industry on many magnetic exploration projects developing instruments and software tools for interpretation. He is currently a Senior Principal Research Scientist at CSIRO working mainly on applying magnetic gradient tensor measurements to the marine environment. His extensive and impressive publication record and his experience with industry provide an excellent background for this position. Phil's email address is phil.schmidt@csiro.au.

New members

The ASEG welcomes the following new members to the Society. Their membership was approved at the Federal Executive meeting on 30 November 2005.

Luke David Hugh Fredericks	
BHP Billiton	*NSW*
Allen Rodeghiero	
BHP Billiton	*NSW*
Imam Sarjono	
CGG Australia Services Pty Ltd	*WA*

Vale – Anita Heath 1955 – 2005

On December 11, 2005 a tragic sailing accident on the Swan River, lead to the death of Anita Heath one week later on December 19th. She was a well respected and loved member of the petroleum and geophysical communities. This was evident in the huge attendance at her funeral service held on the December 28, 2005 and the many floral tributes sent to her family from around the world.

Most readers of this journal will know Anita as one of the first editors of *Preview*, carrying out this job from 1988 to 1992. During this period she oversaw Preview's growth across 22 issues from a news-sheet to a multi-page magazine containing news, regular columnists and short technical articles.

However, to the society she was much more than this, and served it with distinction in various roles for twenty years, including the WA State Branch Committee (1986 to 1988 and 2003), Federal Executive Committee (1989-1991), Perth Conference Committees (1987, 1994 and 2000) and Chair of the WA DISC Committee (2003-2005). For this work she was awarded the Society's Service Medal at the 2003 conference in Adelaide.

Anita was born in Cuckfield, England in 1955, as the eldest child to Tom and Anne Robson and grew up in the south of England. Within her family she was named as a wild woman for her strong will and quick-fire temper, which would disappear as quickly as it flared, leaving no ill will. At school Anita was an active sports-woman participating in many different activities. This sporting prowess carried through to adulthood when she played A-grade tennis and B-grade squash. In recent years she had taken up the endurance sport of rogaining, often outlasting younger competitors, and after taxiing her eldest daughter to rowing was giving that a go as well.

Growing up on the South Downs of England and fossicking for fossils along the chalk cliffs kindled an interest in the earth sciences and Anita moved to Nottingham to complete an honours degree in geology in 1978. While at university she became a member of her first committee, running the social side of orientation week. This gave her an opportunity to increase her own social life by having free

Careers Presentation Night - All Saints College 18 months ago - Display provided by Curtin University of Technology.

entry to all the events. At university Anita also developed the self discipline and strong organisational skills that allowed her to participate in all the endeavours of her later life with equal commitment and intensity.

On completion of her degree Anita joined SSL as a seismic processor, which eventually led to her immigrating to Australia in 1980 in company with her first husband, Steve Jones. After some years processing Cooper Basin seismic, they moved to Western Australia. Here Anita worked for several years as a processing geophysicist, both in the city and the field, with several companies including EERC, Hosking Geophysical, GSI and Tensor. She would often find herself the only female on the seismic crew, but her good nature and extreme professionalism would always stand her in good stead.

Unfortunately this period of time saw the breakup of her marriage but it was also when she initially met her second husband, David Heath. However, it was some years before they would marry and have their two daughters, Anne and Verity, who would become the focal point for her life. In 1985 Anita's career changed direction from processing to interpretation and from then until her death she worked for Cultus, WMC, Woodside, Shell and recently as a consultant geophysicist through her own company and ECL.

Away from work Anita was a lady who actively engaged life rather than passively floating through it. Being highly community-spirited she found it difficult to say no, and apart from her ASEG work she was heavily involved in various committees associated with her children's schools and with her and her family's sporting and cultural activities. So much so that at the time of her accident she had yet to tell Dave of her presidency of the school music support group.

To all of us whom Anita knew, she was a bright light in our lives. Her easy, out-going, enthusiastic and non-judgmental personality allowed her to fit in with all groups of people, both professional and social. She will be greatly missed by Dave, Anne and Verity and all of us across the world whose lives she touched.

Compiled by Craig Dempsey

Australian Capital Territory – by Adrian Hitchman

ACT members enjoyed a convivial Christmas function with the ACT Branch of the GSA in December. Members of both societies relaxed at a BBQ in the picturesque grounds of the Research School of Earth Sciences, ANU, and relished the opportunity to meet old friends and make new ones on a balmy Canberra evening. Guests were challenged and entertained by quiz master Leonie Jones. The function was a pleasant precursor to the ASEG-GSA Earth Science Convention in Melbourne in July, and the success of the evening bodes well for the joint convention.

ACT members have been delighted with the wines provided by the SA Branch in the 2005 wine offer. We are grateful to the SA Branch (and a little envious) for their extensive efforts to sample a number of wines before selecting two excellent wines to offer to the society. Many thanks from ACT members and congratulations on a job well done!

Members and guests are invited to the ACT branch AGM which will be held at Geoscience Australia on 21 February. Following the business, outgoing President Jacques Sayers will outline the exciting work he and his team have been doing on CO_2 sequestration as part of the CO2CRC. All are welcome; refreshments will be provided.

Throughout 2006 the ACT Branch will continue its regular program of talks from invited guest speakers together with other activities of professional interest to its members. New members and visitors who may wish to participate in branch activities are always welcome. Please contact the Secretary, Adrian Hitchman (02 6249 9800, adrian.hitchman@ga.gov.au), or President, Jacques Sayers (02 6249 9609, jacques.sayers@ga.gov.au), with enquiries.

South Australia - by Selina Donnelley

The Annual ASEG Student night was held on the 23rd of November, and the SA Branch were pleased to have three excellent presentations made by Honours students from the University of Adelaide, the Australian School of Petroleum and Flinders University. Diana Plavsa from Adelaide University gave an interesting talk entitled: Crustal structure and tectonic evolution of the Litchfield Province, Northern Territory using integrated geophysical/petrological approach. Diana's work included Magnetotelluric traverses and metamorphic studies which were combined to give a better understanding of the evolution of the Litchfield region, south-west of Darwin. David Spence from the ASP, who was awarded the prize for Best Presentation, gave a talk entitled: Seismic facies-based reservoir characterisation of a deepwater Miocene canyon complex,

Cont'd on page 11

Cont'd from page 10

offshore NW Africa. He described the mapping he had undertaken and attempted to identify lithologies from seismic for a canyon complex and answered the tough questions from the audience well. The winner of the Best Paper Award was Roger Cranswick from Flinders University for his talk: Regolith controls on surface water – ground water interaction. Roger had a good contingent of fellow students and family present, and gave an excellent talk detailing interesting field work conditions and geophysical modelling combined with shallow well-bore studies in the Adelaide Hills. All three students gave excellent, confident presentations, and we wish them well in their careers.

The ASEG Christmas Party was held on Wednesday 14th of December on a warm Adelaide evening. A gourmet BBQ, nibbles and healthy quantities of drinks helped the SA Branch members celebrate another successful year in the geoscience community.

We again thank our sponsors for technical meetings in 2005: PIRSA, Schlumberger, Santos, Cooper Energy, Australian School of Petroleum, Minotaur Resources, Petrosys, Zonge Engineering, Beach Petroleum, Stuart Petroleum & PGS Reservoir. We hope to include this generous group again in 2006 as sponsors for the SA Branch.

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

Cont'd from page 3

2-6 July 2006
The Australian Earth Sciences Convention 2006 ASEG, in collaboration with GSA; ASEG's 18th International Conference and Exhibition, and GSA's 18th Australian Geological Convention
Venue: Melbourne, Vic.
Website: www.earth2006.org.au

24-27 July 2006
AGU Western Pacific Geophysics Meeting
Sponsored by the AGU, 10 Chinese societies and many others
Venue: Beijing, China
Website: http://www.agu.org/meetings/wp06/

1-6 October 2006
SEG International Exposition & 76th Annual Meeting
Venue: New Orleans, Louisiana, U.S.
Contact: http://seg.org/meetings/calendar

5-8 November 2006
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/

16-28 November 2006
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

18-22 November 2007
ASEG's 19th International Conference and Exhibition, Perth, WA
Contact: Brian Evans
Email: brian.evans@geophy.curtin.edu.au

$370 million for new research projects

As reported in the December 2005 *Preview* the Government announced the allocation of $370 million, on the advice of the Australian Research Council, to 1214 new research projects in November 2005. The bulk of the money ($274 million) was allocated for 917 ***Discovery Grants,*** followed by $59 million for 194 ***Linkage Grants.***

Mineral Research Institute off to flying start

The mineral resource industries fared well with the new ***Australian Mineral Science Research Institute*** (AMSRI) awarded $8.64 million over five years. This is believed to be the largest Linkage Grant of this type awarded by the ARC.

AMSRI is based in Adelaide and is a consortium of four major Australian research centres, including the Ian Wark Research Institute in SA; the Julius Krutschnitt Mineral Research Centre at the University of Queensland; the Australian Research Council Special Research Centre for Multiple Processes at the University of Newcastle; and the University of Melbourne's Australian Research Council Special Research Centre for Particulate Fluids Processing. It came into being in January this year.

John Ralston - Director of the Ian Wark Research Institute - will be the CEO of AMSRI, which is also receiving $2.5 million from the SA government, $7.5 million from the Australian mining industry and $4 million from the Universities of South Australia, Queensland, Newcastle and Melbourne combined. In-kind support from 24 industry organisations and the universities brings the total value of support to $30 million.

Although it appears that the centre will focus initially on mineral processing research the SA Premier Mike Rann stated that he hoped that "Research facilities like this will maximise the benefits of exploration, production and processing."

Well done AMSRI!

Funding for Discovery Projects gets harder

Discovery Projects aim to support excellent fundamental research by individuals and teams; to expand Australia's knowledge base and research capability; and to encourage research training in high-quality research environments.

Table 1 shows a summary of the funds provided for Discovery Projects in the last three years. Notice how the success rate has steadily declined even though the funding has increased in the same period.

	2004	2005	2006
Applications received	3,260	3,441	3,766
Applications funded	875	1,055	917
Average total grant size	$271,939	$282,030	$298,350
Success Rate (%)	27.0	30.9	24.5
Total bids for funding (million)	1160.6	$443.7	$496.1
Total funding approved (million)	$238.0	$295.5	$273.6

Table 1. Discovery Project funding, 2004 through 2006.

Interestingly, the success rate (23.8%) for projects (165) approved not under the National Research Priority umbrella was very similar to the overall success rate of 24.5% for the 917 projects.

It makes one wonder about the point of having National Research Priorities.

ANU and Sydney top the list

Seven institutions received funding of more than $10 million. These are all part of the Group of Eight Universities. The University of Adelaide was the only Go8 representative not to make the $10 million mark. But it was not far short with a total allocation of $9.8 million. Notice that the success rates of the top two universities (Sydney and The ANU) stand out above all the others, but the rest were close to the average of 24.5%. (see Table 2)

Success rate for Linkage Projects also declines

The ***Linkage Projects*** scheme funds collaborative projects between University researchers and Collaborating Organisations. The prime objective of a linkage project is to:

- encourage and develop long-term strategic research alliances between higher education organisations and other organisations, in order to apply advanced knowledge to problems and/or to provide opportunities to obtain national economic, social or cultural benefits.

As can be seen in Table 3 the success rate has dropped considerably from more than 50 percent to close to 35 per cent in one year and the number of grants has fallen from 237 to 194.

Successful Applicants

The list below contains all the geoscience-related grants awarded. I may have missed some because one has to troll through each organization to find the geoscience results.

Where the projects relate to geophysics and exploration the project summary is also included.

Geoscience-related Linkage Projects[1,2]

A highly sensitive mass spectrometer for trace analysis of biomarker molecules to study changes in recent and ancient environments

Researchers: JJ Brocks, GD Farquhar, K Grice, RR Haese and R Shalliker
Funding: 2006: $390,700
Partner Organisations: ANU[3], Geoscience Australia, Curtin University of Technology and University of Western Sydney

Project Summary: Maintaining the quality of water and soil is a critically important issue for Australia's economic and social development. To be able to predict and plan the future of our natural assets, it is critical to understand their ecological past and their state before and after European settlement. We will utilize the new instrument to develop

1 Discovery Grants will be listed in the April issue of *Preview*
2 Project summaries not listed can be obtained either the editor or from the ARC website.
3 Administering organisation in bold

Institution	Applications received	Approved Applications	Success rate %	Total Allocation 2006-2010
University of Sydney	340	115	33.8	$40,397,958
Australian National University	358	113	31.6	$36,184,535
University of New South Wales	366	91	24.9	$26,336,559
University of Queensland	310	83	26.8	$26,090,661
University of Melbourne	353	91	25.8	$25,252,574
Monash University	269	70	26.0	$20,944,806
University of Western Australia	162	41	25.3	$14,106,734

Table 2. Top seven institutions for Discovery Projects.

	2004	2005	2006
Applications received	581	463	529
Applications funded	301	237	194
Average total grant size	$230,225.	$282,030	$301,546
Success Rate (%)	51.8	51.2	36.7
Total bids for funding (million)	$128.0	$109.1	$149,1
Total funding approved (million)	$69.3	$55.5	$58,5

Table 3. Summary for Linkage Projects starting 2004 to 2006.

Administering organisation	Projects Approved	Success rate %	Funding over project life	Partner Contribution
University of South Australia	9	43	$10,106,538	$16,393,023
University of New South Wales	22	47	$7,235,150	$9,377,236
University of Melbourne	19	42	$4,512,415	$6,283,986
University of Queensland	16	43	$4,439,000	$8,222,279
Australian National University	13	57	$3,745,402	$5,042,527

Table 4. Results from top five Organisations for Linkage Projects Round One 2006

and apply innovative technologies providing Australia with new knowledge about the causes and effects of toxic cyanobacterial blooms, eutrophication, and contamination of reservoirs by bush-fires. The new facility will also supply advanced oil fingerprinting techniques to the petroleum industry minimizing exploration risk and increasing the chance of the discovery of new oil deposits..

Instrumentation for combined seismic and electromagnetic earth sounding

Researchers: BL Kennett, GS Heinson and SY O'Reilly
Funding: 2006: $350,000
Partner Organisations: The ANU, University of Adelaide and Macquarie University

Project Summary: The set of geophysical recorders will provide the means to enhance understanding of the structure of the Australian continent in 3D. The interpretation of multiple images of Earth structure will help to link features in the crust and mantle beneath, and provide controls on the evolution and assembly of the present continent, with a major contribution to possible geotransects as recommended in the 2003 National Strategic Plan for the Geosciences. Combining seismic and electromagnetic methods will provide both geochemical and geophysical constraints, e.g., on zones of alteration and shear with the potential for deep mineralisation.

An Advanced Computed Tomography Facility - high capacity and high resolution for dynamic studies in porous and granular materials

Researchers: TJ Senden, MA Knackstedt, WV Pinczewski, ST Hyde, A Sakellariou, AP Sheppard, V Robins, CH Arns, T Aste, RM Sok, A Limaye and Y Cinar
Funding: 2006: $240,000
Partner Organisations: The ANU and The University of NSW

Project Summary: Characterising complex materials in 3D is an emerging discipline which is driving design concepts for new materials and assists in understanding properties of real world materials. The ANU/UNSW collaboration has developed an internationally recognized program in this emerging discipline and successfully applied the technology to applications in the oil and gas industry, groundwater remediation, tissue engineering, medical diagnosis of osteoporosis, granular packing and the design of new materials. The present application will give the collaboration

the ability to study a larger number of systems and to image the dynamics of materials in 3D. This will significantly broaden the impact and scope of the applications of this new technology.

A new X-ray spectrometer facility for VIEPS: major and trace element characterisation of geological materials

Researchers: JD Woodhead, JM Hergt, MW Wallace, IA Nicholls, RA Cas and IS Buick
Funding: 2006: $186,000
Partner Organisations: The University of Melbourne and Monash University

Project Summary: Australia has a well-earned reputation as a leading innovator in analytical geochemistry and the acquisition of this instrumentation will reinforce that standing. The equipment will support a broad range of research activities and enhance our capability for research training at Honours and post-graduate student level. In addition this project addresses directly our current National Research Priority 'an environmentally sustainable Australia', and priority goals 'Developing deep earth resources' and 'Responding to climate change and variability'

Western Australia Palaeomagnetic and Rock-magnetic Facility

Researchers: Z Li, ME Barley, PA Cawood, LB Collins, MC Dentith, IC Fitzsimons, DW Haig, SA Pisarevsky, SM Reddy, MT Wingate, K Wyrwoll, ZQ Chen, and IM Tyler
Funding: 2006: $246,000
Partner Organisations: The University of WA, Curtin University of Technology and the Geological Survey of WA

Project Summary: The WA Palaeomagnetic and Rock-magnetic Facility is an essential piece of infrastructure for geoscience developments in WA and Australia in general. It not only serves the needs of the scientific community, but also supports resource-related projects sponsored by government and the resource industries, and serves the educational needs of postgraduate, undergraduate, and school students. Upgrading of the WA facility will enhance the research capacity of the WA geoscience community and maintain its international position in tectonic, palaeogeographic, and palaeoclimatic studies, and in ore genesis research.

Aiding the search for diamonds in South Australia: source and origin of Mesozoic kimberlite dyke swarms and their mantle samples

Researcher: JD Foden
Funding:
2006: $90,006
2007: $88,796
2008: $90,238
Partner Organisations: The University of Adelaide, Flinders Diamonds Ltd and Primary Industry and Resources South Australia

Project Summary: Because of significant, yet tantalising, alluvial diamond discoveries in the Adelaide Hills and Flinders Ranges over more than 100 years, South Australia can be viewed to have considerable potential as a diamond producer. Yet this potential is unresolved because little is known about the occurrence and diamond content of the kimberlite source rocks that have carried the diamonds to the near surface and shed them into the weathering environment. This collaborative research project will use new uncommonly available samples provided by commercial diamond exploration to determine the structure, geochemistry and history of the mantle that underlies the Flinders Ranges and Adelaide Hills at depths between 40 and 250 km.

Dynamic gas permeability investigations of highly stressed coals

Researchers: V Rudolph, J Esterle, SD Golding; and P Massarotto
Funding:
2006: $140,000
2007: $130,000
2008: $130,000
Partner Organisations: University of Queensland and Santos Ltd

Project Summary: Coal Bed Methane (CBM) is an emerging energy resource in Australia, which has multi-billion dollar CBM reserves. Gas is clean burning, produces little greenhouse gas and almost no disruption to surface activities (like farming) during extraction. These environmental benefits, with low cost, make gas the fuel of choice for power and heat worldwide. This project seeks to assist development of CBM engineering from deep coal seams. These contain the most gas, but are technically more difficult to develop than shallower reservoirs. In particular, it examines how natural and induced stress fields can be used to improve productivity, by understanding the relationships between different coal types, their environment and gas production rate.

Australian Mineral Science Research Institute: transformation of resource-based industries through the generation and application of new technologies

Researchers: J Ralston; TW Healy; GJ Jameson; DV Boger; DY Chan and TJ Napier-Munn
Funding:
2006: $1800,000
2007: $1800,000
2008: $1800,000
2009: $1500,000
2010: $1500,000
Partner Organisations: University of SA, AMIRA International and Primary Industries & Resources SA

Project Summary: The research conducted within AMSRI will enable our existing resource-based industries to be transformed through the application of new technologies,

helping to create an environmentally sustainable nation, a key national research priority. The research programs in energy efficient liberation, frugal water use and waste management, innovative processing, material and interface science, advanced analysis and mathematics in minerals processing are of critical importance to Australia's major export industry. AMSRI will produce unique graduate students, educated in a multi-university, industry-linked research environment, who will provide a strong intellectual resource to both Australian industry and research institutions.

Model studies of the wettability of reservoir and seal rocks as recovered and after treatments to alter surface properties

Researchers: R Sedev, J Ralston, JG Kaldi, MB Clennell, D Dewhurst, PJ Boult, NP Tupper and RJ Suttill
Funding:
2006: $75,000
2007: $75,000
2008: $75,000
Partner Organisations: University of SA, Primary Industries and Resources SA, Santos Ltd and Origin Energy Ltd

Project Summary: Key contributions will be made to the science that underpins petroleum recovery. The combination of diverse expertise in interfacial physics and chemistry, petroleum geology and petrophysics provides a large innovative potential for the industry. Two graduate students will be educated in a rich multi-disciplinary research environment with a strong emphasis on both academic and industrial aspects of the problems. The research conducted will enable the industrial partners to improve existing technologies for predicting where oil and gas is trapped and for petroleum recovery.

Genesis of platinum group element-rich, unconformity-style, hydrothermal mineral deposits, as inferred from a Northern Territory example

Researcher: GJ Davidson
Funding:
2006: $24,650
2007: $24,650
2008: $24,650
Partner Organisations: University of Tasmania, and NTGS

Project Summary: Mineral products currently provide a great deal of Australia's exports to international markets, and underpin much of our economy. However, Australia can only maintain this position through continued improvement of mineral discovery rates, particularly for high value, deep earth resources. This project aims to improve the likelihood of the discovery of higher value hydrothermal orebodies. This will improve the value of mineral exports, raise exploration levels in some Australian provinces (thus stimulating economic activity in regional and industrial sectors), and help invigorate training within the geoscience arm of the university sector.

Biogeography and evolution of Australia's fossil reptiles: a global perspective

Researchers: MS Lee, BP Kear and MW Caldwell
Funding:
2006: $10,000
2007: $10,000
Administering Institution: The University of Adelaide

ASEG Research Foundation

Project Results

The ASEG Research Foundation has been supporting students in all facets of Applied Geophysics at the BSc (Honours), MSc and PhD (or equivalent) levels for 15 years. In this issue of Preview we provide a summary of a research project undertaken at The University of Adelaide

ASEG Research Foundation Project RF05M03:

A 3D resistivity crust and mantle model of the Gawler Craton, South Australia

Student: Rachel Maier; Honours Student 2005 at the School of Earth and Environmental Sciences, The University of Adelaide
Supervisor: Graham Heinson (University of Adelaide) Funding: $3143

Project Summary

Little is known of the broad-scale electrical resistivity structure of the Gawler Craton in South Australia. This study aimed to develop a 3D model of the Gawler Craton based on magnetotelluric (MT) and geomagnetic depth sounding (GDS) data, in order to define the framework of the craton and identify potential zones of mineralisation. The resistivity depth profile for the 3D model and mantle properties were determined from 8 new long-period MT sites. The sites were approximately 70 km apart and collected over the Gawler Range Volcanic of the Gawler Craton. A large-scale electrically anisotropic zone with lower resistivity than could be explained by dry olivine was found between the Moho and the base of the lithosphere, 40 to 150 km (Figure 1). The anisotropy may be due to mineral alignments from past deformation events and the deposition of graphite along aligned grain boundaries. This graphite could also account for the decrease in resistivity within this zone. The asthenosphere (150 – 400 km) was 180 Ω.m less resistive than dry olivine. This decreased resistivity could be explained by the incorporation of 100 ppm (parts per million) of hydrogen as a charge species into the olivine (Figure 1).

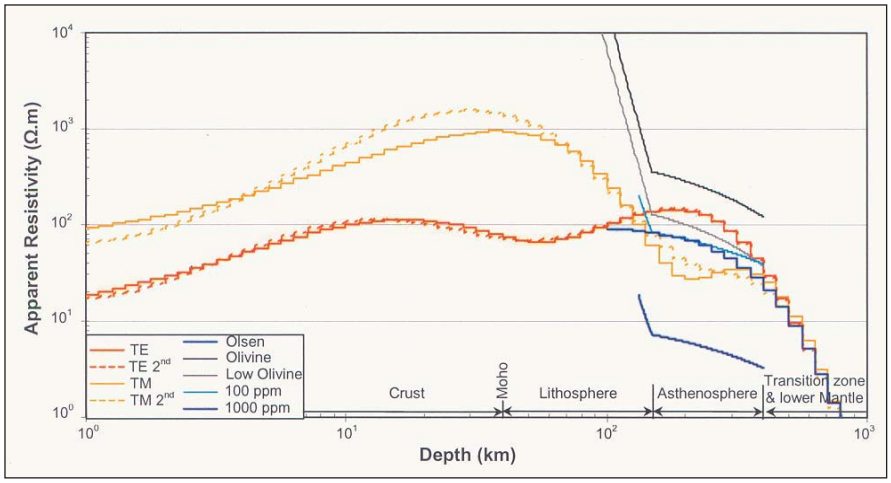

Fig. 1. Apparent resistivity depth profiles for TE and TM modes of the MT response, produced by 1D Occam inversion (bold red and yellow line respectively). Expected apparent resistivity values for dry olivine (black), its lower resistive limit (grey) and olivine containing 100 and 1000 ppm of hydrogen (light and dark blue respectively). The depths of significant layers within the earth beneath the Gawler Craton are indicated.

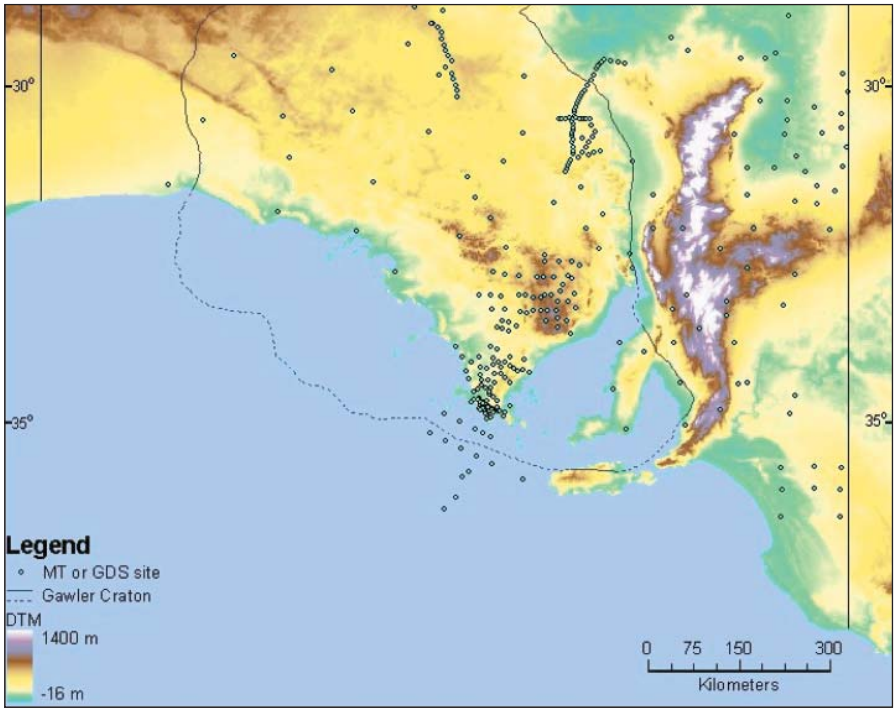

Fig. 2. The digital terrain model (DTM) of South Australia with the outline of the Gawler Craton indicated by the black line. All MT or GDS sites are shown.

A 3D model of the crust was developed using 2D inversions of regional profiles (> 900 km) and was based on a newly created database containing 385 MT and GDS sites from surveys in South Australia (Figure 2). The Gawler Craton was found to have a central, almost circular resistive core (~2500 Ω.m), surrounded by conductive crustal bodies (~100 Ω.m). The core was not associated with any geological boundaries and incorporated some of the Archaean complex and smaller Proterozoic blocks. The edge of the resistive core corresponded to known mineralisation, potentially making the mapping of large-scale resistive cores a method for identifying zones of mineralisation.

Key words: Asthenosphere, Electrical resistivity, Electromagnetic modelling, Lithosphere, Magnetotellurics.

Otway Basin chosen as first geosequestration demonstration project

The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) announced plans, on 9 January 2006, to conduct the first carbon dioxide (CO_2) geosequestration project in Australia.

Geosequestration is the geological storage of CO_2 in deep rock formations and is an important option for making cuts in greenhouse gas emissions to the atmosphere, along with improved energy efficiency; switching to less carbon-intensive fuels; and using renewable energy.

The Chief Executive of CO2CRC, Peter Cook, said: "Preliminary project assessments have already taken place and work would begin in early 2006. The injection of CO_2 into deep geological formations was expected to begin late this year or early in 2007.

The research project, which will be situated in the onshore Otway Basin in western Victoria, will cost around $30 million and involve approximately 40 Australian and overseas researchers. It will meet Victorian government planning and environment requirements.

The project will simulate the capture of CO_2 from a power station by using the CO_2 from a naturally occurring source; transporting it over several kilometres by pipeline; and storing it about two kilometres beneath the Earth's surface.

Wells in the onshore Otway Basin have a history of providing significant quantities of CO_2 and it is hoped that approximately 100,000 tonnes will be extracted and re-buried there over a two year period.

It is understood that the Buttress-1 and Naylor-1 (see Figure 1) wells are most likely to be used for the project. They are located about 30 km WNW of Peterborough.

Buttress-1 was completed in early 2002 as a potential gas producer. The well logs indicated the presence of a 46 m gross gas column containing approximately 18 m of net reservoir-quality sandstone at a depth of about 1600 m in the Cretaceous Waarre Sandstone.

For the demonstration project the well is likely to produce CO_2 and methane. The methane will be used to power the compressors and other machinery needed to separate, capture and transport the CO_2 (see Figure 2).

Naylor-1 also targeted the Warree Sandstone and was drilled to a depth of approximately 2200 m in 2001. Naylor will be used as the storage well. Both wells were drilled by Santos (90%) and Beach (10%) in PEP 154.

The behaviour of the stored CO_2 will be monitored closely using very sophisticated techniques that can detect and track the CO_2 deep beneath the Earth's surface from a new well to be drilled close to Naylor-1. This part of the project will involve the Lawrence Berkeley National Laboratory based in California.

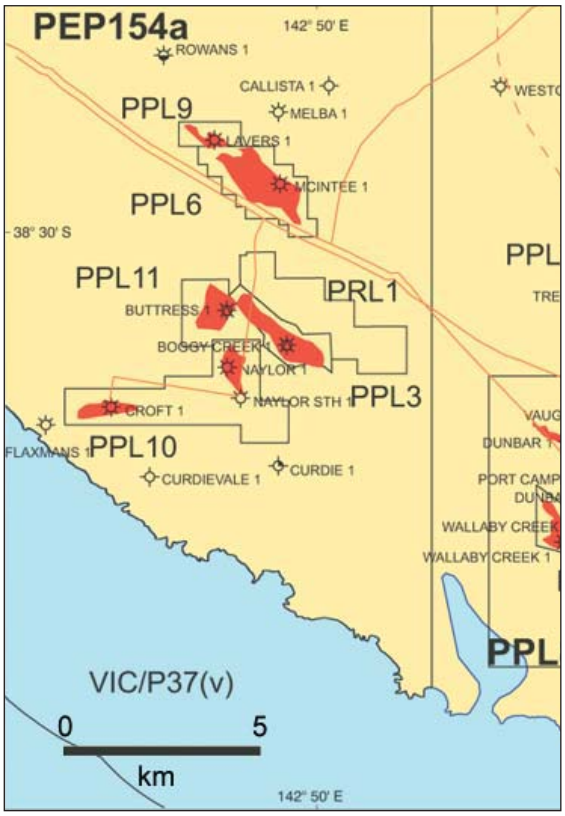

Fig. 1. Location of the Buttress-1 and Naylor-1 wells likely to be used as the production and injection wells (respectively) for Australia's first demonstration geosequestration project. Both wells were drilled in 2001/02 on PEP 154 operated by Santos (90%) and Beach (10%).

Ian Macfarlane, the Commonwealth Industry, Tourism and Resources Minister, welcomed the Otway Basin project's timely announcement ahead of the six nation climate change technology partnership meeting held in Sydney in January.

He estimated that about half of Australia's carbon dioxide emissions could potentially be sequestered. He also stated that Geoscience Australia has now identified 65 viable carbon dioxide storage sites in Australia.

This project therefore fits in well with the government's main approach to clean up the emissions from the coal and oil industries and will be a key plank in its greenhouse gas reduction strategy.

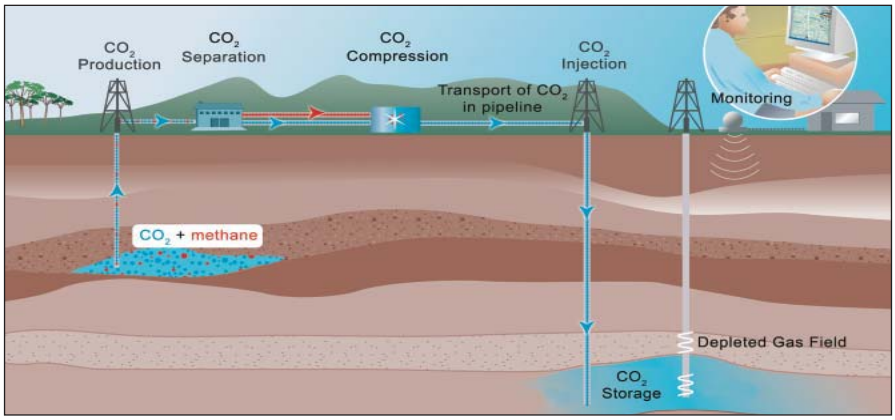

Fig. 2. Diagrammatic representation of the proposed arrangements planned for the Otway Basin geosequestration demonstration project. The CO_2 production well is likely to be Buttress-1 and the injection/storage well Naylor-1. The monitoring well will be new and have to be specially drilled (diagram provided courtesy CO2CRC, which holds the copyright).

 by Doug Morrison sth.lands@optusnet.com.au

Paul Passalsky: a young man's legacy to geophysics

Odessa, Weinberg and Leyst

In 1901 Professor Boris Weinberg, who was in later years appointed the director of the Central Physical Observatory at Leningrad, and Ernst Leyst, Professor of Physics at the Imperial University, Odessa had the foresight to save and publish an exceptional piece of pioneering geophysical study – and without their efforts there would be little record of the work by the young exploration geophysicist Pavel Timoféevic Passalsky (Figure1).

Fig. 1. Pavel T. Passalsky 1871-1900 (Author's collection).

Pavel (or Paul) Passalsky had died suddenly on the 12/25[1] November 1900 at the age of only 29.

Ernst Leyst recorded, in a short monograph, that Passalsky had been born in 1871 at Kischinef in Bessarabia (Moldavia). He had attended the local high school before enrolling, in 1890, in the faculty of physics and mathematics at the Imperial University at Odessa.

Leyst wrote that Passalsky, in 1893, graduated with 1st Class Honours in mathematics and received the university's gold medal for his studies on thermodynamics. In 1894 he was appointed to two positions at the university, as a lecturer in meteorology and as a tenured observer at the university's magnetic observatory. He soon commenced detailed studies into terrestrial magnetism and methods for improving secular and diurnal corrections of his observations, his particular interest. By 1896 he was publishing results of observations made at the Odessa Observatory.

To Krivoi-Rog and elsewhere

In the summer of 1898 Passalsky expanded his horizons somewhat, and travelled to the Dnieper Basin where he commenced a historic magnetometer field survey of the Krivoi-Rog iron mining region, where, according to Professor Weinberg, he "uncovered magnetic anomalies until then unknown" (Figure 2). The task that Passalsky had set himself in surveying the Krivoi-Rog region was such that he needed to revisit and complete his survey in the following year. Passalsky's prime interest at Krivoi-Rog was an academic one – he was actually trying to determine if short-term or diurnal changes in the Earth's magnetic field were obvious, consistent and correctable to observations made in magnetically disturbed regions (in comparison to quiet regions). He was to make numerous and quite detailed magnetic component measurements – a task way ahead of his time – he was conceptually producing 3D data.

Fig. 2. Passalsky's Krivoi-Rog survey area, the asterisk indicates the location of his detailed observations.

According to Professor Weinberg, Passalsky, in the summer of 1900, also travelled to the Crimean Peninsula where he made magnetometer observations at over 200 stations as part of the Imperial Geographical Society's drive to regionally cover the Russian empire with magnetometer observations.

Passalsky's equipment

Passalsky did not describe the magnetometers or the equipment he used for any of his work (travelling on horseback) but he did write on what was the ideal set-up for a magnetometer survey:

> "*Instruments*. For conducting a magnetic survey the following instruments and appurtences are necessary: A theodolite magnetometer, dip circle, one or two chronometers, an aneroid barometer, a tripod, a screen, umbrella or tent for protection against sun and wind, a small set of locksmith's tools, oil, vaseline, alcohol, alcohol varnish, a supply of cocoon threads, some rags, chamois, a brush for removing dust, *etc.*"

To avoid damage from concussion he wrote that equipment should be thoroughly screwed into boxes with additional protection of a layer of hay and then outside boxes – he was particularly concerned on the transportation of his chronometers:

> "instruments should be carried at a gait no faster than a pace"

It was shortly after this, on his return to Odessa, that Passalsky unexpectedly died leaving his many works unfinished. Weinberg wrote that Passalsky's death was deeply felt throughout the university and in a short obituary described him as having been hard working, tireless and totally devoted to his work.

Passalsky's work gets published

At the time of his death Passalsky had been writing a review of both his observatory and field work and had left an unfinished memoir titled *A treatise on the distribution of magnetism on the surface of the terrestrial globe. W*hen Weinberg and/or Leyst recovered this memoir and other papers they were so impressed and interested that they arranged publication of his results, including having fine drawn maps made from his original field plans and notes.

In late 1901 Passalsky's posthumous work was published in Odessa, as a separate and complete issue of the Imperial University of Odessa's regular bulletin, being a weighty volume of 547 pages, 8 illustrations and 17 maps of his Krivoi-Rog survey.

This volume titled *ОБЪ ИЗУЧЕНІИ РАСРЕДБЛЕНІЯ МАГНЕТИЗМА* (which translates as *A Treatise – Distribution of the Earth's Magnetism*) was fully referenced; indexed and included an astonishing bibliography of 1249 titles, most being geophysically related. Georg Neumayer's Victorian exploration work of the 1860s gets mentioned, as does some of the comments by the relatively unknown but significant Melbournian, William Sutherland.

Neither Weinberg nor Leyst were credited in the volume, despite the fact they had commissioned and edited it.

Passalsky's writings

The subjects addressed by Passalsky were mostly related to terrestrial magnetism of course, and there were chapters on global magnetic surveys, journeys of exploration, charts and tables on periodic oscillations, secular variations and diurnal changes, sunspots, moon and planet influences, magnetic storms, instrument comparisons, Gauss's theories, Passalsky's own studies on magnetic anomalies, gravity, earthquakes, vertical currents, influence of

[1] Russia used the Julian Calendar until ~1918 when Lenin decided to fix things – it was 13 days ahead of the Gregorian Calendar.

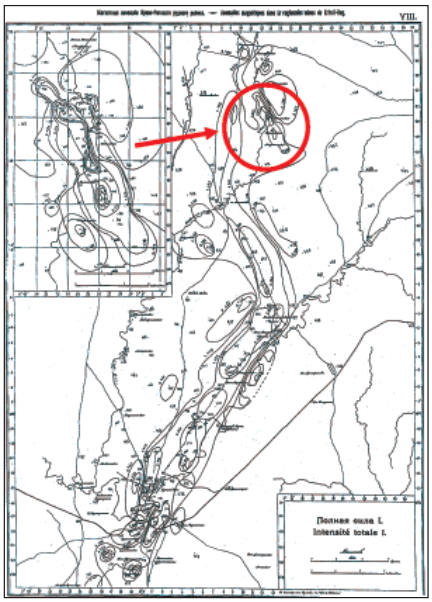

Fig. 3. Passalsky's Total Intensity map of the Krivoi-Rog survey with detailed anomaly highlighted. Contour intervals 0.01, 0.02 and 0.1 cgs units (equivalent to 1000, 2000 and 10,000 nT). Spot values (stations) are in cgs × 10^3.

height, etc., etc. Importantly there were 17 maps of his survey of Krivoi-Rog – showing some ***real*** exploration data!

Portions of Passalsky's writings were translated into English in 1908 when three edited instalments of his work were produced by Paul Wernicke, Professor of Modern Languages at the State University, Lexington, KY and published in the old journal *Terrestrial Magnetism and Atmospheric Electricity* (Wernicke, I guess, was either commissioned or had an interest in geophysics). Since that time the memory of Passalsky has more-or-less become lost.

The Krivoi-Rog maps

The first nine maps published in Passalsky's volume, were regional maps drawn at a scale of 1:126,000 and each map included a detailed block of data at 1:42,000 in the top left corner (see Figure 3). Passalsky had located his survey area in geographic co-ordinates, originating from the Russian observatory at Pulkova[2], and each map had a scale bar graduated in both verst[3] and kilometres. The map legends, interestingly, were bi-lingual in both Russian and French.

These nine fine-drawn maps were bi-coloured (red and blue) and were: (I) geographic location of points i.e., his stations, (II) declination, (III) horizontal intensity, (IV) inclination, (V) northerly component-X, (VI) easterly component-Y, (VII) vertical component-Z, (VIII) total intensity-I and (IX) "horizontal and vertical anomaly intensity".

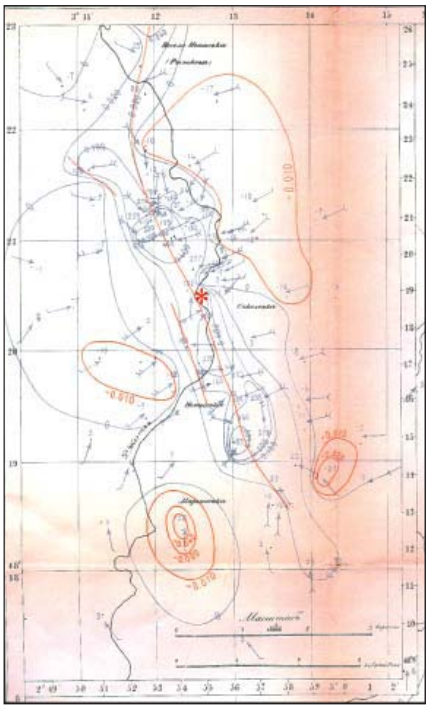

Fig.4. Passalsky's historic 1:42,000 "Intensités anomales horizontale et verticale". Contour intervals 0.01and 0.02 cgs units (1000 and 2000 nT). Spot values (stations) are in cgs × 10^4. The Earth's regional magnetic field has been removed in this map. Author's asterisk indicates the location of detailed Area "No.1" (Author's collection).

Map IX being an interesting and historic product for as well as showing vectors it is the earliest contour map I have sighted that has the earth's regional magnetic field removed – possibly the first residual magnetic contour map! - maybe. See Figure 4.

Passalsky's other published maps, Plates X to XVII, were a suite of large scale plans drawn at 1:2000 of two detailed areas, identified only as Areas "No.1" and "No.2". In these detailed maps the scale bars were graduated in the Russian measurement sazhen[4] and metres. Some examples of his Area "No.1" component maps are shown here (Figures 5a, 5b, 5c). These component measurements being made by a theodolite magnetometer that had both horizontal and vertical circles, Passalsky however did not describe the instruments he used and there are no extant illustrations to assist in determining his measuring methodology.

It is possible that Passalsky's 1:2000 detailed surveys were made to map the extension of a known mineral deposit, or show a discovery, but it is suspected he was really out to produce examples to support his research into diurnal and secular effects in magnetically disturbed areas – a subject that he wrote on in detail in his memoir.

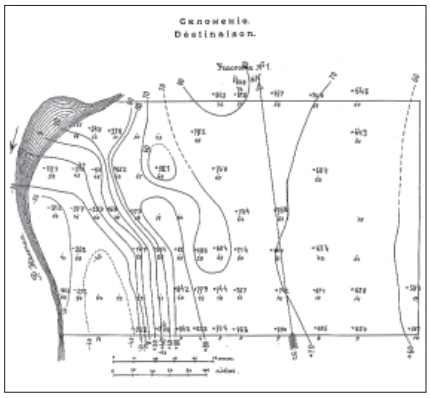

Fig. 5a. Passalsky's detailed Area "No.1". Declination. Contour intervals 10 and 20 degrees.

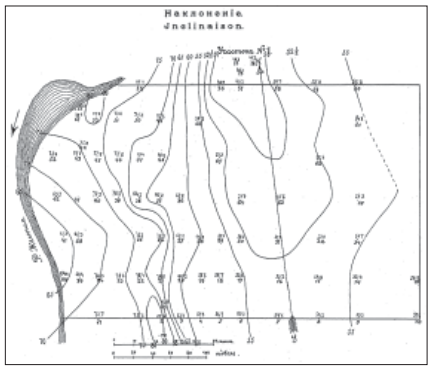

Fig. 5b. Passalsky's detailed Area "No.1". Inclination. Contour intervals 2.5 and 5 degrees.

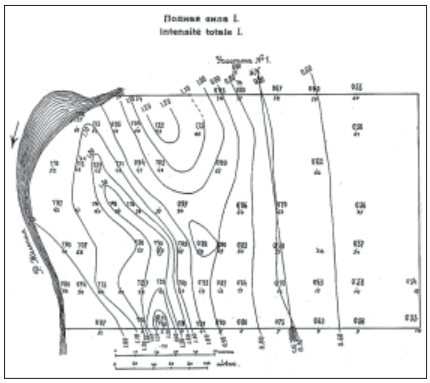

Fig. 5c. Passalsky's detailed Area "No.1". Total magnetic intensity. Contour interval 0.1 cgs units (10,000 nT).

Passalsky's magnetic mapping of the Krivoi-Rog region of the Ukraine is indeed historic – he mapped it well enough to where it certainly could be digitised and subjected to current analysis techniques. Maybe some of his uncommon component maps are worth investigating?

I am glad to have rekindled Paul Passalsky's memory.

Cont'd on page 25

[2] The old Pulkova Observatory near St. Petersburg being 30° 19′ 34″ E of Greenwich.
[3] One verst equals 1066.8 metres.
[4] 500 sazhen equals one verst.

Instream geophysics (NanoTEM): a tool to help identify salt accession risk

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Introduction

The relatively recent demand on the South Australian Riverland region to support intensive irrigation has resulted in an increased hydraulic and salinity strain on the River Murray and floodplain environment. In an effort to reduce the immediate impact of river salt accession, (estimated in excess of 700 tonnes/day in S.A., Porter, 2001), there is significant ongoing financial investment into salinity management such as salt interception schemes (SIS).

Since the initial successful trial of the instream, floating NanoTEM system at Waikerie in 2002 (Barrett et al., 2005), a number of more wide-ranging surveys have been completed in the main river channel and anabranch systems of the River Murray. In September 2003 Zonge Engineering & Research Organisation completed a detailed survey at Loxton and Bookpurnong for the Department of Water, Land and Biodiversity Conservation (DWLBC), Berens et al., 2004. A continuous instream data set between Blanchetown, SA to Mallee Cliffs, N.S.W, was collected in February 2004 (Telfer et al., 2005). Additionally, to complement the main channel data set, more specific surveys have collected data over parts of the River Murray's anabranches including Pike River, Ral Ral Creek, Chowilla Creek and the Anabranch of the Darling River. Figure 1 provides the survey extent (study area) of the 2003 Loxton/Bookpurnong survey

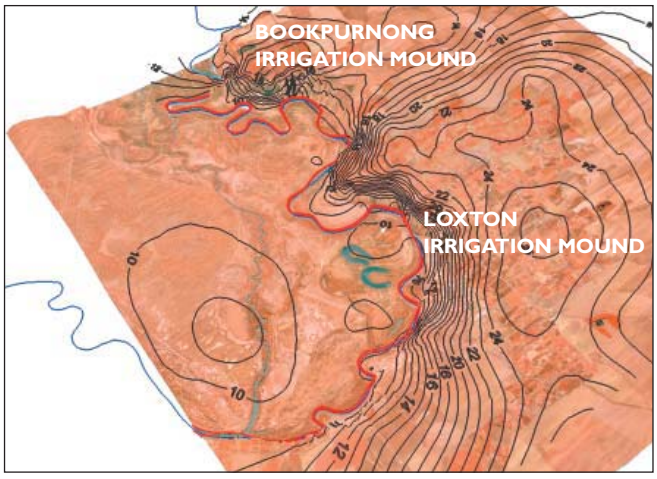

Fig. 1. Aerial view of the Loxton/Bookpurnong study area with groundwater potentiometric surface superimposed. The red line indicates the river surveyed with instream geophysics.

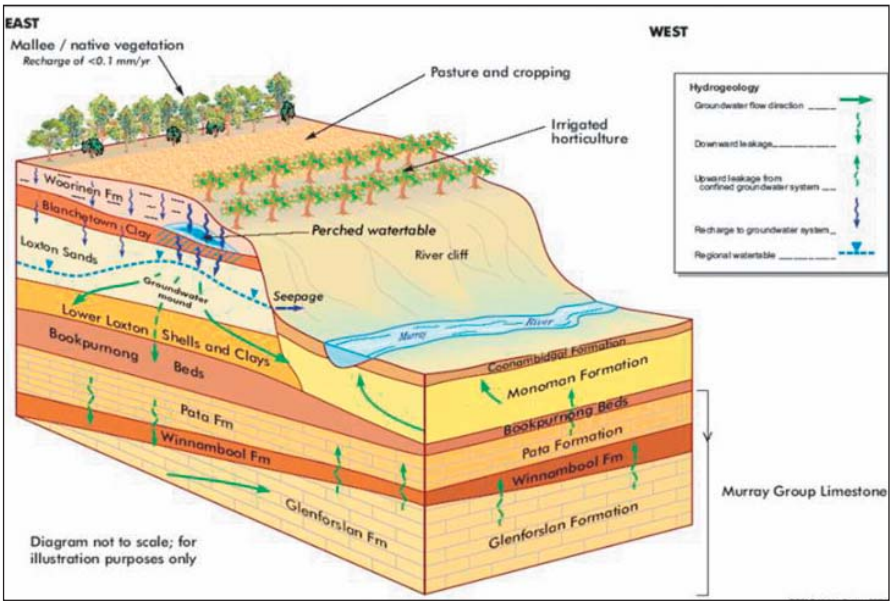

Fig. 2. Characteristic Hydrogeology of the study area. Groundwater mounding results from excess irrigation drainage near the River Murray.

Hydrogeology

The study area has the characteristic hydrogeology of the lower eastern Murray Basin (Figure 2), and is adjacent the Bookpurnong and Loxton highland irrigation districts. Excess irrigation drainage (recharge) from the irrigation districts has led to the development of localised and significant groundwater mounding. The Loxton groundwater levels have increased by up to 12 m creating a 16 m head difference between the centre of the mound near Loxton and the river pool level. The resulting displacement of regional saline groundwater (in excess of 30,000 mg/L) leads to salt accession and salinisation of the river and adjacent floodplain.

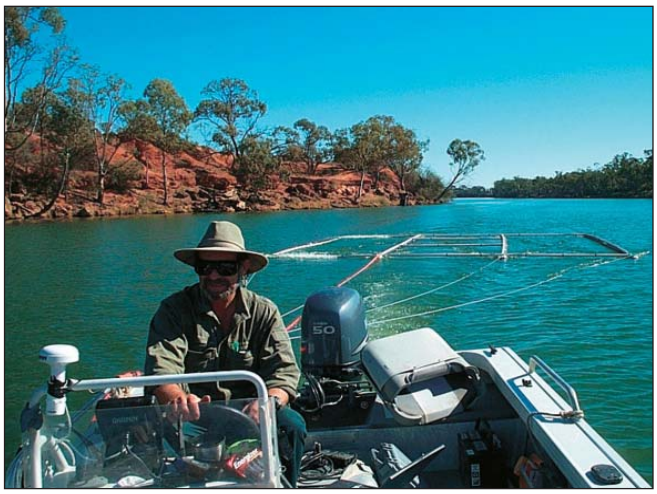

Fig. 3. The instream NanoTEM system under tow along the River Murray.

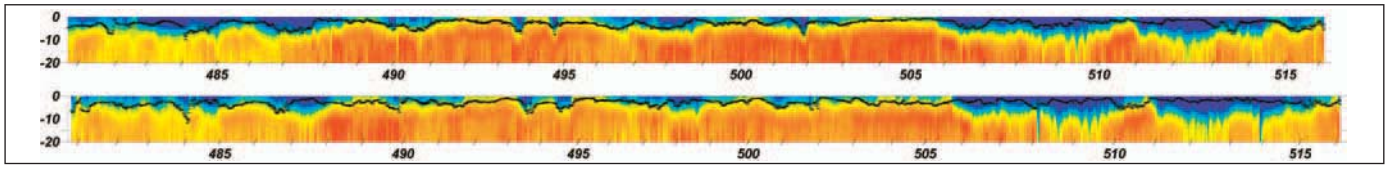

Fig. 4a. 'Strip' Resistivity Plot: black line represents the river/sediment interface.

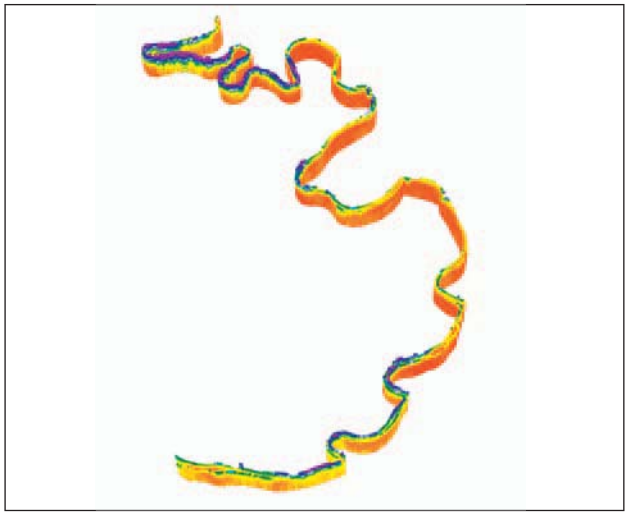

Fig. 4b. 'Ribbon' Resistivity Plot: river sediment resistivity only.

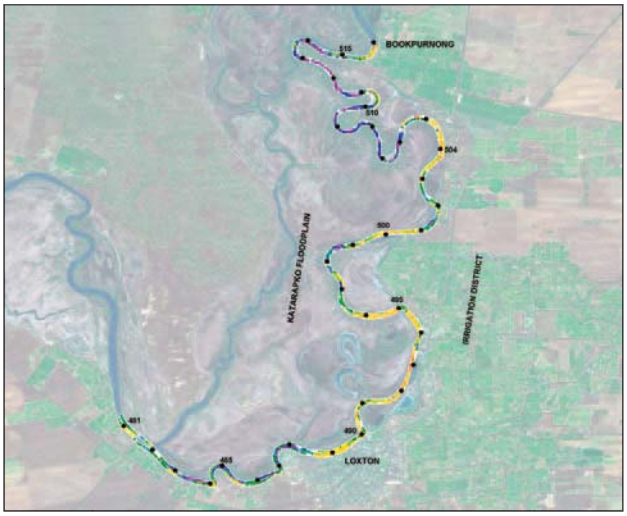

Fig. 4c. 'Plan' Resistivity Plot: shallow river sediment resistivity only.

Instream NanoTEM

Zonge Engineering's NanoTEM has increased shallow resolution via the use of much smaller loops and faster sampling rates than mining exploration systems and by measuring the decay very quickly after transmitter turnoff. The system is designed to take data from within one to two metres of the surface and down to a depth of 20 to 50 metres (Hatch *et al.,* 2002).

The geophysical data for the instream survey were collected using a floating version of Zonge's land-based NanoTEM system. The single-turn transmitting antenna (7.5 m x 7.5 m) and receiving antenna (2.5 m x 2.5 m) were mounted on a stiff PVC framework of four floating pontoons (Figure 3). Data are acquired in a nearly continuous mode every 4 seconds using 64 cycles at a repetition rate of 32 hertz and a sampling rate of 1.2 or 1.6 microseconds. An average boat speed of 5 km/h results in a TEM sounding approximately every 5 to 8 metres along the river. The vessel is fitted with a Garmin 186 GPS Plotter Sounder. This unit logs position and water depth approximately every 10 metres. All three data sets are time stamped and synchronised, accurately locating every TEM sounding and associated water depth.

Data results and presentation

The TEM data are presented in three styles; 'Strip' (Figure 4a), 'Ribbon' (Figure 4b) and 'Plan' Plots (Figure 4c). 'Strip' Plots are gridded resistivity sections with depth represented on the vertical axis and river kilometre location on the horizontal axis. They provide an effective means to closely examine resistivity variations both horizontally and vertically. 'Ribbon' Plots and 'Plan' Plots are presented with real earth reference (using a GIS). 'Ribbon' Plots are similar to the strip Plots displaying horizontal and vertical resistivity variations but following the trace of the river. 'Plan' Plots present only the shallowest TEM data values below the river water and river sediment interface. The plan view offers the quick way to view resistivity variations occurring within the top meter or two of river sediment. It is this shallow zone (interface) that is likely to be most critical in the inference of stream conditions (losing or gaining).

Figure 4 shows that the resistivities along (and under) the river range between around 0.5 Ω.m to around 100 Ω.m. From the Plan Plot, regional variations in the shallow sediment resistivity are apparent along the length of the survey. From the Strip Plots we can notice that the river itself shows up as the most resistive region (generally > 20 Ω.m). Resistivities greater than 20 Ω.m (blues and purples) are likely to indicate the presence of considerably fresher pore water (possibly water sourced from the river). Resistivities less than 5 Ω.m (yellows, oranges and reds) in the zone immediately under the bottom of the river are suggested to indicate the presence of saline groundwater and have the potential to pose a salinity risk for the River Murray.

Instream coring & sampling

Following the collection and processing of the instream geophysical data set, considerable interest in its interpretation followed from a diverse array of River Murray projects. Particularly with regard to the Loxton Salt Interception Scheme, as to how much inference could be made about the salinity of water within the river sediments and the determination of the water source (surface or groundwater). To help validate the NanoTEM data and interpretations, in-river sediment samples were collected in September 2004 using GeoCoastal Australia's vibro-coring system. This system uses a technique which allows the collection of minimally disturbed continuous core from unconsolidated sedimentary sequences.

The vibro-core rig was mounted on a floating platform modified to allow coring through its centre (Figure 5). 32 sediment cores up to 10 m in length and 60 mm diameter were retrieved from the core barrels and emplaced

into plastic core sleeves. Each core was sub-sampled every 20 cm from the top two metres and every 50 cm thereafter, resulting in over 500 discrete core samples. For each interval a 500 ml and a 25 ml sample were collected. Twenty five 500 ml glass jar samples were submitted for petrophysical analysis and the full set of 25 ml samples were analysed for pore water chloride.

The instream coring at Loxton and Bookpurnong was also a large component of a separate but perhaps relevant hydro-geochemical study. Future analysis and correlation of pore water stable isotopes and major ions may reveal additional evidence to support and analyse the geophysical data set.

Petrophysical analysis

To determine the effectiveness of the instream NanoTEM survey for its ability to map the resistivity of the subsurface, Systems Exploration Pty Ltd analysed laboratory scale resistivity from 25 river sediment core samples. EC 1:5, pore water conductivity, galvanic resistivity, inductive conductivity, porosity and bulk density were measured for each submitted core. Core intervals were chosen to represent a range of resistivity responses in the TEM data and at a range of depths. The majority of samples selected were relatively clean sands (Monoman Sands Formation), with 5 from the Bookpurnong Clays Formation. Samples were selected, based on their proximity to TEM survey station locations, with preference given to those samples providing the closest spatial relationship. The samples represent a range of locations along the survey as well as a broad range of depths within the river sediment, TEM resistivities are accordingly selected to provide correlation in the horizontal and vertical plane.

Laboratory measurements of resistivity

Both laboratory inductive and galvanic methods were used to formulate linear relationships between the nanoTEM and the laboratory results. The inductive technique uses a magnetic source that is somewhat similar in theory to that of the instream NanoTEM data. Galvanic techniques are analogous with DC resistivity type geophysical surveys, and draw on a direct electrical source (Emerson, 1969).

Figure 6 shows the result of the laboratory measured galvanic resistivity for the 25 samples plotted against the resistivity of the nearest TEM data point. These samples represent a range of depths between 0.4 m and 7.0 m below the base of the river. Overall the results with a least squares fit, R2 of 0.84, convincingly suggests that the remotely sensed resistivities at the surface using the NanoTEM are doing a good job of representing the true resistivities over a range of depth.

EC 1:5 and pore water conductivity

After Emerson and Yang (1997), the EC 1:5 test is a standard and helpful measure for determining soil conductivity and in a sense is a surrogate for indicating soil (and soil water) salinity. The correlation between EC 1:5 and the nearest NanoTEM conductivity is presented Figure 7, and provides a persuasive indication that the soil and soil water salinity are closely linked to the sample set conductivity as determined by the instream TEM technique.

Gravity extraction methods were used to extract pore waters. From the 25 samples, 12 yielded enough pore water and were measured for salinity (conductivity). Estimates of the absent pore waters have been derived from the regression equations of pore water resistivity against EC 1:5. Two equations (power and linear fits, R2 = 0.98) are both apparent and reasonable, with subsequent estimates providing a fairly accurate idea of the likely pore water. Comparison of the

Fig. 5. GeoCoastal's barge-mounted vibro-coring rig.

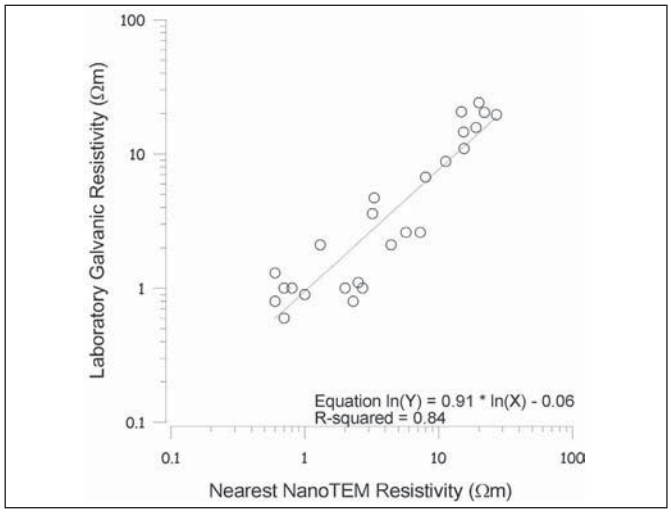

Fig. 6. Comparison between the remotely measured TEM resistivity and laboratory determined galvanic resistivity from collected core samples.

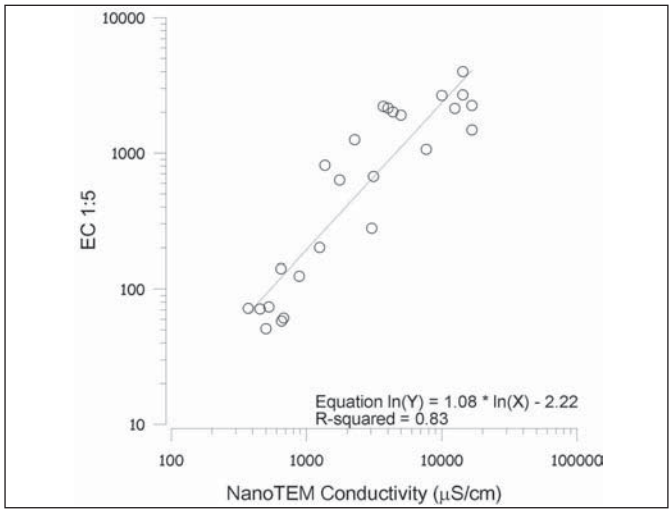

Fig. 7. EC 1:5 salinity analysis corresponds closely with the nearest TEM conductivity. Providing a good initial indication that groundwater salinity is a dominating influence on conductivity beneath the river.

predicted pore water conductivity (Systems Exploration) and the pore water salinity in mg/L (CSIRO) for the same sample intervals are expectedly well matched providing a degree of confidence in both analyses.

Chloride analysis

For each of the 500 plus core samples, a 25 ml chippet sub-sample was tested for chloride concentration by CSIRO Land and Water, South Australia. Chloride concentration is defined as the mass of chloride per kilogram of soil, as per Taras (1975). This large data set has enabled comparisons to be made between the geophysically measured conductivity and the pore water salinity. Note that up to now all the TEM data have been presented in resistivity units (Ω.m). For the following results, the TEM data are presented as conductivity (µS/cm). Of the 32 in-river core sites, a small number could not provide direct meaningful correlation due to proximity with TEM soundings or additionally, due to core length limitations, some river cores have not been suitable for inclusion in the correlation of resistivity and pore water salinity (Chloride). The correlation between pore water salinity (Chloride) and NanoTEM conductivity are presented in number of ways.

Chloride profiles

Full chloride profiles exist for all 32 river cores, 4 of the chloride profiles are presented with accompanying geophysical conductivity profiles from the nearest TEM sounding (Figure 8). These are indicative of the trends and relationships between these data. In these plots, the chloride profiles (mg/L) and TEM conductivity profile (µS/cm) are plotted against depth below river base (vertical axis). Chloride concentration and TEM conductivity are plotted on the same horizontal axis (note the units remain different).

Chloride and conductivity depth intervals

Chloride Depth Intervals vs Conductivity Depth Intervals are compared for those sites of generally deeper core retrieval where 3 or more TEM resistivities are represented or fall within the core profile (such as those presented in Figure 8). The data are calculated as the average chloride or conductivity over a chosen interval divided by the length of that interval. Of the suitable cores, 16 had core lengths adequate for this analysis. Figure 9 presents the close relationship between the pore water chloride and the TEM conductivity for the CDI analysis.

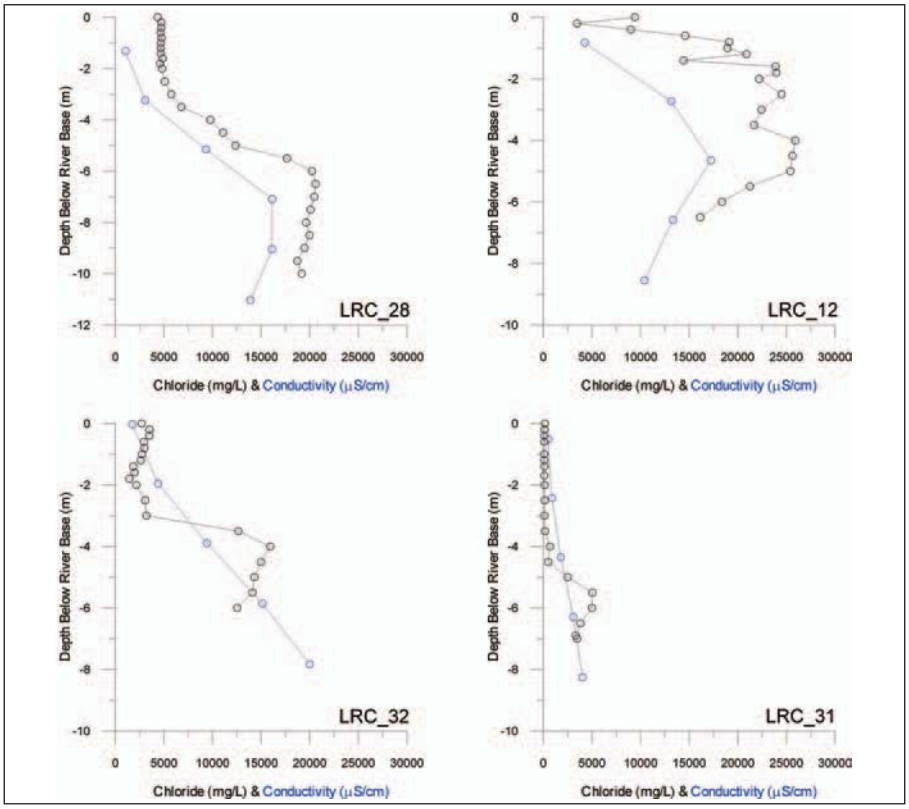

Fig. 8. Loxton River Core chloride profiles (black) compared with the nearest TEM conductivity profiles (Blue). X-axis units are different, but are presented on the same scale.

Shallow chloride

For a data set of 24 cores, the shallowest NanoTEM conductivity below river base was compared with the corresponding chloride result, giving a subset (one per drill site) of chloride per shallowest TEM conductivity. The displayed chloride values are chosen from the chloride profile to best correlate with the depth below the river base at which the nearest and shallowest TEM data value exists. Figure 10 presents these data, and again presents a convincing correlation between the TEM conductivity and the chloride content (R2 = 0.86), and over a broad range of conductivities and chloride contents.

Discussion

Broad features and zones of high conductivity are apparent in the NanoTEM data, inferred to be regions of highly saline groundwater at and below the river sediment interface. One of the interesting results of this study is that there is an excellent correlation between the laboratory-derived resistivities and the instream field-derived resistivities. 2D vertical sections (Strip Plots) are used to identify broad scale variations in resistivity within the river sediments and Ribbon Plots present a novel way to view the data. Generally broader interpretations regarding losing and gaining stream conditions can be made from the Plan Plots.

The likely sources of conductivity in this data set are primarily, either the presence of saline ground water or the presence of conductive mineralogy such as clay, or some combination of the two. An important result is the correlation between the soil water chloride concentration (a direct indicator of groundwater salinity) and the instream resistivity. It convincingly supports the notion that the conductive response seen in the study area is dominated by saline groundwater, more so than other influences such as clays.

Intuitively the factors effecting the groundwater interaction with the river are a result of the hydrogeological system in the region and other external influences such as groundwater and surface water manipulating infrastructure (such as locks and SIS). Conveniently the salinity of the regional aquifer in connection with the

alluvium is between 14,000 and 35,000 mg/L for the Loxton study area, and provides considerable contrast to that of river water at around 300 mg/L.

Some interesting applications of the TEM data indicate that resistivity below the river is very useful towards the understanding of surfacewater and groundwater interactions (Berens and Hatch, in press, 2006). It follows that the presence of, type and quality (surface water or groundwater) dominates the geophysical response. Resistive shallow sediments are likely to represent the presence of fresh (more resistive) river water and hence, represent a losing stream. Conversely, conductive data directly below the river sediment interface could suggest that saline groundwater is in contact and possibly adding saline groundwater to the river. This interpretation of the data is most apparent in the 'Plan' Plots. However, the extent to which freshening occurs at depth within the sediment is best seen in either the 'Strip' or 'Ribbon' Plots.

Affiliated work

Other projects and comparisons of the NanoTEM data have acknowledged that the resistivity data are providing useful information towards the understanding of surfacewater and groundwater interactions. These include additional work such as Aerial Electro-Magnetics (AEM), Land EM and Numerical Modelling.

As part of a Weir Pool Lowering investigation (Barnett et al., 2003), a number of land-based NanoTEM surveys were completed perpendicular to the instream surveys, with the aim to assess how instream resistivity patterns could be related to adjacent floodplain groundwater salinity. The results indicated that where instream resistivity was high, a region of floodplain adjacent to the river was receiving fresh inflows. In contrast, where instream resistivity is low, no such freshening (or flushing) was evident with high salinity groundwater in contact with the river. These results were corroborated in many locations by existing groundwater information.

A recent study over a 14 km river stretch, investigated correlations between numerically modelled groundwater fluxes into and out of the river, TEM resistivity data, and salt accession tonnages calculated from 'Run of River' surface water EC monitoring (Porter, 2001). Doble et al. (2004) demonstrated strong linkages between the three data sets correlating high resistivity TEM data with river zones of low or negative modelled groundwater flux (losing stream), and conversely the low resistivity regions matched zones of high salt accession and groundwater flux to the river. Although care should be taken due to the fact that resistivity cannot be used to interpret a flux (particularly magnitude), the positive result in this case could lead to the useful (initial) transference to other study sites.

Conclusions

The instream TEM system has been effective in mapping resistivity variation within the river sediments down to 30 m. The correlation between groundwater salinity and resistivity, plus other evidence provides confidence in the ability to interpret losing and gaining stream conditions along the South Australian River Murray. From the results it is believed that the primary cause for resistivity variability (at least in the near surface) is related to groundwater salinity directly beneath the river, rather than clay content. The results from these investigations strengthen the resolve for instream NanoTEM technique as being a valuable and effective tool in salinity mapping on the River Murray. This newly developed instream geophysical technique provides a valuable data set to complement established techniques.

Acknowledgements

The authors would like to thank Trevor Graham and Kent Holmes for their work in the instream coring, and Don Emerson for his petrophysical services. Additionally we would like to thank Barry Porter and Andrew Telfer for their contributions towards the development of the NanoTEM. Finally the authors are grateful for the financial support from the Murray Darling Basin Commission, the Mallee Catchment Management Authority and the Department for Water Land and Biodiversity Conservation.

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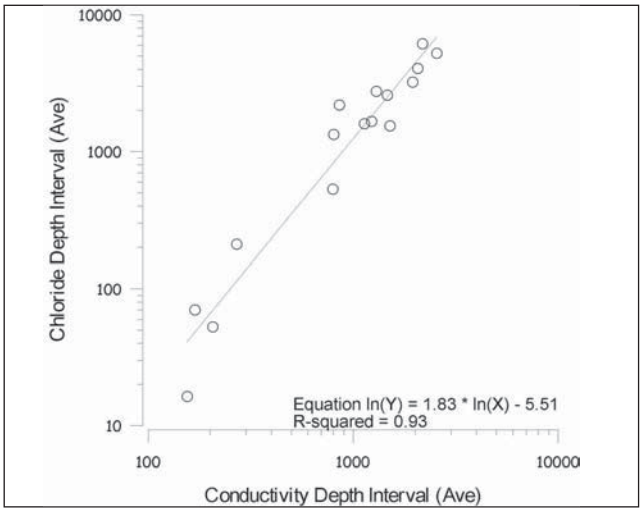

Fig. 9. Conductivity and chloride depth intervals. The average analysed chloride or TEM conductivity over an interval divided by the length of the interval.

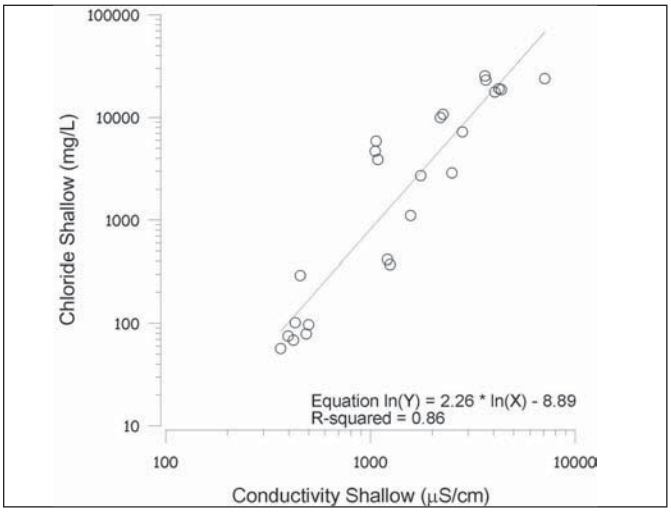

Fig 10. For only the shallowest TEM conductivity, the relationship with the associated pore water chloride result is presented, showing a clear relationship between groundwater salinity and conductivity.

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Big New Oil delivers new opportunities

Introduction

In 2003 the Australian Government provided $61 million over four years to Geoscience Australia (GA) to provide new geoscience information on some of the more unknown offshore areas within Australia's jurisdiction. This is the ***Big New Oil Program.***

Australia is a whole continent

The challenge is to arrest the decline in Australia's oil production by encouraging more oil exploration and finding more oil. With the reduction in production from the Gippsland Basin and the dramatic increase in global oil prices, as a result of increased demand from China and India, as well as the political uncertainty in the Middle East and Nigeria, oil supply is now a critical issue.

One of the main challenges to find new oil is that, although there are many petroleum systems in Australia, from Proterozoic to Cainozoic, almost all oil production so far has come from only two source rock facies. These are the marine Late Jurassic of North West Shelf and the non-marine Late Cretaceous of Gippsland Basin. So the question becomes: should we be looking for plays in other rocks or still focus on the rocks which we know have produced oil? In fact, one probably has to have a bet each way, and that is how the Big New Oil Program has been structured.

In October 2005, roughly half way into the four-year program, GA organised a workshop to review the work done to that date and also to encourage companies to bid for areas where the new information is now available. I was able to attend this two day event, which also addressed future plans for the Big New Oil Program.

In the few pages available in Preview it is not possible to cover all the work presented. In particular I have not discussed any of the excellent work that has been done on oil seeps in the Arafura and North West Shelf basins. Readers can obtain the CDs of the presentations for these materials.

At the outset, I must say that it was one of the best geoscience workshops I have attended. The quality of the interdisciplinary science undertaken, the focus of the work on important national issues, and the evident enthusiasm and abilities of the participating scientists showed the excellent value that can be obtained from government investment in strategic research directed to national priority areas.

All the information I have used was extracted from two CDs produced by Geoscience Australia. The first is *Presentation from the Bremer Sub-basin Study,* (contact Barry Bradshaw, barry.bradshaw@ga.gov.au) and the second is *Additional Presentations from Geoscience Australia's Frontier Basin Workshop* (contact Paula Boldra, paula.boldra@ga.gov.au). Both these CDs can be obtained from GA and they provide a comprehensive record of the presentations.

I would like to acknowledge Geoscience Australia for making this information available for publication and to advise that GA holds the copyright of all the illustrations.

Program Portfolio

The four year program is built around the following projects (see Figure 1): The Southern Australian Frontiers Project, including the Bremer Sub-basin and the Naturaliste-Mentelle and deepwater Perth Basins, the Arafura Basin, the central North West Shelf, the Lord Howe Rise and a Seep Detection Program.

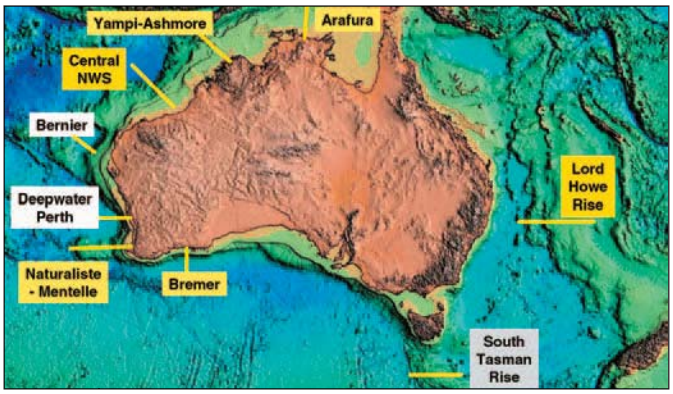

Fig. 1. Program options presented to industry in 2003. The adopted work program focuses on the Southern Australian Frontiers Project, including the Bremer Sub-basin and the Naturaliste-Mentelle and deepwater Perth Basins, the Arafura Basin, the central North West Shelf, the Lord Howe Rise and a Seep Detection Program.

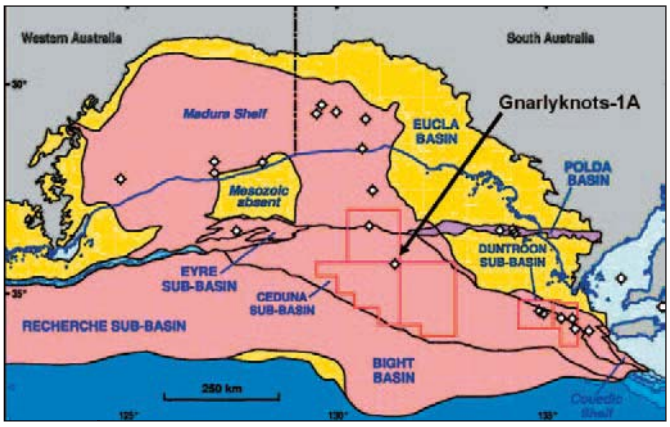

Fig. 2. Central part of the Southern Australian margins – showing the Bight and other basins in the region.

Southern Australian Frontiers Project

The ***Southern Australian Frontiers Project*** aims to understand and document the geology and petroleum prospectivity of frontier basins on the southern and southwestern Australian margins. The main structural features of these basins were associated with the separation of Australia and Antarctica, which has been progressing for at least 100 million years.

There area is huge and the geology is poorly known. Figure 2 shows just the central part of the frontier – the Bight Basin. This is a major extensional system that forms much of the southern margin of Australia. It is the largest frontier basin for petroleum exploration in Australia, and with less than 20 offshore wells

drilled to date, all in the eastern part of the Bight Basin, it is ripe for exploration.

Figure 3 shows a seismic section of the deltaic sediments in the Ceduna Sub-basin. There is evidently a very thick sedimentary sequence, with several interesting structural features. However, the water is deep over most of the area, seismic coverage is poor and most importantly exploration is very expensive. For example, Gnarlyknots-1A, which was drilled in 2003 by a consortium headed by Woodside, was located approximately 325 km off the southern Australian coast in 1.5 km of water. It was plugged and abandoned due to deteriorating weather conditions at a total depth of 4,736 m, well short of the target depth of 5,600 m - not a cheap adventure.

In terms of petroleum exploration this area is one of high risks and possible large rewards.

Bremer Sub-basin

The Bremer Sub-basin is a classic frontier area and bids for acreage releases in this area close on **20 April 2006.** It is situated at the western end of the Bight Basin and has an area of about 40,000 km. To date not even one well has been drilled there. GA had to start from scratch to build up its knowledge base.

Firstly, it mapped out the extent of submarine canyons and collected important sub-surface geological data from 45 dredge sites within the Bremer Sub-basin. This turned out to be vital because without any wells, dredged samples proved to be the only 'real rocks' available.

It then acquired 1300 km of new seismic data and purchased the licensing rights to 2224 km of seismic data originally acquired by ESSO in 1974, and reprocessed by Fugro in 2001. In addition, some deep seismic data were acquired (see Preview 119, p. 15, December 2005) and analysed, and all the gravity and magnetic data available were also assembled to complete the interpretations.

All of these data sets are available through Geoscience Australia's Data Repository at the cost of transfer and Figure 4 shows the locations of the dredge sites and the seismic lines.

The dredge results were crucial in developing the geological framework of the Sub-basin. Figure 5 shows how the dredge sampling results were used to interpret the seismic reflection records. This is probably the first time this technique has been used on this scale to understand the geological framework of an offshore basin.

The petroleum prospectivity for the region is good. A structural framework study has shown that sediments in the Bremer Sub-basin are up to 9.5 km thick, which is more than sufficient to generate hydrocarbons. In particular, there is a potential large source-kitchen area in central part of the Sub-basin and smaller sources in the eastern and western parts of the Sub-basin.

Seismic and structural mapping indicate that hydrocarbon traps are present throughout the Sub-basin and geohistory modelling suggest that expulsion has occurred from several source rock intervals, with favourable post-trap expulsion from the central source-kitchen. Therefore, all the key elements of a potential petroleum system are present.

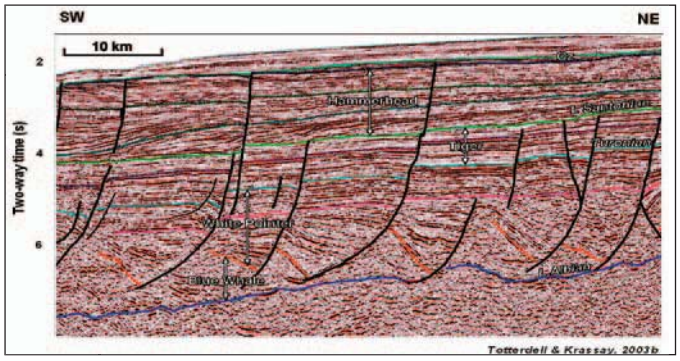

Fig. 3. Seismic cross-section over the Ceduna Sub-basin showing more 5 km of mostly deltaic sediments.

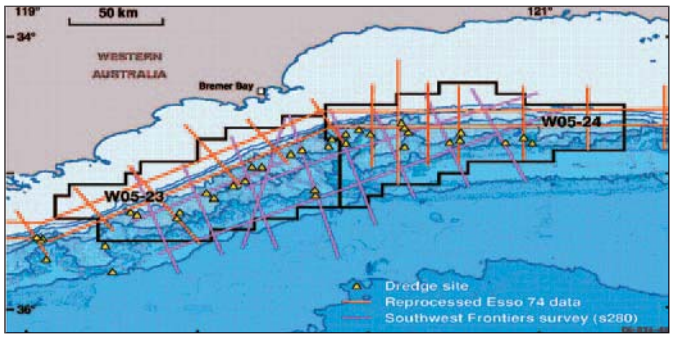

Fig. 4. The Bremer Sub-basin showing the locations of the 45 dredge sites, and the 1974 and 2004 seismic surveys.

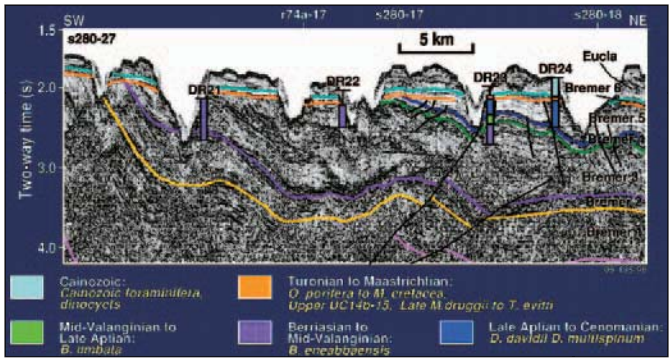

Fig. 5. SW-NE cross-section across the canyons showing the dredge sites and the seismic cross-section.

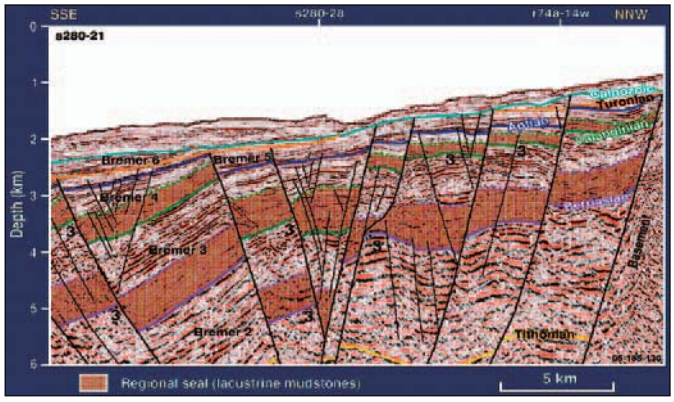

Fig. 6. Fault block trap style in the Bremer Sub-basin – see text for details.

Three main play types are evident in the Bremer, these are: ***fault block, anticlinal,*** and combined ***structural/stratigraphic*** plays.

A good example of a ***fault block play*** associated with an intra-basin fault system comes from the Zephyr depocentre (see Figure 6). The section shows potential fault block traps in fluvial sandstones from the Bremer 1-3 seismic stratigraphic units, with top seal and cross-fault seals provided by lacustrine mudstones.

Any valid traps present in this central part of the Bremer Sub-basin will have good exploration potential due to their closeness to a potentially large source-kitchen area.

Simple calculations of potential field sizes for these structures indicate that they could hold a P50 volume of approximately 250 million barrels of oil in place, with a P10 estimate of 500 million barrels.

The key risk for exploration will be trap preservation, with many faults being reactivated during break-up in the Turonian, and some large sub-marine canyons (specifically Bremer Canyon in the centre of the sub-basin) locally incising up to 2 km into the Bremer Sub-basin.

The most promising ***anticlinal play*** found so far probably occurs in the Leata Depocentre, where a large anticlinal structure exists with potential closure on depth-converted strike and dip lines (see Figure 7).

In the figure it appears that the anticline has four-way dip closure at several levels with minor growth on the Berriasian to Valanginian strata indicating the time of structuring.

Simple calculations of potential field sizes for these anticline structures indicate they could hold a P50 volume of approximately 500 million barrels of oil in place, with a P10 of about 1 billion barrels.

Valid anticlinal traps have excellent exploration potential as they are not intersected by faults. However, the main risk of these plays is access to a large source-kitchen. Here in the Leata Depocentre (north eastern part of the Sub-basin), hydrocarbons may have migrated from mature Bremer 1 syn-rift, and lacustrine mudstones at the base of Bremer 2.

It is also worth noting that anticline plays occur in water depths ranging from 500 to 800 metres.

This is a relatively large feature, extending ~8 km up-dip from the Arpenteur Fault, and reaches a maximum thickness of ~250 m. It is certainly worth exploring.

Fig. 8. Potential structural/stratigraphic trap in the Arpenteur Depocentre Bremer Sub-basin, see text for details.

Other Basins assessed

Deep water Perth (Vlaming Sub-Basin) and Mentelle Basins

These basins are located on the south west margin (see Figure 1) and have both been explored to a very limited extent.

For example in the Vlaming/Perth area, extensive vintage seismic data has been obtained and 16 offshore wells have been drilled. However, the last well was drilled in 1993 (Araucaria 1) and previous exploration was hampered by poor quality seismic data, structural complexity, inadequate bio-stratigraphy and problematic seal prediction. In view of the previous oil and gas discoveries in the Perth Basin it was decided to undertake a review of the basins in the region.

This investigation is still underway and comprises: a regional basin analysis, new biostratigraphic and geochemical analyses, new seismic data obtained from re-processing 2000 km of previously acquired data and acquiring 300 km of new deep seismic data and a remote sensing study.

At the same time, one exploration permit has been awarded and two new acreage blocks are available for bidding (closing in April 2006).

An example of the re-processed seismic data is shown in Figure 9. Both Peel-1 and Warnbro-1 provided indications of oil, and oil was recovered from Araucaria-1. There is clearly considerable thickness of sediments but the geology appears to be very complex. However, water depths range from 20 to 200 m over most of the Sub-basin although these do increase to 1000 m in the western areas. Certainly worth another look!

By contrast the Mentelle Basin is poorly explored. The water depths range from 200 - 4000 m and the sedimentary thickness

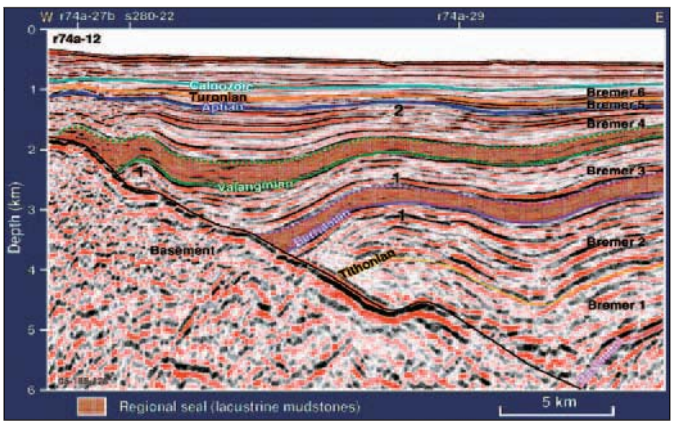

Fig. 7. Anticlinal play – Leata depocentre, Bremer Sub-basin, see text for details.

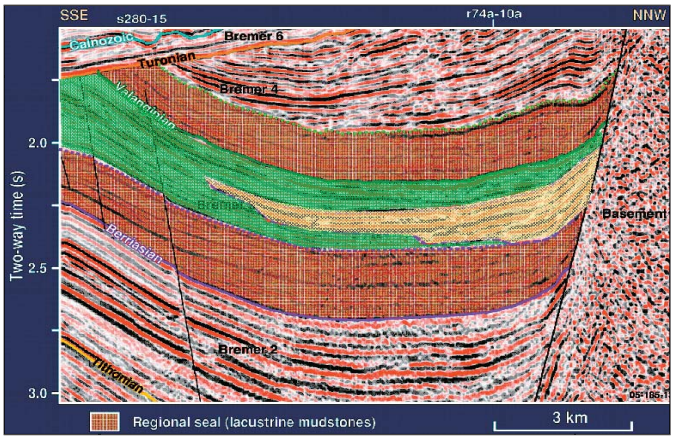

Fig. 8. Shows an example of a potential structural/stratigraphic trap in the Arpenteur Depocentre (western part of the Sub-basin), where a fluvial channel complex in Bremer 3 has migrated to the south and pinches-out up-dip.

usually ranges from 2.5 - 5 km. The current work program includes: a seismic stratigraphic study, a comparison and correlation to Vlaming Sub-basin, a review of marine survey data, new biostratigraphic and geochemical analyses, the acquisition of 1650 km of new deep seismic data (12 s TWT) and some remote sensing studies. There were two DSDP wells drilled in the western part of the basin (DSDP 256 and 264), but they only penetrated 270 and 215 m respectively and were drilled in areas of thin sediment. However, DSDP did penetrate Cretaceous sediments.

Figure 10 shows the results from one of the new lines. The sediments are much thinner than those in the Perth Basin and the geology appears to be even more complex with the age of the sediments possibly going back to the Permian.

At present the geological information is very limited but there is potential for a Jurassic source-kitchen in the western basin.

The completed program will provide a revised geological framework for the Mentelle Basin and a new petroleum prospectivity assessment.

Lord Howe Rise

As Marita Bradshaw said at the Workshop: "The Lord Howe Rise is just too big to ignore". It is the size of Queensland and is one of the largest fully submerged continental features on Earth (see Figures 1 and 11). As can be seen on Figure 11 the area under Australian jurisdiction is considerable and should not be neglected.

Unfortunately most of the Lord Howe Rise (LHR) is situated beneath water at least 1 km deep, and only nine DSDP holes, between 1972 and 1983 (Legs, 21, 29 and 90), have been drilled into the feature. Furthermore, none of these wells penetrated more than 750 m of sediments, with the oldest estimated as being Late Cretaceous.

The LHR includes rift basins underlain by continental rocks similar to those of eastern Australia, from which it separated in the Late Cretaceous (~82 mya) when the Tasman Sea was formed. Consequently the post-Cretaceous sediments are usually very thin.

However, several reconnaissance seismic reflection lines have been shot over the Lord Howe Rise and some of the record sections obtained are shown in Figures 12-14 just to whet the seismic interpreters' appetites. The sections come from the Capel and Faust Basins, which are on the western side of the rise and the Fairway Basin which is on its eastern side.

Future Program for LHR

The New Oil Program in 2006 for the LHR includes:

- An integration and up-dating of current data holdings;
- Interpretation using seismic, potential field modelling and palaeogeographical information;
- Coring, swath mapping and dredging using the Marion Dufresne;

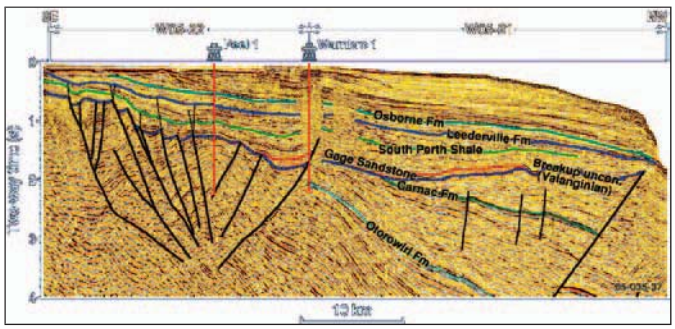

Fig. 9. Re-processed seismic data from the Vlaming Sub-basin – see text for details.

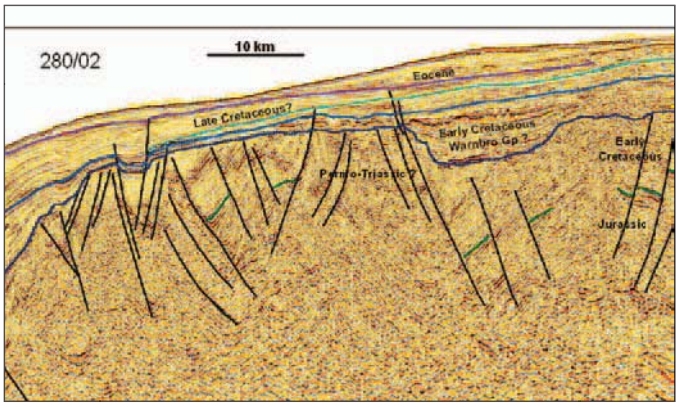

Fig. 10. New seismic data acquired from the Mentelle Basin.

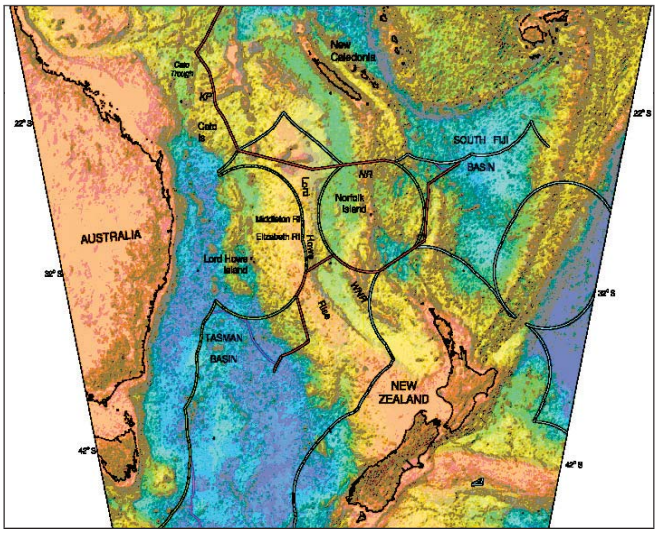

Fig. 11. Bathymetry of the Lord Howe Rise. The red curves represent the 1982 Australia-France treaty boundary (northern segment) and the 2004 Australia New Zealand treaty boundary. The other curves relate to the exclusive economic zones, which usually extend 200 nautical miles from land.

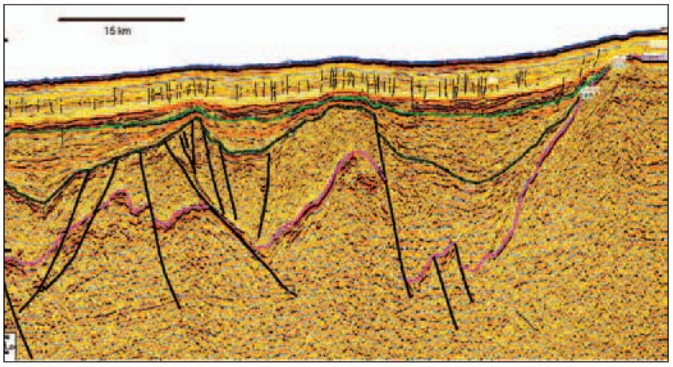

Fig. 12. A sample of a seismic record section across the Capel Basin. This basin contains Late Cretaceous to Cenozoic sediments, is a remote offshore frontier basin located on the Lord Howe Rise approximately 500 km off the east coast of Australia. The basin contains 1500 to 3750 m of sediment in water depths ranging from 500 to 3000 m.

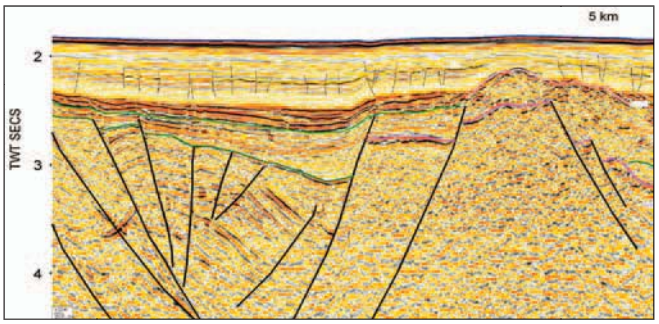

Fig. 13. A sample seismic record section across the Faust Basin. This basin contains Late Cretaceous to Cenozoic sediments, is a remote, offshore, frontier basin located about 750 km off the east coast of Australia. The basin forms part of the Central Rift Province of the Lord Howe Rise and contains approximately 1500 to 3000 m of sediments, in water depths ranging from 1500 to 2000 m. The Central Rift Province is characterised by a series of basement blocks as shown on the section.

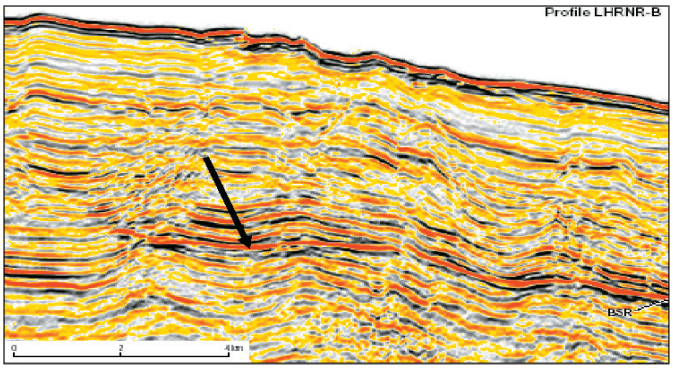

Fig. 14. A sample seismic record section across the Fairway Basin. This basin contains Early Cretaceous to Recent sediments, is located about 1000 km off the east coast of Australia on the eastern flank of the LHR. It contains approximately 2500 m of sediment in water depths ranging from 1500 to 3000 m. The arrow identifies a flat spot that could indicate a gas hydrate (BRS)

- Using a Calypso corer in areas of key gas hydrate BSRs (bottom-simulating reflectors) in the western part of the Fairway Basin to test for the presence of thermogenic hydrocarbons in the region.
- Planning for possible major seismic acquisition program in 06/07

The likely critical factors are:

- The presence of an effective source rock (richness + maturity);
- The effects of early volcanogenic components -did they swamp organics and reduce the porosity and permeability?
- Maturity for generation and expulsion and;
- Overburden – depth of burial, source rocks have to be deeper than the Early to Middle Cretaceous because there is no thick Tertiary for late loading; and
- Are we seeing the complete prospective section? Could there be older basins?

Final Remarks

This report only covers part of the proceedings of the workshop. I have not dealt with the Arafura and North West Shelf Basins, or the extensive studied that have been undertaken on the identification and analysis of oil seeps. I recommend that anyone wanting information on these aspects of GA's program, or more information on the basins I have discussed here, contact Paula Boldra, (paula.boldra@ga.gov.au) directly.

The multidisciplinary research being undertaken in this government program is top quality and crucial to our energy situation in Australia. The government should be encouraged to fund a further four year program in 2007.

Applications of infrasonics in hazard reduction

by David Brown

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Introduction

The interest in low frequency atmospheric acoustics has been heightened in the last decade, mainly in response to the monitoring requirements of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). The CTBT bans nuclear explosions in any environment. In order to monitor compliance of the treaty when it enters into force, the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO), located in Vienna, Austria, is currently installing a global network of monitoring stations, known as the International Monitoring System (IMS), designed to detect clandestine detonations.

Although a primary goal of the IMS network is the detection of any explosion with one kiloton yield (1kt) or higher, it could also play a significant role in the mitigation of other natural hazards, such as the detection of volcanic activity that may cause a potentially deadly ash cloud event for aircraft.

The IMS Network

The International Monitoring System (IMS) consists of a global network of 321 stations and 16 radionuclide laboratories, as indicated in Table 1, that monitor all terrestrial environments for clandestine nuclear detonations.

technology	number of stations	disposition
seismic	50 120	primary auxiliary
infrasonic	60	primary
hydroacoustic	6 5	hydrophone T-phase
radionuclide	40 40	fissile fissile+noble gas

Table 1. *Composition of the IMS global monitoring network*

The infrasound component of the IMS network (Christie, 1998), which as of December 2005 has 31 stations sending data in real-time to the CTBTO, is shown in Figure 1.

Geoscience Australia will operate four and The Australian National University will operate one of the IMS infrasound stations as part of the Australian Government's commitment to monitoring the CTBT

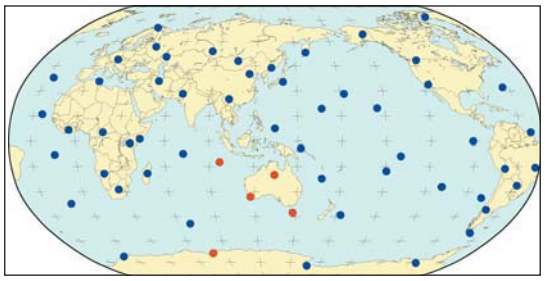

Fig. 1. *The 60-station IMS infrasound network. Australian operated stations are shown in red.*

Infrasound propagation in the atmosphere

Both empirical and theoretical results indicate that a 1kt explosion in the atmosphere radiates acoustic energy with a dominant frequency of around 0.2 Hz. To aid event characterisation, and to distinguish local activity, the pass-band of interest for infrasound monitoring of atmospheric explosions is 0.02 to 4.0 Hz.

The absorption of acoustic energy in the atmosphere is roughly proportional to the frequency, so that although audible sound in the hundreds to thousands of Hertz range attenuates rapidly - becoming inaudible within a kilometre - infrasound can propagate many thousands of kilometres before it is rendered undetectable.

The propagation of sound is tied very strongly to the ambient temperature T through the relationship for the thermal sound speed, C_s, given by $C_s = \sqrt{\gamma RT}$, where γ is the specific heat capacity of the atmosphere for constant pressure processes divided by the specific heat capacity of the atmosphere for constant volume processes, and R is the Universal Gas Constant. Refraction of acoustic energy in the atmospheric temperature gradient is expected as the ambient temperature has a well-defined variation with altitude. In practice, the sound speed gets modified by the presence of the ambient wind resulting in the effective sound-speed $C_{\text{eff}} = C_s + \mathbf{u} \cdot \hat{\mathbf{n}}$, where $\mathbf{u}$ is the ambient wind-field vector and $\hat{\mathbf{n}}$ is a unit vector in the direction of sound propagation.

Figure 2 shows both the thermal and effective sound speeds as a function of altitude and season for a point at 45° S latitude.

Two 'sound-channels' generally develop, the Stratospheric sound channel centred at around 15-20 km altitude, and the Thermospheric sound channel centred at around 90-100 km altitude. The seasonal nature of the winds at 50 km altitude can have a profound effect on the stratospheric duct, either enhancing or completely destroying it, whereas the thermospheric duct is always present. Representative acoustic ray-paths from a hypothetical source located on the northern coast of NSW in December are shown

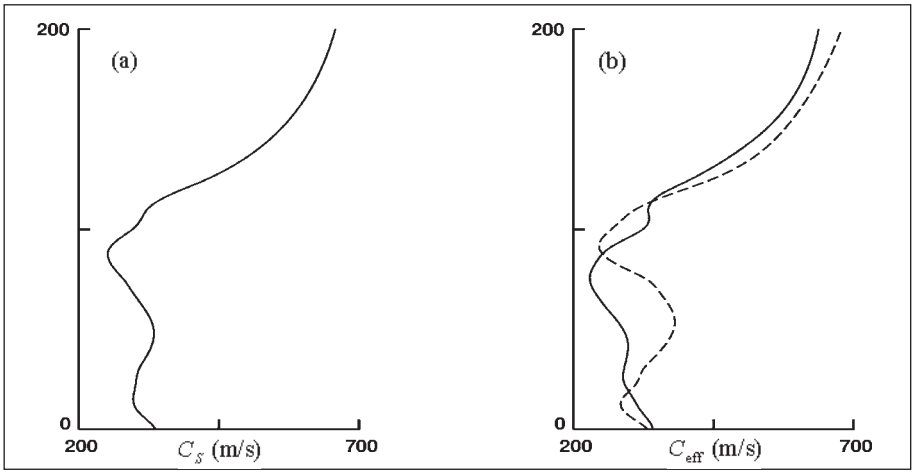

Fig. 2. Sound speed as a function of height for a point at 45° S latitude in January (a) thermal sound speed (b) effective sound speed, solid line: propagation against wind, dashed line, propagation with wind.

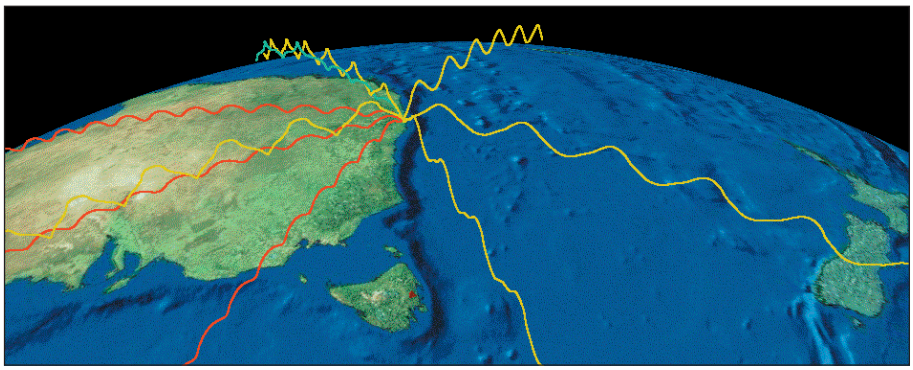

Fig. 3. Acoustic ray paths from a source located on the northern NSW coast in December. Red paths indicate propagation via the stratospheric sound channel, yellow paths indicate propagation via the thermospheric sound channel, and the blue path is a hybrid where multi-pathing occurs.

in Figure 3. The paths shown in red are propagating in the stratospheric duct turning at around 45 km altitude with skip distances of around 240 km, and the yellow ray paths are propagating in the thermospheric duct turning at around 120 km altitude with skip distances of around 400km. In the summer months the stratospheric winds blow toward the West, and reverse direction in the winter.

Infrasound signal detection and parameter estimation

The detection of infrasonic signals via automatic detection algorithms is an important aspect of the data handling performed at the CTBTO. This is an aspect of signal processing that can differ significantly from the seismic signal detection problem.

An interesting method of infrasound signal detection has been recently developed that relies on techniques originating in pattern recognition theory. Motivation for this work was the desire to detect the signals of the type shown in Figure 4 -in this case, an acoustic signal from a spaceshuttle launch at Cape Canaveral recorded at an infrasound station located in New Mexico, USA (signal courtesy Rodney Whitaker, LANL). To create this figure, the waveform data are band-pass filtered from 0.5 to 2.0 Hz and then successively sampled at very short time intervals (i.e. 'pixelated') and the azimuth, speed across the array, and correlation of the signal determined for each pixel. Here a nonlinear measure of the normalized correlation provided by the Fisher statistic (Fstat), is displayed. In a strict sense, the Fstat is defined to be the power in the beam directed at a given slowness, over a short time duration, divided by the sum across all channels, of the power in each channel minus the beam, subject to a multiplicative constant determined by the number of sensors. It is important to note that each channel needs to be transformed to a zero-mean unit-variance process in order for the exquisite cancellation called for in the denominator to succeed. The Fstat can often be represented approximately by the relation $F = N\frac{\Gamma}{1-\Gamma}+1$ where N is the number of sensors and Γ is the normalized correlation.

Traditionally, infrasound detectors have been based around Fstat detection. In this case, a detection is declared when the Fstat achieves a certain predefined threshold. However, such detection strategies have proven to be difficult to use, they cannot be reliably operated at a threshold that yields a favourable probability of detection for an acceptable false alarm rate. The signal shown in Figure 4, for example, proves difficult to detect and signal parameters correctly estimated because the Fstat is fairly low. Also, the Signal/Noise ratio contained in the signal is fairly low, so that energy detectors such as STA/LTA detectors may fail. However, the signal onset and duration is obvious to the human eye as the azimuth achieves a constant value to within a small error. We would like a numerical procedure that would extract the information regarding the 'straight line' from the otherwise noisy azimuthal data. The Hough Transform (Hough, 1959) from pattern recognition theory is just such a tool.

The Hough Transform is a patented method for extracting parametric curve information from binary pixelated data in the presence of noise. It is a slope-intercept transform in which the abscissa for each point is used as the slope and the ordinate of the point is used as the intercept of a line in parameter space. It has the very useful property that each point in the original space that lies on the same straight line gets mapped to a line in parameter space that intersects in the same point. As an example, consider the set of points $S = \{x_i, y_i; i = 1, \cdots, N\}$, which may be represented graphically as in Figure 5.

This set contains 100 randomly distributed points into which 20 points were placed that lie along the same straight line. If we apply the transformation $\mu = x_i\tau + y_i$ for i = 1,…, N, divide the parameter space P into cells and count the number of intersections in each cell we arrive at the surface shown in Figure 6.

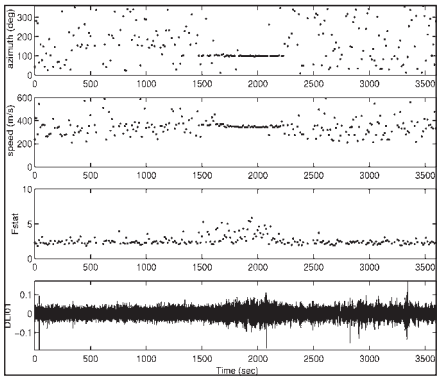

Fig. 4. Acoustic signal recorded from a Spaceshuttle launch at Cape Canaveral, recorded in New Mexico, USA. Top panel: measured azimuth. Second panel: measured speed. Third panel: measured Fstat. Bottom panel: filtered waveform, 05 to 2.0 Hz, for channel 1.

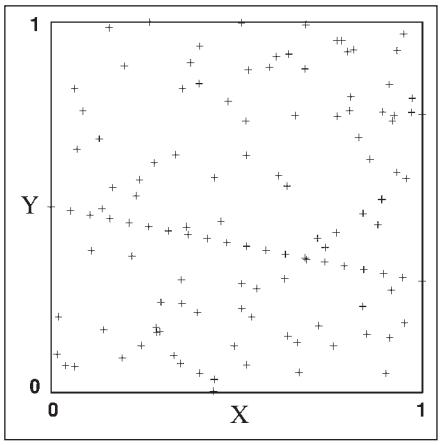

Fig. 5. Test data set consisting of 100 randomly distributed points in which a straight line consisting of 20 regularly spaced points is placed.

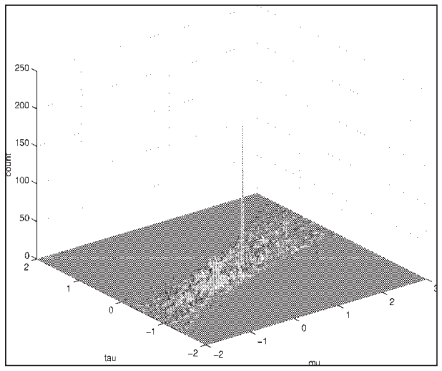

Fig. 6. Result after applying the Hough Transform to the data contained in Figure 5

The peak due to the straight line is obvious and can be 'detected' using straightforward minimization procedures. A similar procedure can be applied to the pixelated azimuthal data for the Spaceshuttle signal, which yields the results shown in Figure 7.

The Hough Transform has provided a robust method for doing infrasonic signal detection that otherwise may have proven difficult.

Natural sources of infrasound

Many natural sources of infrasound exist that generate signals that are regularly recorded on IMS infrasound stations.

Microbaroms

By far the biggest radiator of natural infrasound is the surface of the sea. These are the microbaroms - the precise atmospheric analogue of the microseisms - but to be clear, isolated travelling waves don't radiate acoustically. Microbarom radiation arises out of a nonlinear interaction of surface waves travelling in opposite directions (Arendt and Fritts, 2000) with approximately the same frequencies. The wake region of propagating storms (Ponomaryov *et al.*, 1998) can often be a good source of microbarom radiation. A good example is the acoustic signal generated by Tropical Cyclone Meena, which wreaked havoc on the Cook Islands from Feb 02 to Feb 08, 2005. Figure 8 shows contours of signal power as a function of slowness for acoustic signals recorded on IMS stations IS05 (near Hobart, Tas.) and IS07 (near Tennant Creek, NT) for microbarom radiation generated by TC Meena. The signals present in Figures 8a and 8b can be used to infer the approximate location of the storm system as shown in Figure 8c.

Bolides

A second source of naturally occurring infrasound are the bolides (meteorites) entering the atmosphere. Bolides impact the atmosphere at speeds ranging from 10-70 km/s and generate acoustic signals in one of two ways. In the first case, the supersonic motion through the atmosphere generates a line source that will be recorded either as a shock wave in the near field, or a linear acoustic wave in the far field. The second mechanism, which produces a larger source of sound, is from the terminating explosion when the kinetic energy of the bolide gets converted into thermal energy. Of all natural sources, this latter phenomenon generates the biggest source of false alarms for the IMS monitoring network. An example of an acoustic signal generated by a bolide impacting the atmosphere near the northern NSW coast is shown in Figure 9. The signal in this case was recorded at IS07 located near Tennant Creek in the Northern Territory.

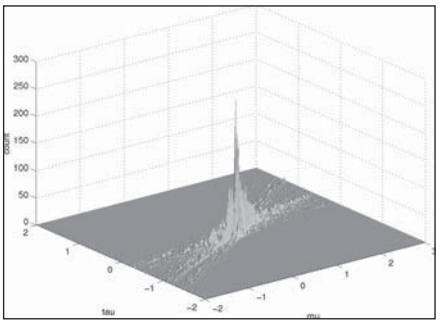

Fig. 7. Result after applying the Hough Transform to the azimuthal data from Figure 4 (Top panel).

Volcanic Eruptions

A third significant source of natural infrasound is volcanic activity. Australia lies near the perimeter of an arc of volcanic activity extending from Vanuatu in the east to Indonesia in the west. The Indonesian/PNG area alone contains some 165 active volcanoes. Higher activity from these volcanoes often registers on the IMS infrasound stations located in Australia. The eruption of Manam volcano, PNG of January 27, 2005 is a good example of a situation in which the IMS infrasound monitoring technology may be able to play a significant role in a multi-technology volcanic-ash warning system for aircraft. After several months of low-level volcanic activity, Manam erupted violently with devastating consequences destroying the Manam seismic observatory, operated by Rabaul Volcanological Observatory, and killing at least one person.

Acoustic signals from the main eruption of January 27 registered strongly on both IS07 and IS05 (Figure 10).

Unfortunately thick cloud cover made satellite analysis of the main eruption event difficult and an ash warning for aircraft was not issued until 14 hours after the event (Tupper, *et al.* 2005). The IMS infrasound network was the first system that could have initiated an ash warning, but also unfortunately the real-time data feed of IS07 data into Canberra was not completed at that time. Interestingly by the time the acoustic signal had reached IS05, the acoustic signal had lost most of its energy above 0.1 Hz - where routine processing was initially confined to and so was not detected by automatic processing. Since the Manam event, routine processing has also been extended to cover the frequency band relevant to large volcanic eruptions.

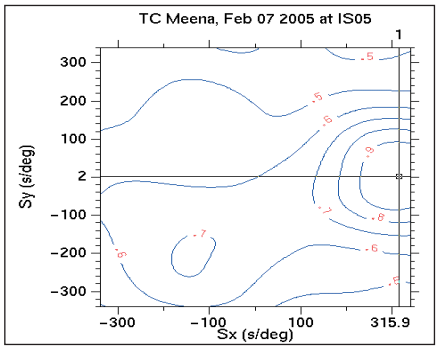

Fig. 8a.

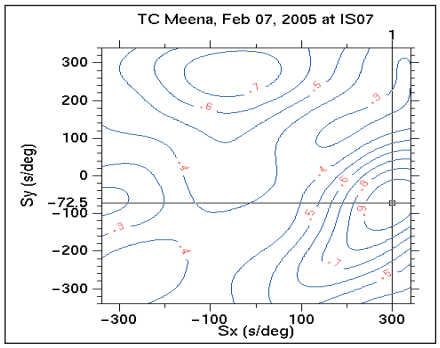

Fig. 8b.

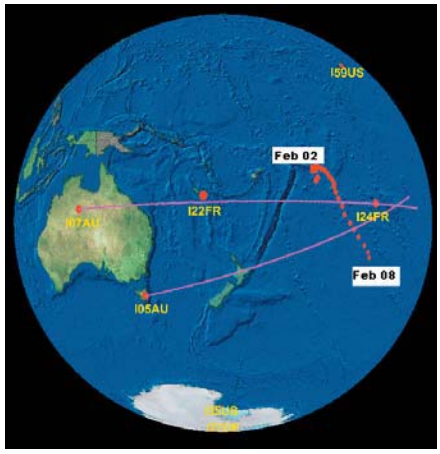

Fig. 8c. Contours of signal power as a function of slowness for the microbarom signals generated by TC Meena recorded at (a) IS07 and (b) IS05. In (c) the path of TC Meena is superimposed with great-circle paths from IS05 and IS07. The azimuths were determined from (a) and (b).

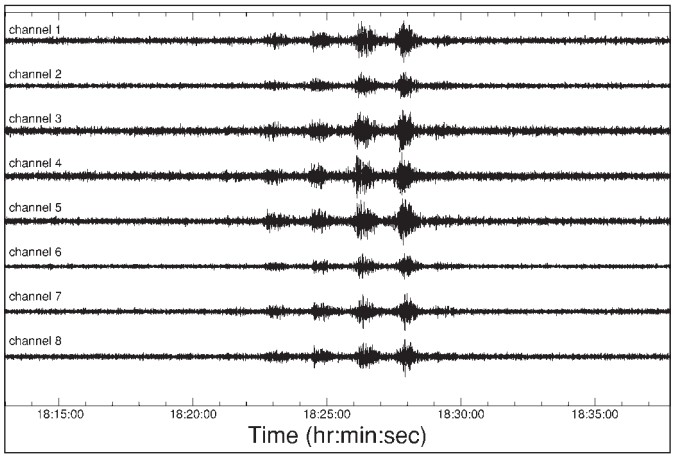

Fig. 9. Acoustic signal from a bolide (meteorite) explosion near Taree, NSW, recorded on station IS07 located near Tennant Creek, NT. Waveform filtered from 0.4 to 1.6 Hz.

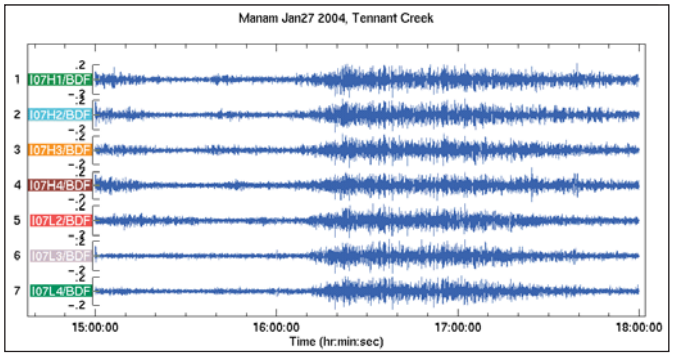

Fig. 10a.

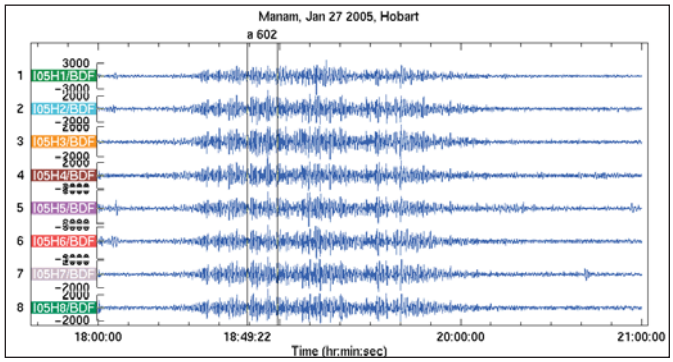

Fig. 10b. Acoustic signals from the eruption of Manam volcano of Jan 27, 2005 recorded on (a) IS07 –filtered between 0.4 and 1.6 Hz and (b) IS05 –filtered between 0.03 and 0.1 Hz.

Conclusions

Low frequency sound can travel considerable distances, its propagation being controlled by the gross temperature variation and wind field up to 150 km altitude. Reception of the acoustic signal, generally by an array of ground-based low-frequency microphones, provides knowledge of the source mechanism as well as the source-to-receiver propagation environment. This knowledge, in the case of acoustic signals generated by volcanic eruptions, may be a useful component in a multi-technology volcanic ash warning system for aircraft.

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Queensland, Western Australia and Geoscience Australia

Progress on current surveys

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 will be acquired over an area of approximately 42,000 square kilometres. At the end of December UTS Geophysics had completed 49% of this survey. Flying is expected to re-commence in late January 2006. See Preview 115 (April 2005 – Page 33) for a locality diagram of this survey.

East Yilgarn WA – airborne magnetic and radiometric survey

This survey is being flown for the Geological Survey of WA (GSWA) with project management by Geoscience Australia. Fugro Airborne Surveys started data acquisition on 14 August 2005 and completed the flying on 12 December 2005. Approximately 164,000 line-km of magnetic and radiometric data were acquired over an area of approximately 58,000 square kilometres. See Preview 117 (August 2005 – Page 34, Figure 3) for a locality diagram of this survey. Figure 1 is a preliminary image from the new magnetic data.

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. UTS Geophysics commenced data acquisition on the survey on 6 October 2005. Approximately 105,000 line-km of magnetic and radiometric data will be acquired over an area of approximately 43,000 square kilometres. At the end of December UTS had completed 45% of this survey. See Preview 117 (August 2005 – Page 34, Figure 4) for a locality diagram of this survey. Flying is expected to re-start in late January 2006.

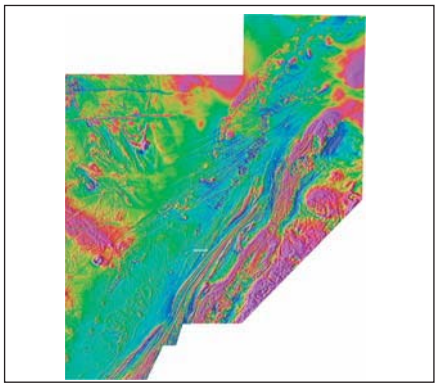

Fig. 1. Preliminary Magnetic image (TMI with illumination from the east) of new data over the East Yilgarn Survey area.

Western Gawler – airborne magnetic and radiometric survey

This survey is being flown for Primary Industries and Resources SA (PIRSA) with project management by Geoscience Australia. Fugro commenced data acquisition on 30 October 2005. Data acquisition was completed on 11 December 2005. Approximately 36,000 line-km of magnetic and radiometric data were acquired over an area of approximately 12,500 square kilometres. See Preview 119 (December 2005 – Page 40, Figure 5b) for a locality diagram of this survey. Figure 2 is a preliminary image from the new magnetic data.

Bowen – Surat North, Bowen – Surat South and West Mt Isa airborne magnetic and radiometric surveys

These surveys are being flown for the Geological Survey of Qld (GSQ) with project management by Geoscience Australia. Fugro expected to commence the Bowen – Surat South and West Mt Isa surveys in the last week of January 2006. The Bowen – Surat South survey will acquire approximately 154,000 line-km of magnetic and radiometric data over an area of approximately 55,000 square kilometres. The West Mount Isa survey will acquire approximately 63,000 line-km of magnetic and radiometric data over an area of approximately 22,000 square kilometres. UTS expects to commence the Bowen – Surat North survey in February. See Preview 118 (October 2005 – Page 41) for a locality diagram of these surveys.

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. It is planned to acquire 5263 new gravity stations over an area of approximately 85,000 square kilometres. At the end of December 2005 Daishsat had completed 68% of this survey. See Preview 118 (October 2005 – Page 41) for a locality diagram of this survey.

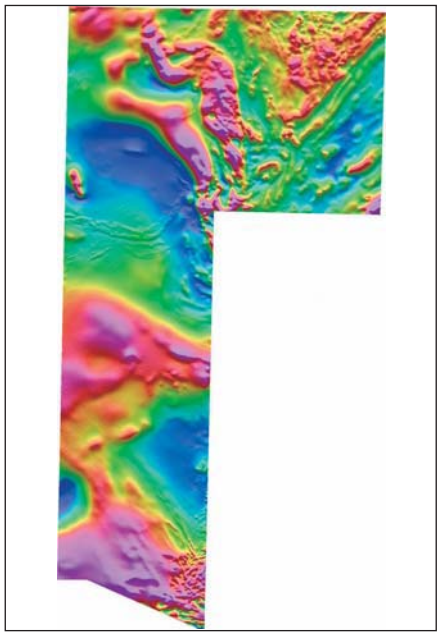

Fig. 2. Preliminary Magnetic image (TMI with illumination from the north) of new data over the Western Gawler Survey area.

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Geoscience Australia

Seismic Reflection Surveys

ANSIR, the **National Research Facility for Earth Sounding**, is planning acquisition of the 2006 central Victorian Seismic Transect. This survey involves Geoscience Australia, as the main contributor, with GeoScience Victoria, pmd*CRC, Leviathan Resources, GoldFields, Ballarat Goldfields and ANSIR. Data acquisition will take place in the second quarter of 2006. This transect is a series of east-west orientated traverses that begin north of Stawell and runs eastwards, going northeast of Bendigo and on into the Melbourne Trough. The survey will provide valuable information on the nature of the crust in the Stawell, Bendigo and Melbourne structural zones and a better understanding of the relationship of gold mineralisation to structure in this part of the Lachlan Fold Belt.

ANSIR is also planning for the 2006 Mt Isa Seismic Transect. This project involves in excess of 500 km of deep seismic reflection profiling within the Mount Isa region. It involves the Geological Survey of Queensland - Queensland Department of Natural Resources and Mines, Geoscience Australia and ANSIR, with the local mining industry being encouraged to get involved. The seismic reflection work will improve the understanding of the linkages between crustal architecture, fluid flow and regional scale mineral systems, and will assist in the discovery of further mineral resources in the region. The east-west and complementary north-south traverses focus on different structures and each incorporates a different set of mineral deposits whose structural setting and regional context are still largely unknown in the third dimension.

Results from the 2005 Tanami Seismic Collaborative Research Project are answering several fundamental questions on Tanami region crustal architecture and associated mineral systems. Final interpretations of the 2005 Tanami Seismic Collaborative Research Project will be presented at a Seismic Workshop in June 2006 in Alice Springs.

ANSIR is preparing for a baseline VSP project for the CO2CRC Otway Basin Pilot Program. ANSIR will use its MiniVib as the energy source for a VSP survey to establish time-depth relationship for improved depth conversion of existing 3D seismic data. The survey will also be used to evaluate the suitability of the MiniVib for future time-lapse VSP/multicomponent acquisition for monitoring changes in depleted gas reservoir from injection of CO_2 and its potential in imaging the Gas-Water contact in reservoir at approx 2 kilometres depth.

ANSIR is scheduling to complete the BHP Billiton Illawarra Coal project with the acquisition of high-resolution seismic data using a IVI Hemi 60 as a source. ANSIR recently completed the collection of high-resolution seismic data using its MiniVib high-frequency Vibroseis source as part of a BHP Billiton Illawarra Coal investigation into the delineation of geological structures for coal mine planning using a variety of sources including explosives, high-frequency MiniVib and large-weight Hemi 60. The final comparisons will have significant implications for coal exploration and mine seam delineation.

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SA Government provides $2 million for drilling activity

SA Government funding of approximately $2 million was committed last December through the Plan for Accelerating Exploration (PACE) initiative. This is the third PACE allocation of funds, which will total $22.5 million over five years.

The plan is to use PACE funding to boost mineral exploration to $100 million a year by 2007. Almost 80 proposals were received for the third round of collaborative funding to

Cont'd on page 40

Mineral exploration expenditure continues to rise, petroleum remains flat

Minerals

Modest increase in 3rd quarter

Figures released by the Australian Bureau of Statistics in December 2005 showed that the trend estimate for total mineral exploration expenditure increased by 2.9% to $281.1M in the September quarter 2005. This estimate has risen in the last eight quarters and is now 17.5% higher than the September quarter 2004 estimate. It is still 40% less than the peak reached in July 1997.

Figure 1 shows the expenditure estimates from September 1997 through September 2005.

Figure 2 shows the longer term trends from March 1986. It indicates that in real terms the level seems unlikely to reach the dizzy heights of 1997 in the foreseeable future.

In seasonally adjusted numbers, all states and the Northern Territory showed increasing expenditure levels apart from Western Australia which had a $7.5M fall. Even so the WA total expenditure of $150.6M is still way above the Queensland ($45.9M) and South Australia ($25.8M) investments, which are 2nd and 3rd respectively.

The Greenfield to Brownfield numbers were $105.5M/$186.6M respectively with very healthy spending in new areas.

Fig. 1. Trend and seasonally adjusted quarterly mineral exploration expenditure from September 1997 through September 2005 (provided courtesy of the Australian Bureau of Statistics).

Drilling activity increased by 4.8% in seasonally adjusted terms from the June Quarter to a total of 1670 km but this number is slightly less than the seasonally adjusted figure of 1749 km for the same period in 2004. As expected the actual metres drilled in existing deposit areas (1100 km) was much larger than that drilled in new areas (735 km) but the ratio between the two areas is very similar.

Gold results of concern

The gold situation is of real concern. In spite of the strong gold price in recent years (see Figure 3), the exploration expenditure for gold has been stagnant (see Figure 4) over the last five years. Perhaps even more worrying is the decline in Australian gold production (Figure 5). After a peak in December 1997 quarter of over 80 tonnes, the decline in production has been relentless. It is now hovering about the 65 t per quarter figure.

In terms of loss of export income, if extrapolated over a full year, amounts to a staggering A$1.3 billion per year over the peak production quarter in 1997!

It is very clear that both industry and governments must work hard to encourage more exploration investment for this very special precious metal.

Petroleum

Expenditure on petroleum exploration for the September quarter 2005 increased by $3.5M (1.3%) to $282.0M.

Exploration expenditure on production leases increased (by $13.5M or 18.3%), while exploration on all other areas decreased (by $10.1M or 4.9%) for this quarter.

There was a decrease of $7.5M (3.6%) in offshore exploration, while onshore exploration expenditure increased by $11.0M (16.0%).

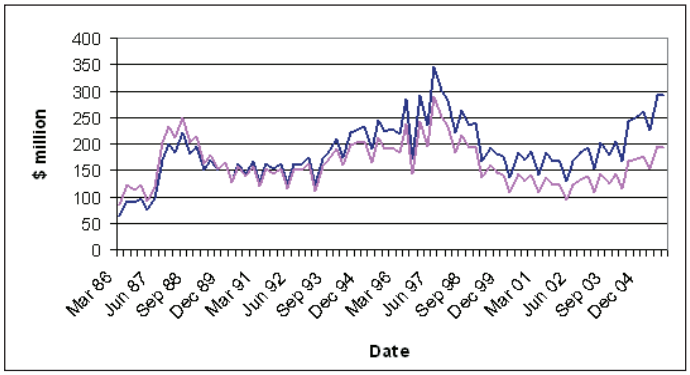

Fig. 2. Quarterly 'actual' mineral exploration expenditure from March 1986 through September 2005 (from ABS data). The black curve represents actual dollars spent and the purple curve shows the CPI adjusted (to 1998/99, RBA data) number. Notice that the CPI adjusted long term trend is now close to the average over the last 20 years.

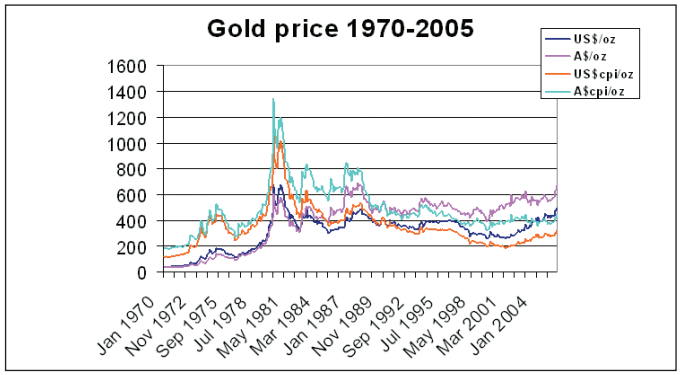

Fig. 3. Quarterly gold price from 1970 through 2005, notice that since the peak years around 1980 the price has declined steadily in real terms until 2001 when there has been a gradual increase. The black and purple plots show the contemporary values in $/ounce for US and A dollars respectively. The orange and turquoise curves represent CPI adjusted values to 1998/90 dollars for US and A dollars (sources are ABS and the RBA).

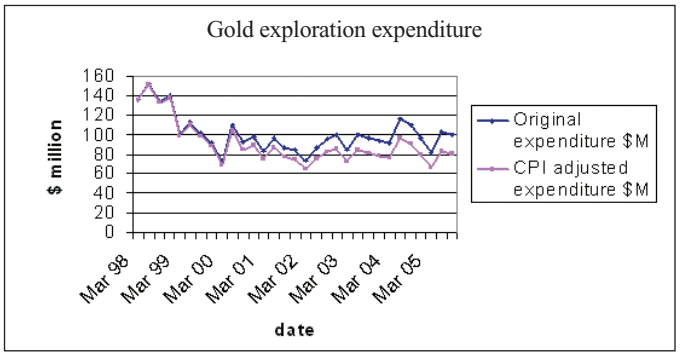

Fig. 4. Actual quarterly exploration expenditure for gold in Australia from 1998 though September quarter 2005 and CPI adjusted expenditure to January 1998 levels. All numbers are in millions of A dollars (sources are ABS and the RBA).

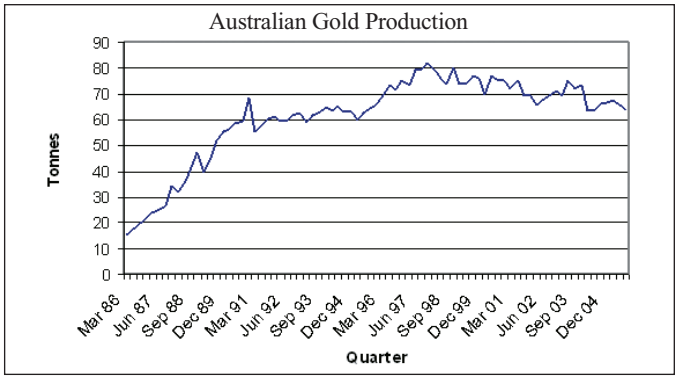

Fig. 5. Quarterly Australian gold production from 1986 through September 2005. Notice the gradual decline since the December quarter 1997. This is equivalent to a loss of $1.3 billion export earnings annually compared to the 1997 level.

Petroleum exploration expenditure movements varied considerably across the states. South Australia, Western Australia and Northern Territory increased, while all other states showed decreases. Victoria had the largest fall of $16.3M (41.8%). South Australia recorded the largest increase of $15.5M (109.9%).

Western Australia continued to dominate the scene with a total quarterly expenditure of $135.1M; $5.7M above the June quarter results.

Figure 6 shows plot of the quarterly petroleum expenditure from March 1986 through September 2005. Notice that over the last ten years in real terms the long term trend is close to zero.

2005 Great year for resource industries

Resource stocks powered relentlessly ahead in 2005, putting in an even better performance than they did in 2004.

During 2005 the total market capital of resource stocks, in the top 150 companies listed on the ASX, rose from $137.8 billion to a whopping $202.1 billion during the year; an increase of 47 percent. At the same time the All Ordinaries Index rose from 4053 to 4709 – still a healthy rise of 16 percent but nowhere near the resource stock gains.

Figure 7 summarises the trends. Notice that the loss of WMC, which was taken over by BHP Billiton in June 2005, hardly shows up on the chart, even though its market capital was valued at $9.2 billion at the time and BHP Billiton's value dropped $1.7 billion in the same week! It seems strange that BHP Billiton's value dropped at the same time as it acquired an asset of over $9 billion.

Anyway, BHP at $82 billion and Rio at $32 billion dominated the market, with the third placed resource company Woodside Petroleum coming a close third at about $26 billion – all the others are in a different league.

Global exploration reaches $5.1 billion[1] in 2005-still short of 1997 peak

A recently released survey by the Canadian Metals Economics Group, based on an analysis of 1,431 companies' exploration budgets (using a $100,000 cutoff), estimated the total 2005 expenditures for commercial nonferrous metals exploration to be $5.1 billion.

Their estimates showed a steady increase through the early 1990s to a crest of $5.2 billion in 1997, before falling to a 12-year low of $1.9 billion in 2002 - an overall decline of more than 63%. Since 2002, expenditure has continued to rise. The 2005 estimate of $5.1 billion is 34% greater than the $3.55 billion estimate for 2004.

Junior explorers grow

Junior-company exploration budgets were up almost 57% to $2.33 billion in 2005 accounting

[1] *All expenditures in $US*

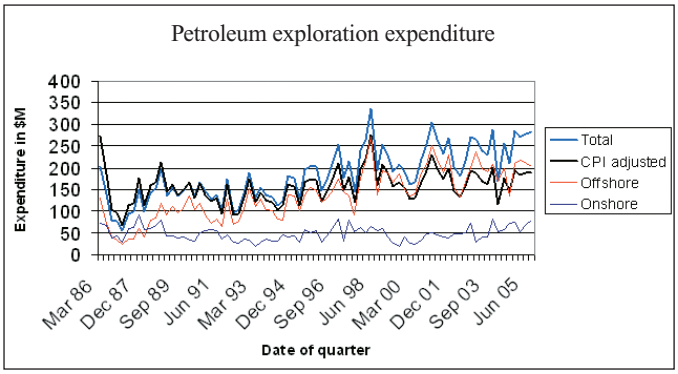

Fig. 6. Quarterly petroleum expenditure from March 1986 through September 2005. The individual offshore and onshore numbers are actual numbers spent, not CPI adjusted. Notice that over the last ten years the CPI adjusted (to 1998/99) numbers, while showing very large scatter, indicate a long term trend that is close to zero (data from the ABS and the RBS).

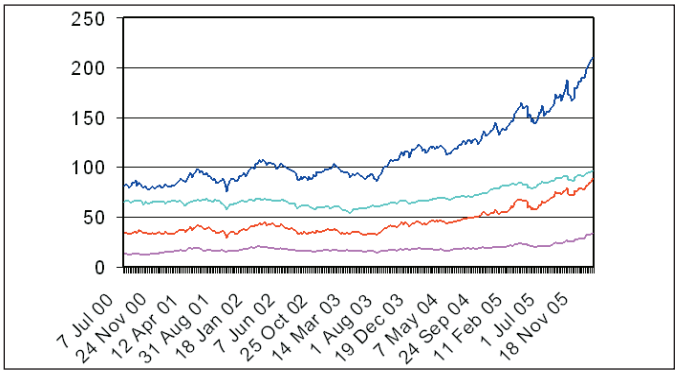

*Fig. 7. Total market capitalization, in $ billion, of resource companies listed in the top 150 of the ASX (top graph, dark blue); All Ords Index * 20 for the same period (2nd graph, turquoise), and the two largest companies, BHP Billiton and Rio Tinto (lower two graphs red and purple).*

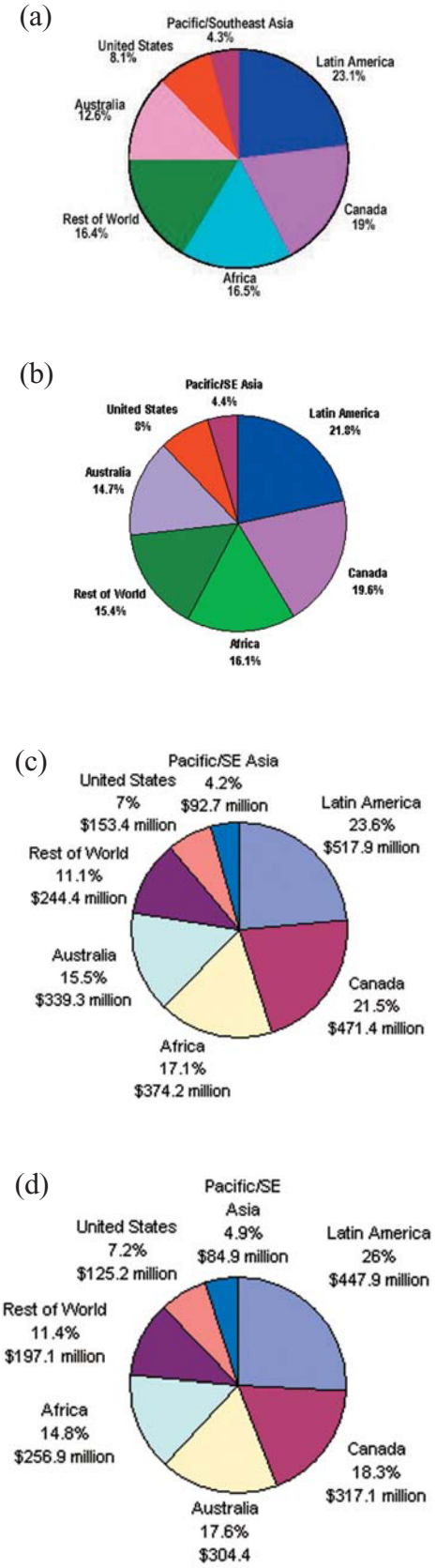

Fig. 8(a-d). Worldwide nonferrous exploration spending by region 2005(a), 2004(b), 2003(c) and 2002(d). Notice how the Australian slice of the pie has fallen from 17.6% to 14.6% during the four years.

for 63% of the overall $1.34 billion increase in exploration allocations by all surveyed companies. Since 2002, junior exploration spending has increased a remarkable 347%, accounting for 57% of the overall $3.2 billion increase in exploration allocations by all surveyed companies from 2002 to 2005.

Latin America still leads and Australia slides

Figure 8a shows the estimated regional distribution of the exploration budgets for 2005. Latin America continues to be the most popular destination for exploration, increasing its lead for the second consecutive year over second-place Canada, after Canada's exploration tax incentives helped close the gap to less than $50 million in 2003. Africa remains in third place by region, closely followed by our rest-of-world category, which includes Europe, the Former Soviet Union, Asia, and the Middle East. Despite a gradual slide from first place by region in 2001 to fifth place this year, Australia remains solidly in second place by country. The United States and the Pacific/Southeast Asia region are in sixth and seventh place, respectively, positions they have held since 2001.

Figure 8(a-d) indicates how the different regions have fared in the last four years.

The full 820-page two-volume study is now available (on the internet and in print) for C$17,000 from Metals Economics Group, P.O. Box 2206, Halifax, Nova Scotia, B3J 3C4, Canada. Email: med@metalseconomics.com; web site: www.metalseconomics.com.

Barrick acquires Placer Dome – Newmont slips to 2nd place

The takeover game continues unabated with the announcement by Barrick Gold Corporation in January 2006 that it had acquired 81% of fellow Canadian, Placer Dome's shares.

The aggregate cash to be paid by Barrick will be approximately US$992 million and the aggregate number of common shares to be issued by Barrick will be approximately 260 million, in respect of the shares tendered to date. This amounts to a US$10.4 billion takeover.

As a result of the amalgamation US-based Newmont is no longer the world's biggest gold producer.

The net result is that one Canadian company will control about 65 per cent of Australia's gold output. The portfolio now contains the following mines: Kalgoorlie Mine, Plutonic, Darlot, Granny Smith, Kanowna Belle, Kalgoorlie West and Lawlers in Western Australia; Osborne in Queensland; Henty in Tasmania and the soon to be developed Lake Cowal in New South Wales – not a bad holding.

As a result of the high gold price (more than US$500/oz) the share prices of several Australian gold producers - including the two biggest, Newcrest Mining and Lihir Gold - have risen strongly in recent weeks due to speculation they could make attractive takeover targets for Newmont or other global goldminers.

No longer are we digging up and selling our own gold – someone else is doing it for us!

2005 a great year for Santos

Santos for example announced "record sales revenue of $2.46 billion for the 2005 full year, up 64% on the Company's previous record of $1.5 billion achieved in 2004. The result was driven by a 19% increase in production to 56.0 million barrels of oil equivalent together with continuing higher oil and gas prices."

The flow on effect of this profit is an increase in exploration expenditure across the Company's Australian and overseas exploration areas to $225 million compared with $187 million spent on exploration in 2005. Good news for Santos.

Aims and Scope

Preview is published by the Australian Society of *Exploration Geophysicists*. It contains news of topical advances in geophysical techniques, news and comments on the exploration industry, easy-to-read reviews and case histories of interest to our members, opinions of members, book reviews, and matters of general interest.

Contents

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Contributions

All contributions should be submitted to the Editor via email at denham@webone.com.au. We reserve the right to edit all submissions; letters must contain your name and a contact address. Editorial style for technical articles should follow the guidelines outlined in *Exploration Geophysics* and on ASEG's website www.aseg.org.au. We encourage the use of colour in *Preview* but authors will be asked in most cases to pay a page charge of $440 per page (including GST for Australian authors) for the printing of colour figures. Reprints will not be provided but authors can obtain, on request, a digital file of their article, and are invited to discuss with the publisher, RESolutions Resource and Energy Services, purchase of multiple hard-copy reprints if required.

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Blackburn, G. J., 1981, Seismic static corrections in irregular or steeply dipping water-bottom environments: *Expl. Geophys.,* **12**, 93–100.

Abbreviations and units

SI units are preferred. Statistics and measurements should always be given in figures e.g. 10 mm, except where the number begins a sentence. When the number does not refer to a unit of measurement, it is spelt out, except where the number is greater than nine. Confusing mathematical notation, and particularly subscripts and superscripts, should be avoided; negative exponents or the use of a solidus (i.e. a sloping line separating bracketed numerator and denominator) are acceptable as long as they are used consistently. The words 'Figure' and 'Table' should be capitalised (first letter) and spelt in full, when referred to in the text.

Deadlines

Preview is published bi-monthly, February, April, June, August, October and December. The deadline for submission of all material to the Editor is the 15th of the month prior to the issue date. Therefore the deadline for the **April 2006 issue is 15 March 2006.**

Advertisers

Please contact the publisher, RESolutions Resource and Energy Services, (see details elsewhere in this issue) for advertising rates and information. The ASEG reserves the right to reject advertising, which is not in keeping with its publication standards.

Advertising copy deadline is the 22nd of the month prior to issue date. Therefore the advertising copy deadline for the **April 2006 issue will be 22 March 2006**. A summary of the forthcoming deadlines is shown below:

Preview Issue	Text & articles	Advertisements
121 Apr 2006	15 Mar 2006	22 Mar 2006
122 Jun 2006	15 May 2006	22 May 2006
123 Aug 2006	15 Jul 2006	22 Jul 2006
124 Oct 2006	15 Sep 2006	22 Sep 2006

Cont'd from page 36

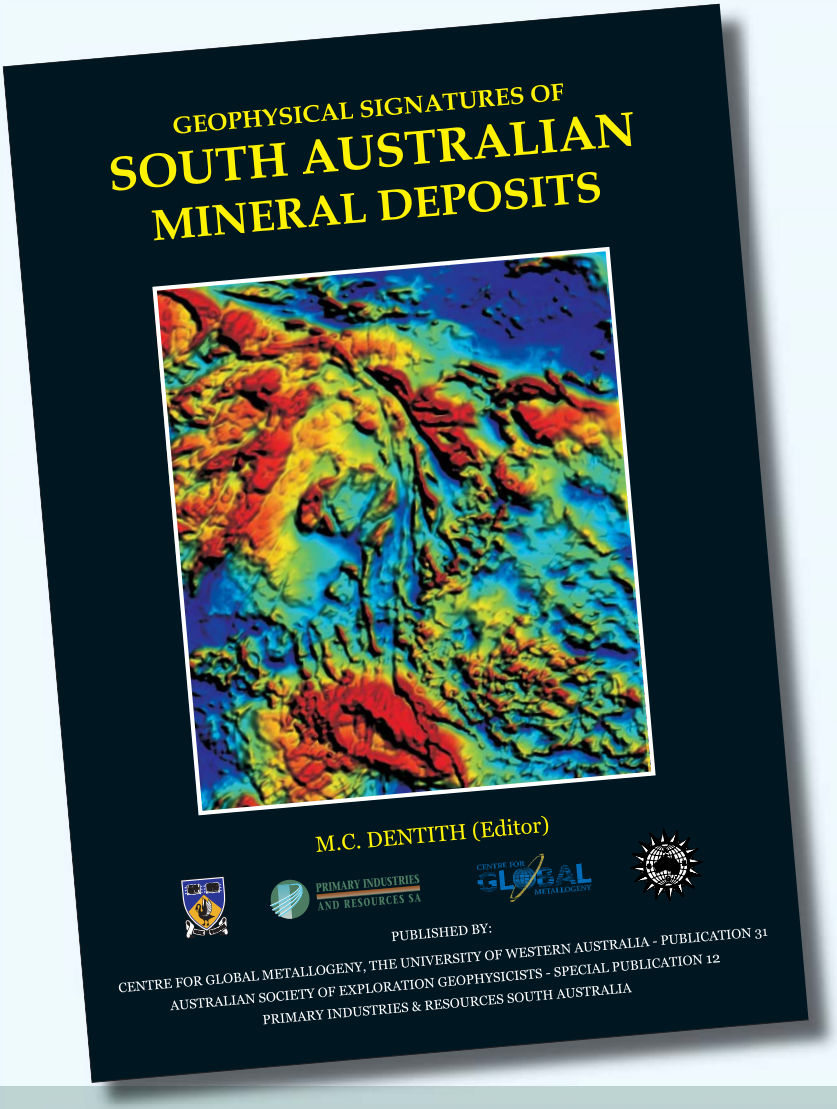
search for minerals, oil, gas and geothermal prospects in South Australia. This round focused on support for drilling projects, in which the State will fund up to 50% for each drillhole on the approved list.

The latest round of proposals includes new targets, new exploration ideas, and interest in a wide range of minerals including copper, gold, nickel, uranium and geothermal resources.

Of the approved projects, nine are in the Curnamona Province, 22 in the Gawler Craton, two in the Adelaide Fold Belt and one each in the Musgrave Province and the Cooper Basin.

South Australia has enjoyed a significant increase in exploration activity during the last two years. According to Australian Bureau of Statistics figures mineral exploration spending for the 2004-2005 financial year was $66.8 million - a 60% increase on the $41.7 million spent in 2003-2004.

For more information see the PACE website: http://www.pir.sa.gov.au/dhtml/ss/section.php?sectID=1991



The Geophysical Signatures of South Australian Mineral Deposits

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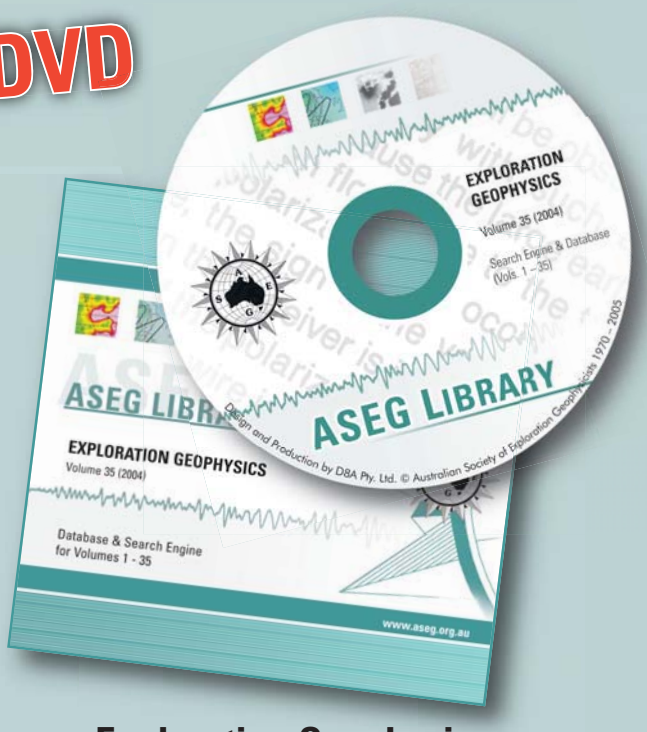

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Atlantis is a unique 3-component borehole tool for the low-noise measurement of magnetic (B) fields in TEM, MMR and other electrical geophysical surveys or geomagnetic applications. Atlantis is fully integrated with EMIT's SMARTem receiver system for automated low-noise data acquisition and superior performance, even in electrically noisy environments.

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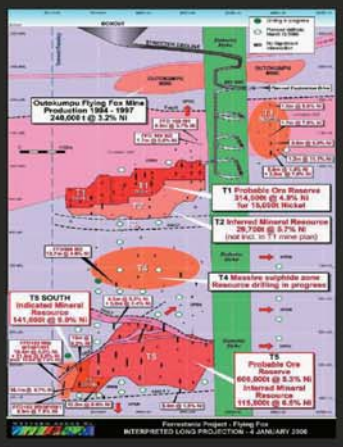
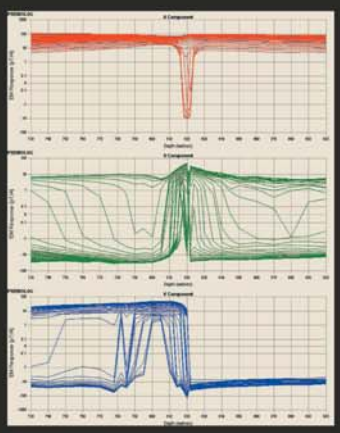
Atlantis measures borehole azimuth and inclination. A unique suite of products are available from an Atlantis survey, including full off-time and on-time responses. Atlantis data can be interpreted using EMIT's Maxwell software and other packages.

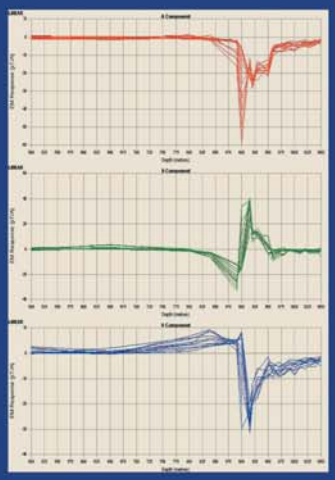


Western Areas NL, Flying Fox Deposit, W.A.

An Atlantis survey in December 2005 was responsible for the siting of a drill wedge into the Flying Fox T4 Deposit that intersected nickel mineralisation of 13.65m at 4.6% Ni in hole FFD168W2. Shown here (right) is the Atlantis data from FFD168, collected at a base frequency of 0.5 Hz, clearly showing the off-hole anomaly from T4. Interpretation of the Atlantis data by Newexco Services Pty Ltd led to the drilling of FFD168W2. Consultants Newexco explained that "*Atlantis data made the interpretation of the additional massive sulphides unambiguous. B field data clearly showed the highly conductive parts of the target.*"

Data collected by Vortex Geophysics and provided courtesy of Western Areas NL and Newexco Services.





Inco Exploration, Sudbury, Ontario

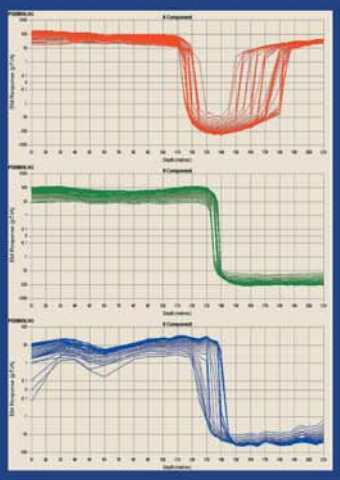
Inco Exploration has been using an Atlantis system in the Sudbury Basin since late 2004 to define nickel exploration targets. Shown here (left) is an example of late-time EM data from the Sudbury area. It was acquired at a base frequency of 3 Hz in a borehole which intersected the edge of Cu/NiS bodies between 900 and 950m depth.

Data provided courtesy of Inco Exploration, Sudbury.

BHP Billiton, Leinster Area, W.A.

BHP Billiton has been using Atlantis systems in the Leinster-Mount Keith area to define nickel resources. Shown here (right) is Atlantis data, gathered at a base frequency of 1Hz, illustrating the EM response of an off-hole target in conductive terrain.

Data collected by Geoforce Pty Ltd and provided courtesy of BHP Billiton.



Independence Group, Long/Victor Nickel Mine, W.A. - A New $470M Resource

EMIT's products have been part of significant exploration success in the mining sector. One such example is at Independence Group's (IGO) Long/Victor Nickel Mine at Kambalda, Western Australia. DHEM surveys with the Atlantis borehole magnetometer system have been a standard part of in-mine exploration at Long since Atlantis was developed in 2004. One Atlantis system has been operating continuously at Long since that time.

In March 2005, IGO announced the discovery of the McLeay Shoot at the Long Nickel Mine. Geophysics has made a significant contribution to the discovery and ongoing delineation of McLeay and the main geophysical tool involved is Atlantis. As of January 2006 McLeay is a resource of 23,600 tonnes of nickel metal, currently valued at $A470M. It remains open to the north, south and east. Mining is being planned.

IGO: "*Atlantis allows us to make more effective decisions in our mine, and is an integral part of our exploration effort. IGO is pleased to take a lead role in the deployment of Atlantis and the continual improvement of the associated tools and software.*"

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