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PREVIEW

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

NEWS AND COMMENTARY

Farewell to Stewart Gunson
22nd ASEG conference round-up
2012 Honours and Awards citations
TESEP – award-winning program
1st Australian Geoscience Teaching Workshop

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FRONT COVER

Rubber tracked DX80 80 000 lb vibrators crossing sand dunes in the Rub' al Khali, Saudi Arabia (see article beginning p. 38) (image courtesy of WesternGeco).

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Ann-Marie Anderson-Mayes

I love coincidence and connections – things that come together unexpectedly and reveal something greater than just the sum of the parts. So, I am very grateful to Greg Street who told me on the last afternoon of the ASEG Conference in Brisbane that I must visit the nearby Queensland Art Gallery to view the exhibition, 'Eugene von Guérard: Nature Revealed'.

Von Guérard was an Austrian born artist who came to Australia in 1852, aged 41 and already an established artist. His art was inspired by a close observation of nature and thus his work provides a wonderful visual record of the Australian landscape in the period 1852 to 1881 (when he returned to Europe). Von Guérard is of interest to geophysicists because he was friends with Georg von Neumayer.

Von Neumayer is considered Australia's first exploration geophysicist. The story of his geophysical career, written by Doug Morrison, can be found in a 5-part series in *Preview* (Issues 121–125, Apr–Dec 2006). In the spring of 1862, von Neumayer invited von Guérard to join his team in a magnetic survey of north-east Victoria and Mount Kosciuszko, involving some 1400 kilometres of travel. Von Guérard recorded the journey in his sketchbook and later created some beautiful paintings from the expedition. In particular, one sketchbook shows Neumayer's wagon, which was used to transport all his measuring equipment.

And this is where the 'connection' comes in. Here was I, looking at the original sketch of a wagon used to carry geophysical equipment 150 years ago. And I had just spent three days learning about all the latest and greatest things happening in the world of geophysics. Von Guérard recorded images of the expedition with the simplest of technology, pen and paper – not for him the digital camera I had just used to record images of presenters and exhibitors. In exactly the same way, von Neumayer recorded all his scientific observations and data in notebooks. The computer power of modern geophysics seems a world away from these laboriously hand-written measurements. And yet, this team was recording the very best scientific observations they could with the technology available, just as scientists have done throughout history.

Geophysics has come a very long way in 150 years, but in some ways this expedition was no different to a modern geophysical survey. Travel to remote locations, looking after equipment, recording the best data possible, working as a team, dealing with the impact of adverse weather conditions, meeting the locals – these were all part of von Neumayer's magnetic survey of Victoria, just as they are of many geophysical surveys today.

The 22nd ASEG Conference and Exhibition was another excellent ASEG event, made just a little more special for me because on the last day I felt like I had almost reached out and touched a part of the early history of our profession in Australia. One of those connections that makes the world we live and work in just that much more interesting.

ASEG Report Card for 2011–2012

This year's ASEG Annual General Meeting (AGM) was held in Adelaide on 3 April. The AGM is an open meeting where the Federal Executive presents a 'report card' on the Society's financial health and activities over the past year. Most of our members will not be able to attend that meeting so I will use this month's President's Piece to summarise it.

The technologies used in exploration geophysics are rapidly evolving and, for me, the most important aspect of the ASEG is helping members keep abreast of these new technologies. The ASEG does this with technical talks at our local branch meetings, short courses, our publications (*Preview* and *Exploration Geophysics*) and our conferences. Over the past year, the ASEG has sent eight different distinguished lecturers to our various branches around Australia. Their lectures included topics as diverse as seismic imaging, New Zealand seismology, gravity and magnetic modelling, virtual seismic sources, shale gas, seismic petrophysics and seismic acquisition.

If our local branch technical talks are 'sipping at the fountain of geophysical knowledge' then our recent very successful ASEG Conference and Exhibition in Brisbane was 'drinking from a fire hydrant of geophysics'. The Brisbane Conference and Exhibition has been receiving rave reviews for its technical program of over 130 technical talks presented over three days. One of the key reasons for this successful conference was that the Conference Organising Committee (COC) invited 21 international experts who gave world-class keynote talks for most sessions. The COC chose a format of five concurrent streams of talks each day with two streams dedicated to petroleum geophysics, two to mining geophysics and the fifth stream reserved for geothermal, groundwater, coal, near surface seismic, coal seam gas, and CO_2 sequestration. There were over 950 registrants. Nine different full-day workshops were offered before and after the conference. The number and quality of the commercial exhibitors was also excellent – in fact the size of the rented exhibition hall had to be expanded twice to satisfy demand for exhibition space.

The ASEG also continues to help support smaller focused geophysical workshops and symposiums. We have supported the new West Australian Geothermal Energy Symposium (WAGES), which occurred April 2011 and again in April 2012. We are supporting an EM Induction Workshop in Darwin later this year and a Near Surface Geophysics Workshop (in China) next year. Our support for these workshops consists of 'seed' loans and organisational expertise.

Our publications – *Preview* and *Exploration Geophysics* – continue to deliver. Late last year we concluded an agreement to jointly publish two issues of *Exploration Geophysics* per year with the Korean SEG and SEG-Japan. And we understand that the impact factor of *Exploration Geophysics* (a world-wide measure of how often articles in our technical journal are referenced) will soon be revised upwards yet again.

We are engaged in an extended process to obtain a new contract for our publications, and we hope to cut costs in this area. One of our desires with a new publishing contract is to give members the choice of receiving paper or digital copies of *Preview* and *Exploration Geophysics* – and those who choose to receive only the digital copies are likely to see lower yearly membership dues.

There has also been considerable progress on our website in the past year. The position of ASEG webmaster was vacant for a few months when the previous webmaster took a new job in Canada. We now have found a new webmaster (Carina Kemp) who has steered us through a competitive bid process for the design of our new website. Our new website is currently under construction and should be delivered in June or July. I am pleased to report that the ASEG has shared costs with PESA for design of our new websites. PESA and the ASEG recognised that both societies needed a new web page, and that our design criteria were very similar. So between ASEG and PESA we will get two new websites for the price of one. The structure of the two sites will be the same but with different logos, membership databases (accessible only to members), technical talk schedules and lists of committee chairmen.

An important part of any AGM is a report on the financial health of the Society. I am pleased to report that the ASEG continues on very firm financial footing. Our income in 2011 was $532 000 and our expenses were $641 000. The ASEG usually has expenses larger than income for those years when we do not hold a conference (our conferences are held every 18 months and the financial reporting year finished before our February 2012 conference). Our conferences are sufficiently profitable to make up for the negative cash flow of non-conference years. Driving home this point is that fact that our current cash balance is $972 000.

So this is my last President's Column. Starting with the next issue of *Preview*, this column will be penned by Kim Frankcombe, our incoming President. Please join me in welcoming Kim to his new role. I have been honored to be the President of the ASEG for the past year and I look forward to providing continued input to the new Federal Executive.

Dennis A Cooke

ASEG Awards in Brisbane

The ASEG's Honours and Awards acknowledge the outstanding contributions of members to the profession of geophysics and to the ASEG. ASEG President, Dennis Cooke, presented six awards at the Opening Ceremony of the 22nd ASEG Conference in Brisbane on Monday, 27 February. Our warmest congratulations go to all the award recipients.

Honorary Membership of the ASEG – Mike Smith

Honorary Membership of the ASEG, *for distinguished contributions by a member to the Society and the profession over many years*, has been awarded to Mike Smith.

Mike is well known to most members of the ASEG through his exceptional involvement with and contributions to the ASEG, both at State Branch and Federal level for over 30 years, and also for his significant involvement with both the Australian Institute of Geoscientists, and the Australian Geoscience Council.

Mike has made and is still making enormous contributions to Australian geoscience. He applies his infectious energy and enthusiasm to everything he does, particularly as these relate to exploration geophysics and the broader geosciences.

His achievements in the exploration profession are impressive. He has more than 35 years experience in mineral exploration. He has managed operations in Australasia, Asia, Europe and South America and has explored for mineral sands, copper, gold, silver, lead, zinc and uranium. Mike is currently General Manager Exploration for Austpac Resources.

Mike has been a member of the ASEG since 1975, and has always had a strong commitment to local Branch and Federal ASEG activities. He has served as Federal Treasurer, First Vice-President and in 1999 he was the ASEG President. He has always put his hand up to assist with Conferences, and to provide guidance to the Executive on running and managing a healthy and relevant organisation.

Mike has never been backward in advocating a good cause whenever he had the opportunity, and those in attendance at the 2000 ASEG Congress in Perth would not forget Mike's input at the Opening Ceremony. After the Western Australia's Minister for Resources had made the usual benign speech and opened the Congress, Mike immediately seized the opportunity to encourage the Minister to get his act together and co-operate with the Commonwealth on the vexed issue of land access for exploration. And we witnessed a rather lively impromptu debate for the only time we can remember at one of our opening ceremonies.

But that is only a part of the Mike Smith story. He has played an active role in other professional geoscience societies in Australia. From 1993–1996 he was President of the Australian Institute of Geoscientists for three successive terms. During that period he was instrumental in establishing a mechanism for registration of Australian geoscientists and he still chairs AIG's Registration Board.

Mike was also instrumental in revitalising the Australian Geoscience Council. Since 1998 he has served continuously on the Council and during that time has been its President and currently is its Chairman.

The AGC is the Peak Council of geoscientists in Australia, representing eight major Australian geoscientific societies with a total membership of over 7000 individuals comprising industry, government and academic professionals in all fields of geoscience. The AGC provides advice to governments on matters involving the geosciences and their application; promotes the development of scientifically sound policies for effective geoscience education and research; and provides the Australian public with a greater appreciation of the economic, environmental and cultural values of the geosciences.

These objectives coincide with Mike's beliefs of what we as geoscientists should be doing outside our disciplinary boxes. He is already planning programs that will bring geosciences to the broader public throughout Australia.

Mike was one of the main drivers to bring the International Geological Congress to Australia this year in Brisbane. The AGC is the formal organising entity for this event.

In his home state Mike has lobbied the Department of Education to include Earth Sciences in the secondary school's curriculum, through the Geological Society of Australia; he did a magnificent job in attracting sponsors to the Sydney Conference in 2010; he introduced geophysics into the Geological Society of Australia's Conventions; and has lobbied parliamentarians in Canberra to promote the value and concerns of geoscientists to Federal politicians.

Mike was awarded the ASEG Service Medal in 2001 for his 'extraordinary and outstanding service to the ASEG over many years', followed by the Lindsay Ingall Memorial Award in 2003 for promotion of geophysics to the wider community. Since then, his ongoing contributions to the ASEG, his energy and persistence have continued to serve the ASEG well. Mike is a most worthy and distinguished recipient of Honorary Membership of the ASEG.

The Lindsay Ingall Memorial Award – John Mignone

The Lindsay Ingall Memorial Award honours the memory of Lindsay Ingall for his capacity to cross geoscience boundaries and for his enduring commitment to assist geoscientists across

Australia. It is awarded *to an individual who has actively promoted geophysics to the wider community*.

The award this year is made to Mr John Mignone of the South Australian Department for Manufacturing, Innovation, Trade, Resources and Energy, for his significant contribution to the geological and geophysical education and promotion of the resources and environmental industries to students and the general community.

John has been actively involved in geological education and promotion of the mining industry for almost 20 years. John visits primary and high schools in South Australia; not only metropolitan areas but also rural and remote communities, to teach the fun of learning geology and geophysics, as well as the interaction between the resource industry activities and the environment. A notable emphasis has been his focus on remote Aboriginal communities. The number of students taught by him to date must count in the thousands.

Although employed by the South Australian Government, his activity and influence extends interstate and internationally. Many current geologists, geophysicists and environmentalists were inspired by him in their early lives. Many of these are now working world-wide in their respective fields.

His creativity and experience have been captured in the educational package: 'Resources – Working for the Right Balance', which won the Australian Gold Serif Award in 1997. This is a kit for school students, comprising movies, game-like software to explore resources, workbooks of geological and geophysical techniques, and instruction to teachers. This package has been distributed through schools and purchased by individuals and organisations within Australia and overseas.

In 1995, John prepared and organised the first Student Day for the ASEG conference in Adelaide. This was the first time the ASEG organised such an event, and John's excellent organisational skills, creativity and imagination culminated in the Student Day being a great success. This success resulted in the Student Day becoming a regular event at ASEG conferences. John has continued his contribution to ASEG Student Days in subsequent conferences.

For his services to the community in resource education, John has been awarded South Australia's Science Communication Award in 1999 and Centenary Medal for Education in 2001.

The ASEG now recognises and acknowledges John's contributions to the Society and community-wide geoscience education, as recipient of the 2012 Lindsay Ingall Memorial Award.

ASEG Service Medal – Phil Schmidt

The ASEG Service Medal, *for outstanding and distinguished service by a member in making major contributions to the shaping and sustaining of the ASEG*, is presented to Phil Schmidt.

Phil has, over many years, provided distinguished service to the ASEG, through contributions to his State Branch, Federal Executive, ASEG Conferences, and ASEG Publications. In particular, his valuable work as Chairman of the ASEG Publications Committee has had a significant impact on the Society's good standing throughout the geoscience community.

Phil has been a member of the ASEG since 1971, and has been involved in the Society's activities, both at a state and federal level for many of those 40 years. He has been an active contributor to the NSW state branch, including Branch treasurer for several years. He has served on the Federal Executive for many years and is still actively involved on the Executive Committee.

In 2010, Phil was Chair of Technical Program Committee for ASEG Sydney Conference. He facilitated a strong technical program for the Conference, which contributed to attracting a high delegate attendance resulting in a financially successful event for the Society.

Of greatest note, Phil has been the Chairman of the ASEG Publications Committee since 2005. Publications are arguably the most important aspect of the ASEG's activities, in terms of impact and financial investment. Over 50 percent of our budget is allocated for publishing *Exploration Geophysics*, *Preview* and the *Membership Directory*. Since Phil took over responsibility on the Federal Executive Committee for this activity, ASEG's publications have progressed from strength to strength.

During his time at the helm he has actively pursued the improvement of the Society's publications. Both *Exploration Geophysics* and *Preview* now have online access, and importantly *Exploration Geophysics* is now an academically recognised journal. Under his leadership, *Exploration Geophysics* is now indexed by Thompson Reuters and its Impact Factor is routinely evaluated and published. This has confirmed a growing acceptance among academic and industry geophysicists to publish in, and read, the Society's journal.

Phil also guided the ASEG through the challenging time of changing publishers. He was responsible for the tendering process and the final negotiations with CSIRO Publishing, which now handles all our publications. The time and attention to detail for this work was huge. As a component of this change, Phil helped establish online access to both *Exploration Geophysics* and *Preview*, allowing more geophysicists to access the Society's publications on a regular basis.

The current status of our publications owes much to Phil's leadership and management skills as well as the time he has devoted to the Society. Phil is a most deserving recipient of the ASEG Service Medal.

ASEG Service Certificate – Doug Morrison

An ASEG Service Certificate, *for distinguished service by a member to the ASEG*, is awarded to Doug Morrison.

This award is made to Doug for his continuing service, contributions, loyalty to and promotion of the geophysics profession over 50 years and to the ASEG over 30 years through his sustained support of NSW Branch activities, his regular contributions to ASEG publications, and mentoring junior geophysicists.

Doug started his career in contracting exploration geophysics with Aero Service Corporation on 26 February 1962. He worked in the airborne geophysical and photogrammetric compilation section, making photo mosaics for navigation and subsequent survey positioning. Doug became an expert at manual levelling of airborne geophysical data, and of hand contouring survey data, skills that would rarely be known among the current generation of young geophysicists.

In 1966, Doug (with a senior partner, Brian Lenon) commenced a business compiling aeromagnetic and scintillation geophysical and topographic surveys. Within a year this business merged into the full-blown aerial survey company Geophysical Resources Development Company. His career then continued at Geometrics, Geoterrex and Fugro Instruments where he is still contracted. He also ran his own geophysical data processing consultancy, which provided geophysical data processing services to companies worldwide. In the early 1980s, on the instigation of Bob White of Getty Oil, Doug pioneered the reprocessing of old and large aeromagnetic datasets. Much of Doug's Australian product (dating from 1963 or so) now resides within the National Airborne Geophysical Database at Geoscience Australia.

Doug's major direct contribution to the ASEG has been as a regular contributor and an associate editor for *Preview*. In 2004 he initiated a series of articles focussing on Geophysical History. His column subsequently became one of the most widely read of the magazine, and his articles are featured on overseas websites because of their global interest. Doug's enthusiasm for geophysical history, and the high quality and thoroughness of his work has made a real difference to the breadth and interest of *Preview*. Doug is preparing more contributions for future issues.

Behind all this, Doug has always been active in promoting the ASEG to young geophysicists in industry. He has mentored many young geophysicists and other operational personnel, and has continued supporting them in the geophysics industry. This includes a high proportion of women, who continue in the geophysics industry and as members of the ASEG.

Doug's significant contributions to the ASEG and the promotion of the geophysical profession are deserving of the ASEG Service award.

ASEG Service Certificate – Mark Lackie

An ASEG Service Certificate, *for distinguished service by a member to the ASEG*, is awarded to Mark Lackie. Mark has provided distinguished service to the ASEG over many years, through his contributions to his State Branch, ASEG Conferences, and ASEG Publications.

Mark has served as NSW Branch President since 2007. As Branch President, he has been pro-active in organising stimulating monthly meetings, encouraging and selecting speakers through his academic and research contacts, collaborating with other universities to arrange student presentation nights and encouraging members to attend social events.

In addition, Mark showed outstanding leadership as the Co-Chair of the Organising Committee of the 21st ASEG Conference held in Sydney in 2010. Mark played a major role in the smooth planning and running of this very successful conference. He displayed considerable skill in motivating the newer members of the COC and closely monitoring the performance of the PCO. He managed the relationship between ASEG and PESA throughout the planning and implementation stages to obtain excellent results for each organisation.

In recent years, Mark's considerable contributions as Editor-in-Chief of *Exploration Geophysics* from 2009 to present are notable. The role of the Editor-in-Chief is a demanding position but pivotal to maintaining a vibrant and vital journal such as *Exploration Geophysics*, and in developing journal strategy, scope and direction. Mark has taken this task on board with energy and enthusiasm.

Finally, but not least, Mark's encouragement of students to become geophysicists and the education of numerous students in geophysics who have passed through Macquarie University during 2000 to 2011 also warrants considerable recognition. As well as all the other duties as Co-Chair of the 2010 Sydney conference, Mark played a primary role in coordinating student participation in the 2010 conference, including organising a day that included instructive practical demonstrations of geophysical applications for High School students. His efforts clearly demonstrate his belief in the importance of stimulating new members of the profession.

Mark has enthusiastically embraced the ASEG in many of its aspects for many years, and continues his long association with the ASEG through his ongoing contribution to State Branch and Publications, and his efforts in encouraging students to join and get involved in the activities of the Society.

ASEG Service Certificate – Wayne Stasinowsky

An ASEG Service Certificate, *for distinguished service by a member to the ASEG*, is presented to Wayne Stasinowsky (or 'Staz' as he prefers to be known) for distinguished services to the ASEG, through long-standing contributions to State Branch and Federal Committees, and specifically for contributions since 2006 to updating and maintaining the ASEG website.

Wayne has had a long association and involvement with the ASEG, and has

been an active contributor as a past President of the Queensland Branch from 1994 to 1996, as well as Federal Vice-President and member of the Conference Advisory Committee from 1996 to 2000.

Wayne became the ASEG's Web Master in 2007. In 2007 he also wrote a website review document detailing the functionality and responsibilities for the whole ASEG website. This served as the basis for the design of the new website. In 2008 the ASEG website provider cancelled the contract with the ASEG at short notice leaving the ASEG with no website. Wayne managed to get an interim solution up within one week. He then took it upon himself to continue to develop and maintain this solution until the Society was able to specify and design a more permanent one.

The design work, coding and maintenance of the interim solution were carried out by Wayne on an entirely voluntary basis and in his own time. This was against a background of substantial personal and professional changes culminating in his move to Canada in 2010.

Wayne's vision for the website was that it should become an instrument for the members and should allow for the various parts of the Society to maintain their own requirements. Wayne's efforts gave the Society a workable website and enabled the Society to take the time to develop a more permanent solution for the future.

Over the past year he has continued to assist with maintenance of the website from the other side of the world and helped the current Web Master with the specification of the new website.

The Federal Executive is pleased to recognise Wayne's commitment and service to the ASEG by this Service award.

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National Rock Garden website – photos needed from around Australia

In October 2011, *Preview* (Issue 154, pp. 17–18) reported on the National Rock Garden. The NRG Newsletter from the GSA reports that the project is progressing well. The entrance road to the site has been completed, a Memorandum of Understanding has been signed with the National Capital Authority, and progress has been made towards identifying potential rock specimens.

The website for the National Rock Garden is now being developed professionally by a company in Sydney. The website will highlight significant geological features from around Australia. A library of photo images is being compiled but we need more. Hence we are asking Friends of the National Rock Garden to submit outstanding images for use on the website. They should all have that 'Wow' factor. Images should be in JPEG format and generally be 1 Mb or larger in file size. Landscape orientation is preferred but portrait orientation images can also be used. Every image should have information on the location, geology, cultural or industrial significance, and photographer. The NRG email address is rockgarden@gsa.org.au.

ASEG Research Foundation thanks conference donors

The ASEG Research Foundation would like to congratulate the organisers of the 2012 ASEG Conference in Brisbane. It was a highly successful event and thoroughly enjoyed by everyone who attended.

The ASEG Research Foundation was established in 1991. It has the purpose of providing funds to support research projects carried out by students in the course of their studies towards achieving an academic qualification. Specifically, support takes the form of grants to enable students to carry out essential field and laboratory studies. In the current year the Foundation has seven projects in a variety of institutions for a total outlay of $75,400. Since 1991 grants have totalled $728,042.

The Foundation's activities are funded through the generosity of the ASEG membership, support of corporate members and non-members, and through grants from the ASEG Federal Executive.

During the 2012 ASEG conference in Brisbane, the Foundation carried out a fundraising activity at the conference dinner that consisted of a raffle for a fine bottle of Australian wine and a pledging program from various companies represented at the dinner. These activities raised $3,500 through the raffle and $11,500 through the generosity of the companies listed in the table above.

Company	Location	Contact	Amount
Velsies Pty Ltd	Brisbane	Steve Hearn	$1,000.00
CCG Veritas	Calgary, Canada	Brian Russell	$1,000.00
Geocon	Thailand	Barry Long	$1,000.00
International Geoscience	Perth	Greg Street	$250.00
Schlumberger Australia	Perth	Denis Sweeney	$1,000.00
Terrex Seismic	Perth	Steve Tobin	$1,000.00
LRS Scintrex	Canada	Chris Nind	$1,000.00
Carpentaria Exploration Limited	Brisbane	Nick Sheard	$800.00
Rio Tinto	Melbourne	Theo Aravanis	$1,000.00
Southern Geoscience	Perth	Bill Peters	$1,000.00
Teck	Canada	Joel Jansen	$1,000.00
Geosoft	Subiaco WA	Darin Bryce	$750.00
Arctan Services	Sydney	Steve Collins	$250.00
Outer Rim Exploration Pty Ltd	Wangara WA	Andrew Carpenter	$500.00

On behalf of the ASEG Research Foundation I would like to thank all of those individuals and companies who participated on the night. Further tax deductible donations may be made through the membership renewal process or by sending donations to:

ASEG Research Foundation
c/o ASEG Secretariat
PO Box 8463
Perth Business Centre
Perth, WA 6849
Australia

Phil Harman

Australian Geoscience Council (AGC) – update

The AGC has investigated better ways of communicating to the public the importance of the geosciences to our Australian lifestyle. The Council's 2012 initiative involves downloadable videos of prominent people speaking on specific aspects of the geosciences. The aim is to reach a wide section of the community with this material.

The eminent Australian historian, Professor Geoffrey Blainey AC, was selected as the first speaker to present a broad overview drawing out the historical and economic implications of the resource industry and its dependence on the geosciences. In the resulting video, Professor Blainey is introduced by former ABC presenter, Peter Couchman, who then asks Professor Blainey interesting questions during a relaxed and informative presentation. The recording gives a fascinating verbal picture of the pivotal roles that mining and exploration have played in the building of contemporary Australia.

This first video should soon be available on the AGC website (www.agc.org.au), subject to web adviser work load. Future video topics might include:

- geoscience communication and education;
- natural hazard mitigation;
- Australian hydrogeology;
- environmental geoscience;
- petroleum geoscience;
- geotechnical and engineering geology;
- and perhaps Planetary geoscience.

If you have any suggestions for possible topics or presenters, or are aware of existing videos that could achieve the desired aims, please email Mike Smith: mike_rpgeo@optusnet.com.au.

The other key activity for the AGC is the planning of the 34th International Geological Congress in Brisbane. See p. 19 of this issue for more details.

Mike Smith, Chairman AGC

New members

The ASEG extends a warm welcome to 26 new members to the Society (see table). These memberships were approved at the Federal Executive meeting held in February 2012. In addition, please note that Active members Terry Lee, Paul Moorfield and Brian O'Neill have transferred their membership to Retired status.

We would also like to welcome ***Geotech Ltd.*** as a new corporate member of the ASEG. Geotech Airborne Ltd. provides full service contract airborne geophysical surveys, data processing and data interpretation. At the present time Geotech offers VTEM (helicopter-borne time-domain electromagnetic), ZTEM and AirMt (measuring natural/passive AFMAG electromagnetic fields in the audio-frequency range), magnetic, magnetic gradient and gamma-ray spectrometer surveys.

Geotech Airborne operates in Australia from its Perth office with three VTEM systems and one ZTEM system. They have flown over 200 projects throughout Australia in the last 5 years. Internationally, Geotech operates a worldwide total of 30 VTEM systems and 10 passive ZTEM-AirMt systems. Geotech Aviation Ltd maintains its own fleet of aircraft, including helicopter and fixed-wing, from its base in Sudbury, Canada.

Geotech's clients are mainly from the mineral and petroleum exploration industries. Its proprietary, large dipole moment VTEM system, in the 10 years since its first commercial survey, has become the airborne system of choice by the exploration community. A large number of exploration successes have been attributed to VTEM surveys by the exploration companies. Geotech's proprietary ZTEM and AirMt tipper AFMAG technologies are unique airborne EM tools that offer unequalled depths of investigation and geologic mapping capabilities that are particularly well suited to porphyry copper exploration, as well as other deep mining, geothermal and oil and gas applications.

Geotech's managerial staff are experienced geophysicists, electronics engineers and managers who understand the business of airborne surveying and the needs of its clients. Geotech also funds a large Research and Development effort to maintain its technological lead in its core airborne electromagnetic technologies.

Geotech now also offers ground MT (magnetotelluric) acquisition and consulting services, in support of its ZTEM surveys, through its newly formed CORE Geoscience division.

Geotech Airborne Australia
c/o Keith Fisk, Managing Partner
Unit 1, 29 Mulgul Road Malaga
Western Australia
Australia, 6090
Ph: +61 (0)8 9249 8814
Fax: +61 (0)8 9249 8894
Website: www.geotechairborne.com.au
Email: keith@geotechairborne.com, info@geotechairborne.com.au

Name	Organisation	State	Member grade
David John Anderson	Southern Geoscience Consultants	WA	Active
Roger Stuart Cant	University of Queensland	QLD	Student
Phillip Andrew Cilli	University of Western Australia	WA	Student
Olivia Collet	Curtin University	WA	Student
Tobias Colson	University of Western Australia	WA	Student
Peter James Eagleton	Eagleton Consultancy Services	VIC	Active
Peter John Eccleston	GBG Maps	WA	Active
Daniel Christopher Eremenco	University of Queensland	QLD	Student
Alister David Forsyth	Atlas Geophysics	WA	Active
Alex Tobias Fuerst	Woodside Energy Ltd	WA	Active
Luke Thomas Hauck	University of Queensland	QLD	Student
William Vincent Jones	Geoscience Australia	ACT	Active
David King	Marine and Earth Sciences	QLD	Active
Beate Leitner	AWT International	QLD	Active
Anne Marie Liszczyk	GroundProbe	WA	Active
Rachel Maier	Shell Development Australia	WA	Active
Rafael Mederios de Souza	University of Western Australia	WA	Student
Ulrike Mueller	ExploreGeo	WA	Associate
Andrew Lachlan Pacey	University of Queensland	QLD	Student
Daniel Reyes	University of Queensland	QLD	Student
Marcel Rive	CGGVeritas	WA	Active
Jacques Sayers	Central Petroleum Ltd	WA	Active
Siobhan Louise Starr	Macquarie University	QLD	Student
Ian Robert Stevenson	Nautilus Minerals	QLD	Active
Thomas Jenkins	GHD	TAS	Active
Benjamin John Wruck	University of Queensland	QLD	Student

Stewart Gunson: 23 July 1925 – 2 March 2012

Stewart Gunson was born and educated in Western Australia. In 1941 he joined the PMG as a telephone technician, completing his secondary education at night school. From 1944 to 1946 Stewart served in the Australian Navy, mainly in Asia. After his discharge, he completed a degree in Physics at the University of Western Australia from 1947–1949.

From 1950 to 1957, Stewart joined the BMR as Geophysicist Grade One and worked on a number of civil engineering projects including the Snowy River project, and on a number of gravity surveys. In 1956 he went on the submarine HMAS Telemachus to conduct a deep sea gravity pendulum survey in the South Pacific, targeting crustal thickness. The survey made 160 dives over a two-month period.

After the birth of twin children, he decided to follow employment that did not involve field work. He lectured in Physics at RMIT, and completed a BEd by part-time study at the University of Melbourne.

In 1968 Stewart accepted an invitation to establish the Associateship in Exploration Geophysics within the Department of Applied Physics at the Western Australian Institute of Technology (est. 1967). He produced his first Geophysics graduate in 1968. His course was accorded Bachelor status nationally in 1972, by which time the final year had 21 students. He supervised the first Masters degree in Exploration Geophysics at WAIT in 1974.

In January 1970, Stewart travelled by road from Perth to Sydney to attend the First International Conference on the Geophysics of the Earth and the Oceans, jointly sponsored by the Society of Exploration Geophysicists and the Australian Institute of Physics. It was at this conference that the formation of the ASEG was mooted.

Stewart was a popular figure in the Department of Applied Physics in its early days. He contributed significantly to the development of the corporate spirit of the fledgling WAIT by arranging a series of wine and cheese afternoons, to which the staff of other Departments were invited as guests.

One of Stewart's strengths was field work. He insisted on practical competence as well as strong theoretical knowledge, and was known to have put the stopwatch on student field operations to improve efficiency. Because of this training, his students readily found employment.

In one of the early years, after having given a lecture on resistivity sounding, he was challenged to a race by two hefty Geology students with a post hole digger, to find the depth to water. Stewart used a metre bridge from the Physics Laboratory, with his Wenner Array, to measure apparent resistivity. Anyone who has tried this will know that the high impedances involved makes it very difficult to get the requisite null reading on the bridge. Stewart completed his sounding, and used his two-layer curves to predict a depth to water. Shortly after that his opponents struck water within a few centimetres of his predicted depth. He was declared the winner.

During his time at WAIT, Stewart took both long service leave and study leave. In Fiji, he worked on a United Nations geothermal project, and in Tonga on coastal saltwater–fresh water interface measurement for the siting of water wells. While in Ethiopia on another UN project he searched for geothermal power generation sources. There he was awarded a US Presidential citation for playing squash. On his long service leave he enrolled in a Tech Course entitled 'Cooking with Yeast'. As an outcome, he became well known for the high quality of his home-baked bread and his home-brewed beer, which partnered each other quite nicely.

Stewart integrated enthusiastically with the geophysical community and encouraged his students to do likewise. In 1975 a committee consisting of Des Rowston, Stewart Gunson, Joe Williams, Hugh Doyle and Norm Uren was formed with a view to establishing a WA Branch of the ASEG. Forty-two people attended their first public meeting, and the WA Branch was established soon after, with Des Rowston as the first WA Branch President. Stewart continued his foundation committee membership for some years after, ensuring that the Branch was soundly established and functioning well.

Stewart formally retired from WAIT in 1985, but continued his participation in field excursions and in the ASEG and other related professional groups. In 1993 he presented a three-week geophysics course to senior geology students at the University of Papua New Guinea.

Those students who Stewart taught (including myself) will remember fondly his friendly style, his concern for their welfare, and the high quality of his instruction. Although he was a learned gentleman, and great to be with on a quiz night team, he was the exact opposite of a reclusive academic. He set the tone and character of what is now the Curtin Geophysics program, where the emphasis was on being able to do the job, and not just learning about it. Stewart's original degree course has been modified often since 1968, as it must to keep abreast of changing times, but the philosophy behind it, which was initiated by Stewart over 40 years ago, continues on today.

Stewart is survived by his wife Anne, family of five children, nine grandchildren and two great-grandchildren.

Norm Uren

Ray Tracey receives Australia Day Achievement Medal

ASEG member Ray Tracey recently received an 'Australia Day Achievement Medal'. This award provides government departments and agencies with the opportunity to acknowledge the contribution of their staff for outstanding performance of special projects or in performance of their core duties. To be nominated for this award, officers must have made a noteworthy contribution to the work of their department during the past year, or given outstanding service over a number of years.

In a long career at Geoscience Australia (GA) and its predecessors, Ray has had a central role in the acquisition, processing and supply of gravity data from the Australian National Gravity Database – one of the most popular of GA's National Geoscience Datasets. Ray has also led the development, testing and oversight of the Australian Fundamental Gravity Network (AFGN), which defines the datum for all gravity surveys conducted in the Australian region.

Congratulations Ray!

Ray Tracey receives his Australia Day Achievement medallion from Geoscience Australia's CEO, Dr Chris Pigram. (Photo courtesy of Geoscience Australia.)

Australian Capital Territory

At the ACT Branch AGM, held on 15 February, Ron Hackney was re-elected as President and Marina Costelloe as Secretary. Fresh blood was injected into the Treasurer's role when Tim Jones was elected to this position. Committee members for the next year are: Barry Drummond, Bill Jones (webmaster), Nick Rawlinson, Eva Papp, Ned Stolz and Ray Tracey. Thanks are due to retiring members Leonie Jones and Matt Purss, both of whom have made considerable contributions to the ACT Branch over many years.

The AGM was brightened by Ray Tracey's reflections on the sweat, flies and sea-sickness that he has encountered in a 37-year (to date) career in geophysics. That career was recently recognised with the awarding of an 'Australian Day Achievement Medal' (see p. 14 of this issue), an award that acknowledges the outstanding performance of government employees during special projects or in performance of their core duties. Congratulations Ray!

A number of ACT members travelled to Brisbane at the end of February for the 22nd ASEG Conference and Exhibition. Feedback from ACT members on the success of the conference was extremely positive. All enjoyed the range of quality keynotes and the wide choice of workshops. Many rated it the best ASEG conference in a number of years.

On 9 March, SEG 2011 Fall Distinguished Lecturer, Doug Oldenburg was coaxed to Canberra to give his 'Imaging Earth's near surface' presentation. Unlike Sydney, Doug's visit to Canberra was sunny, albeit at the expense of an hour circling the fog above Canberra, a temporary return to Sydney and a late arrival. In the end, almost 50 people absorbed Doug's insight into geophysics as a tool to distinguish sub-surface bodies and to characterise the physical properties of the Earth's near surface. His talk reminded all of the incredible range of applications to which geophysics can be applied – from mineral exploration to airport security (by analogy at least).

The ACT Branch tends to hold meetings on an ad hoc basis as presenters are identified. Any visitors to Canberra interested in giving a presentation during 2012 are encouraged to contact us!

Ron Hackney

New South Wales

In **February**, we held our AGM and the usual suspects (myself, Bin Guo and Roger Henderson) were elected to the roles of President, Secretary and Treasurer. Following the AGM, **Dr David Pratt**, Director at Tensor Research, gave a talk on the remote determination of magnetic remanence, 'A myth busted?'. Dave outlined a new technique that combines conventional 3D geological inversion of the 3D target with polar wander data from palaeomagnetic studies, thus being able to resolve both the induced and remanent magnetic field components of the magnetic target. Dave stressed that there is much that remains to be done in exploring the wide range of applications for this new tool and understanding its limitations, but asked the audience to be the judge. Is the myth busted?

In **March**, **Professor Doug Oldenburg**, from the University of British Columbia, the **2011 SEG Fall Distinguished Lecturer** spoke on 'Imaging the Earth's near surface: the 'why' and 'how' of applied geophysics for the 21st century'. Doug outlined the problems in which applied geophysics has made a major contribution and then reviewed the essential elements of the inverse problem needed to map survey data into 3D images of physical properties. Much discussion occurred after the talk, with main talkers and speaker relocating to a restaurant to continue the discussion.

An invitation to attend NSW Branch meetings is extended to interstate and international visitors who happen to be in town at that time. Meetings are held on the third Wednesday of each month from 5:30 pm at the Rugby Club in the Sydney CBD. Meeting notices, addresses and relevant contact details can be found at the NSW Branch website.

Mark Lackie

South Australia/Northern Territory

At the time of writing the SA/NT branch has only held one event for 2012; the annual general meeting in early February. The committee remains the same. Our special guest speaker was Dr Stephan Thiel from the University of Adelaide. His talk was entitled: 'Magnetotelluric modelling from 1D to 4D: examples from geothermal to lithosphere studies.' It was very well received.

We have two events planned for March. The first is a technical meeting where the presenter will be Henk van Paridon from GeoSolve Pty Ltd in Queensland who will be presenting: 'Coal's Dollar Dazzler, Getting the most out of your seismic dollar.' The second event will be our student barbecue in late March. This is an event held at the University of Adelaide which is an opportunity for students to meet industry, government and consulting geophysicists. Please stay tuned to this column in the next edition of *Preview* to hear how these events went.

Our technical meetings (excluding the DISC course and some special events) are now free for members to attend.

Other events planned for this year include the Honorary Lecturers Peter Hatherly and Lucy Macgregor. We also hold an Industry and Student night later in the year. The SEG/AAPG Distinguished Lecturer Minika Prasad will also be visiting South Australia.

We hold technical meetings monthly, usually on a Tuesday or Thursday at the Coopers Alehouse in Adelaide beginning at 5:30 pm. New members and interested persons are always welcome. For further details, or if you are interested in presenting a talk to the local group please contact Philip Heath (philip.heath@sa.gov.au).

Philip Heath

Victoria

On 8 February the ASEG Victorian Branch members participated in the *PESA, SPE & ASEG Summer Social Evening*, enjoying drinks and finger food at the riverside Terrace@Feddish by Federation Square. The evening was much appreciated by all – proving once again that petroleum engineers and geophysicists are more alike than different!

The ASEG Victorian Branch has a full autumn programme for the coming months. On 27 March Charles Funk from OZ Minerals will present 'Using geophysics to explore for IOCG deposits: a case study of the recent exploration at Prominent Hill'. On 24 April SEG Honorary Lecturer Peter Hatherly from Coalbed Geoscience will present 'A role for geophysical methods in meeting the resource requirements of the 21st century'.

Both events will be held at the Kelvin Club, Melbourne Place (off Russell Street) at 6:00 pm (drinks) for 6:30 pm (presentation). We look forward to seeing many ASEG Victorian Branch members at the coming meetings.

Asbjörn Norlund Christensen

Western Australia

The WA branch has continued with a busy technical schedule over the last couple of months, in particular we have had a revolving door of visiting SEG lecturers who we have gratefully been able to accommodate with a bit of date and venue juggling.

We welcomed the year in with a full house attending Tad Smith's Honorary Lecture on 7 February. Tad is the North American HL but was in Perth on business and kindly made time in his schedule to present his lecture on the 'Effective use of log data for seismic analysis'. Rob Ellis of Geosoft was in Perth from Vancouver just before the ASEG conference and presented his talk on the 'Inversion of magnetic data from remanent and induced sources' at the Melbourne Hotel on 22 February. Chris Liner's SEG Distinguished Instructor Short Course on 'A practical overview of seismic dispersion' was held at the City West Function Centre immediately following the ASEG conference on 2 March.

The touring lectures continued with Doug Oldenburg's Distinguished Lecture on 'Imaging the Earth's near surface' on 12 March, which was also very well attended by some 70 people. The next few months will continue to be busy with several honorary lectures already confirmed, so keep an eye out for notices.

Lastly, the West Australian Geothermal Energy Symposium (WAGES) is being held on 2–3 April at City West, Perth. This event is supported by the ASEG and it will also be followed with a special issue of Exploration Geophysics covering geothermal topics. Further information can be found at www.wageothermalsymposium.com.au.

Despite the busy schedule, we are always keen to hear from potential technical night speakers. So contact asegwa@casm.com.au if you would like to present or have any other suggestions.

Anne Morrell

GGSSA – Ground Geophysical Surveys Safety Association

Ground Geophysical Surveys Safety Association (GGSSA) was formed in 2011 with the aim of developing an Australian Standard for high voltage geophysical surveys. The formation of the Association was in response to NSW Government concerns around IP surveying and the failure to adhere to NSW State Legislation and Australian Standards AS/NZ 30000 and AS3007, particularly around electrical protection, and isolation and insulation.

A draft of the Standard is almost completed. This draft will then be circulated to stakeholders for review before final submission to Standards Australia.

The timeline for preparing this Standard is as follows:

- ***February*** – completion of the draft standard document;
- ***March*** – review of the draft standard by electrical engineers, state governments, geophysical contractors, mining companies and any other interested stakeholders;
- ***March*** – open GGSSA to membership;
- ***May*** – present standards to Standards Australia and start the process;
- ***June*** – the formation of a technical committee made up of the members to review other aspects of ground geophysical surveys safety – electrical and non electrical.

The Standard, based on robust risk management principles, will provide guidance in the following key areas:

- Survey Design and Risk Analysis
- Training and Competency
- Equipment Inspection and Maintenance
- Equipment Safety Features
- Loop and Electrode Safety
- Audit Structure
- Safety Sign Register
- Fuel Storage, Handling and Decanting
- Insulation for Electrical Ground Geophysical Surveys
- Geophysical Transmitter Operational Procedure.

If you are an interested stakeholder, please contact Katherine McKenna (Katherine.McKenna@gpxsurveys.com.au). Membership of GGSSA will be open to all Contractors, Government Agencies and Mining Companies.

The Association plans to develop further standards for high-risk geophysical surveys. Members can nominate to join the Technical Committee, which will be tasked with drafting appropriate Standards.

Katherine McKenna

A Successful 22nd ASEG Conference and Exhibition in Brisbane

The 22nd ASEG Conference was one of the largest ASEG conferences, and certainly the largest Brisbane ASEG conference, with nearly 1000 delegates representing over 45 countries from around the globe. The conference provided excellent networking opportunities for all attendees from Australia and overseas.

The conference theme was 'Unearthing New Layers'. It covered a broad range of topics on seismic, borehole logging, gravity, electrical, electromagnetic, and magnetic methods and their applications in exploration for oil and gas, unconventional gases, minerals, and geothermal resources, as well as in geotechnical, environmental and engineering problems. The conference featured:

- 89 exhibitors;
- 9 workshops, which attracted a total of 342 attendees;
- 5 parallel technical sessions with a total of 50 sessions;
- 21 keynote presentations (12 petroleum and 9 non-petroleum); and
- 138 contributed oral presentations consisting of 60 petroleum related papers and 78 non-petroleum papers, and 59 poster presentations.

Every presentation was of the highest quality and of great interest to the audience. This conference was able to provide a true world-class forum where delegates heard about the latest technical advances and research achievements in all areas of applied geophysics. It was truly a pleasure to be part of such an energetic exchange of ideas.

Many people worked diligently behind the scenes to make the conference so successful. In particular, thanks go to the eight scientific committee members who helped compile such a fantastic technical program; the 58 paper reviewers who were responsible for the conference's high calibre presentations, as well as the 50 session chairpersons who were integral to the smooth and timely running of the individual conference sessions. We all congratulate and thank you for your contributions towards such a successful ASEG event.

Special thanks go to all the staff from Arinex, our conference management team, and particularly to Erin Simmons, for doing all the work behind the scenes, communicating with our paper reviewers, chair persons, conference attendees and presentation authors. Without their help, we would not have been able to deliver such a high quality conference.

Conference Awards

As the final highlight of the conference, we presented several awards giving formal recognition to the distinguished contributions from both technical presenters and exhibitors. The following list summarises these awards.

Laric Hawkins Award

This award is presented to the contributor or contributors for the most innovative use of a geophysical technique from a paper presented at the ASEG Conference.

David Pratt, Keith Blair McKenzie and Anthony S. White - *The remote determination of magnetic remanence*

Best Paper – Petroleum

Jeffrey Shragge and David Lumley - *Elliptical dip moveout (EMO) for 3D seismic imaging in the presence of azimuthal anisotropy*

Best Paper – Minerals

Stephen J. Fraser, Glenn A. Wilson, Leif H. Cox, Martin Čuma, Michael S. Zhdanov and Marc A. Vallée - *Self-organizing maps for pseudo-lithological classification of 3D airborne electromagnetic, gravity gradiometry and magnetic inversions*

Best Paper – Coal

Kate E. Godber, James Reid and Guy LeBlanc Smith - *Application of Airborne EM to Bowen Basin Coal Projects*

Best Paper – Environment/Engineering

Niels B. Christensen and James E. Reid - *Assessing the presence of hard rock along a gas pipeline alignment with airborne EM*

Best Paper – Student

Students are the future of geophysics. 72 students attended this conference and 28 students gave talks. To encourage the involvement of the new generation of geophysicists at conferences, we also provided this best paper award for a student.

Wendy Young and David Lumley - *Feasibility of time-lapse gravity monitoring of producing gas fields in the Northern Carnarvon Basin, Australia.*

Best Poster

Hashim Almalki, Mohanad Alata and Tariq Alkhalifah - *Laboratory coupling test for optimum land streamer design over sand dunes surface*

Best Single Booth Exhibitor

GPX Surveys

Best Mid-Size Booth Exhibitor

Ikon Science

Best Large Booth Exhibitor

CGGVeritas

Thank you for everyone's outstanding contributions and we look forward to seeing you and your great work at future ASEG events.

Binzhong Zhou

David Pratt – Laric Hawkins Award

Jeffrey Shragge – Best Paper Petroleum

Kate Godber – Best Paper Coal

Stephen Fraser – Best Paper Minerals

Wendy Young – Best Student Paper

Katherine McKenna, GPX Surveys – Best Single Booth Exhibitor

Ikon Science – Best Mid-Size Booth Exhibitor

CGGVeritas – Best Large Booth Exhibitor

A very happy (and relieved!) 22nd ASEG Conference Organising Committee at the end of the conference: (L to R) Andrea Rutley (co-chair), Cameron Hamilton, John Donohue, Henk van Paridon, Koya Suto, Sylvia Michael, Ron Palmer, Noll Moriarty, Binzhong Zhou, Wayne Mogg (co-chair). (Absent – Margarita Pavlova).

34th International Geological Congress (IGC)

Unearthing our Past and Future
5–10 August 2012
Brisbane, Australia
www.34igc.org

As at 13 March 2012, the Scientific Program Committee of the IGC had received **5050 abstracts** for papers to be presented at the IGC in August**.** These have been received from **4117 individuals** as some authors have submitted multiple abstracts. The real test comes in April because these authors must be paid up as delegates in order to be placed in the technical program. While some authors will drop out, the high number of submitting authors is positive. Several last minute abstract submissions include case history papers given at the February ASEG Conference in Brisbane, these being presentations that have particularly strong messages for our geological colleagues about the beneficial use of geophysics.

A notable highlight of the abstracts is the high level of talks submitted in the themes that are of direct relevance to industry. The distribution of the countries of origin of submitting authors is also interesting:

- highest – Australia at 936, with China second highest at 864;
- between 150 to 300 authors – USA, Brazil, Russia, Japan;
- 60–120 authors – India, Canada, UK, Italy, Germany, South Korea, NZ, France, Iran;
- 1–50 authors – a very long list of countries from Azerbaijan to Zambia.

Sponsorship continues to come in, making a current total of $766,500, which does not include the targeted AusAID support for the Geohost program. Bookings for the GeoExpo have been particularly strong.

A highlight of the IGC will be the release of comprehensive new information and maps from a decade of geological and geophysical surveys conducted over Central and Eastern Asia (for more information, see *Preview* Issue 156, February 2012, p. 14).

Industry-relevant IGC themes

Theme 6. Energy in a Carbon-Constrained World

Coordinators: Peter COOK (pjcook@co2crc.com.au) and David LUMLEY

Global demand for energy continues to grow strongly but at the same time pressure mounts to reduce greenhouse gas emissions to mitigate the impacts of rapid climate change. Symposia will explore issues and options for future energy use including: the future of fossil fuels; carbon capture and storage; geothermal energy including exploration and resource characterisation: renewable energy resources; nuclear energy – including uranium and thorium resources and demand, and nuclear waste disposal.

Theme 7. Mineral Resources and Mining

Coordinators: Graham CARR (graham.carr@csiro.au) and Dale SIMS

This theme will include a global perspective on mineral resources; leading edge technologies for increased automation and decreased wastes and mine-site pollution; high technology commodities for the future; industrial minerals; advances in in-mine geophysics; resource definition, modelling, estimation and reporting; resource development techniques and issues over a range of commodity types; specialist sessions on industry issues and case studies for uranium, iron ore, diamonds, nickel, base metals, sampling and geometallurgy; future sources of industrial and construction materials.

Theme 8. Mineral Exploration Geoscience

Coordinators: Cam MCCUAIG (campbell.mccuaig@uwa.edu.au) and David GILES

This theme will address the science of mineral exploration against the backdrop of increasing global demand for mineral resources. Indicative Symposia topics include: mineralising systems; the science of exploration targeting; exploration geophysics; advances in geochemical exploration; 3D geology and geophysics in targeting; deep exploration and discovery; quantifying and managing uncertainty and risk in exploration, and declining exploration success rates; major discovery case histories; exploration trends and emerging mineral districts.

Theme 9. Mineral Deposits and Ore Forming Processes

Coordinators: Ross LARGE (ross.large@utas.edu.au) and Cornel DE RONDE

Understanding the controls on the distribution and formation of ore deposits is critical to future discovery of new ore deposits. Symposia will include: major mineral provinces of the world; mineral alteration halos; tectonics and ores in magmatic arcs; magmatic sulfides; basin-hosted ores; dating of ore deposits; geometallurgy; iron oxide copper gold (IOCG) – the unhappy family; volcanic-hosted metal sulphide (VHMS) deposits; sediment-hosted base metal and gold deposits; structure and gold; and submarine mineralisation.

Theme 11. Petroleum Systems and Exploration

Coordinators: Marita BRADSHAW (marita.bradshaw@ga.gov.au), Chris URUSKI and Sylvia ANJOS

Global demand for petroleum continues to grow, driving the search for resources to new frontiers as well as the need to extract petroleum as efficiently as possible from existing basins. Indicative topics include petroleum geoscience – advances in seismic applications, petroleum geochemistry, other geophysical techniques, and applications of palaeontology; frontier petroleum basins – extending exploration in time and drilling depths; southern hemisphere petroleum prospectivity; enhanced oil recovery – horizontal drilling, reservoir fracturing, chemical methods, water/CO_2 injection and re-injection; petrophysics – pressure, permeability and rock property predictions; advances in petroleum exploration – new ideas on prospectivity, basin modelling, source rock models, reservoir modelling; putting the geo into geophysics – use of potential fields in interpreting economic basement, structure and reservoir presence/quality, seismic sequence analysis, facies mapping and depositional environments.

Theme 12. Unconventional Hydrocarbons – Emerging Fuels

Coordinators: James UNDERSCHULTZ (james.underschultz@anlecrd.com.au) and Ingo PECHER

Unconventional hydrocarbons, notably shale gas and coal seam gas, have become a vital component of the North American domestic gas supply and are touted to have high potential to be the same in Europe, China, India and southeast Asia. In Australia, coal seam gas production is on the verge of a step change in production to supply a new LNG export industry. However, unconventional gas development has not been without its critics and environmental concerns. What are the lessons learned in North America and how can these be applied elsewhere? Technological advancement in oil sands and enhanced oil recovery has made these resources competitive even at low oil prices. CO_2 enhanced recovery has the potential to add value not only in increased production but also as carbon storage in an emerging global carbon market. Symposia will focus on the unconventional hydrocarbons and their emergence as important future sources of energy including: transport fuels; coal seam gas, resources and extraction and water production and management; shale gas and tight gas resources and potential; and gas hydrates, the ultimate unconventional hydrocarbon.

Theme 28. Groundwater/Hydrogeology

Coordinators: Ken LAWRIE (ken.lawrie@ga.gov.au) and Chris DAUGHNEY

The past decade has seen an increased demand for hydrogeological predictions to sustain growth, promote wealth and protect landscape, infrastructure and biodiversity assets. Improved understanding of hydrogeological systems underpins the development of more effective groundwater models and management strategies and actions. Indicative topics covered in this theme include: climate-change impacts on groundwater; surface–groundwater interaction; managed aquifer recharge; groundwater modelling and parameterisation; delineation and management of groundwater resources; aquifer and aquitard mapping and characterisation; recharge and discharge mapping; groundwater and mining; coastal groundwater; groundwater-dependent ecosystems; risks to groundwater quality including salinity; hydrogeochemistry including water–rock interactions; and socio-economic and legal aspects of groundwater management.

Theme 31. Engineering Geology and Geomechanics

Coordinators: Mark EGGERS (mark.eggers@psmconsult.com.au) and Francisco DE JORGE

The interface between geology and engineering is critical to our rapidly expanding urban space and increasing demand for the Earth's resources. Indicative Symposia in this theme include: geoengineering challenges for our ever-growing cities; geoscience inputs to major infrastructure developments, including underground construction and corridor studies; increasing use of engineering geology concepts in the optimisation of open pit and underground mine design; key roles of geoengineering in mitigating climate change; improving the development of geological models for engineering projects; and advances in geomechanics.

The IGC Organising Committee looks forward to the support of the societies in encouraging attendance at the IGC, especially by younger geoscientists.

Mike Smith, Chairman AGC

ASEG 2013 conference in Melbourne

The preparations for the ASEG 2013 conference in Melbourne are now underway! The ASEG Victoria Branch has formed the ASEG 2013 Conference Organising Committee (COC), and most sub-committee chairman roles have now been filled. We still have many positions vacant in the sub-committees, so if you are interested, then contact any of the chairpersons listed below.

The ASEG 2013 COC is:

- COC Joint Chairman (Petroleum) – Jarrod Dunne *jarrod.dunne@meoaustralia.com.au*
- COC Joint Chairman (Minerals) – Asbjörn Norlund Christensen *asbjorn_n_christensen@yahoo.com*
- Exhibitor Sub-Committee Chairman – Richard MacRae *richard.macrae@mmg.com*
- Technical Papers Sub-Committee Chairman – Mark Dransfield *mdransfield@fugroairborne.com.au*
- Sponsorship Sub-Committee Chairman – *Vacant*
- Publicity Sub-Committee Chairwoman – Suzanne Haydon *suzanne.haydon@dpi.vic.gov.au*
- Finance Sub-Committee Chairman – Theo Aravanis *theo.aravanis@riotinto.com*
- Workshop Sub-Committee Chairman – Bob Smith *greengeo@bigpond.net.au*
- Social Event and Activities Sub-Committee Chairman – John Theodoridis *jthe1402@bigpond.net.au*
- Student Coordinator Sub-Committee Chairman – James Macnae *james.macnae@rmit.edu.au*
- Conference CD Sub-Committee Chairman – Michael Asten *michaelasten@flagstaff-geoconsultants.com.au*

The theme for the ASEG 2013 conference in Melbourne is '**The Eureka Moment**' – capturing the ASEG's quest for discovery, insight and learning, but also with a sub-contextual nod to the golden riches of Victoria's past.

We are currently focusing on securing a fantastic Melbourne venue for the ASEG 2013 conference, so watch this space for further announcements. See you all in Melbourne in 2013!

Asbjörn Norlund Christensen

KSEG

KSEG International Symposium on "Geophysics for Discovery and Exploration"

Fostering International Collaborations in Geophysics

September 19 - 21, 2012
ICC, Jeju Island, Republic of Korea

Dear Colleagues;

We are very pleased to announce that the Korean Society of Earth and Exploration Geophysicists (KSEG) is organizing an "International Symposium on Geophysics for Discovery and Exploration" to be held at the International Convention Center (ICC) of Jeju Island, Korea on September 19 - 21, 2012.

Through sponsorship of this International Symposium, the KSEG intends to foster international collaborations in pure and applied geophysics between our members and our colleagues in other geophysical societies around the world.

For additional details and a preliminary program of the symposium, please visit our website: http://2012symp.seg.or.kr/.

Abstract submission: April 1 through June 30, 2012.
On-line registration deadline: August 15 (Wednesday), 2012.
The correspondent author should pre-register before July 31 (Tuesday), 2012.

We are looking forward to your participation.

Convener:

Dr. Mutaek Lim
Vice President of Korean Society of Earth and Exploration Geophysicists
phone: +82-42-868-3157, e-mail: limmt@kigam.re.kr

Coordinators:

Dr. In-ky Cho (Program Committee) : +82-33-250-8585, choik@kangwon.ac.kr
Dr. Chan Hong Park (Financial Committee) : +82-54-780-5210, chpark@kordi.re.kr
Dr. Jong-kuk Hong (Secretariat) : +82-32-260-6213, jkhong@kopri.re.kr

Mineral exploration powers ahead in 2011; petroleum holds steady

2011 a record year for minerals

The global financial crisis is now almost a distant memory as far as resource exploration is concerned. Figures released by the Australian Bureau of Statistics in March 2012 show that the trend estimate for total mineral exploration expenditure in Australia rose by 2.9% to a record $944.7 million; this is 35.4% higher than the December quarter for 2010 (see Figure 1).

Although the rate of increase is declining the current level of investment is impressive and more than twice that of the 1997 peak, even when adjustments have been made for CPI changes. The two largest states – Western Australia and Queensland still dominate the exploration scene. WA accounted for 52% of the investment in the December quarter and Queensland accounted for 25%. This leaves just 23% for all the other states and territories.

One major change in exploration strategy during the last few years has been the ratio of greenfield to brownfield exploration investment. This number is a good indicator of the state of mineral exploration.

Throughout 2008 the focus was on exploring for new deposits, but this has now changed significantly. In the December 2011 quarter, the focus was on existing deposits and more than twice as many dollars were spent in the vicinity of existing mines as were invested in greenfield areas. In other words the current strategy has a greater emphasis on expanding the resource base from existing deposits rather than going out and looking for something new in an unexplored area. Figure 2 shows how this emphasis has changed in the last five years.

The increase in mineral expenditure over the last few years has been spread across a whole range of commodities. Iron ore is

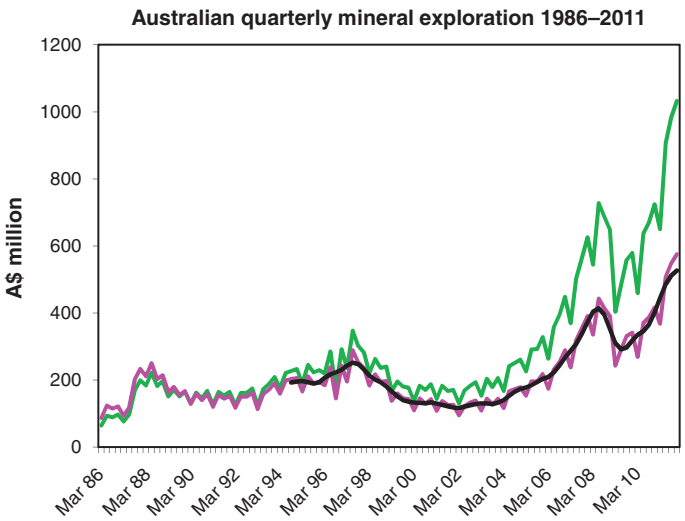

Fig. 1. *Quarterly 'actual' mineral exploration expenditure from March 1986 through December 2011 (from ABS data). The green curve represents actual dollars spent, the purple curve shows the CPI adjusted numbers to 1998/99 levels and the black line is the trend line (ABS data). Notice that the effects of the GFC have been overcome completely.*

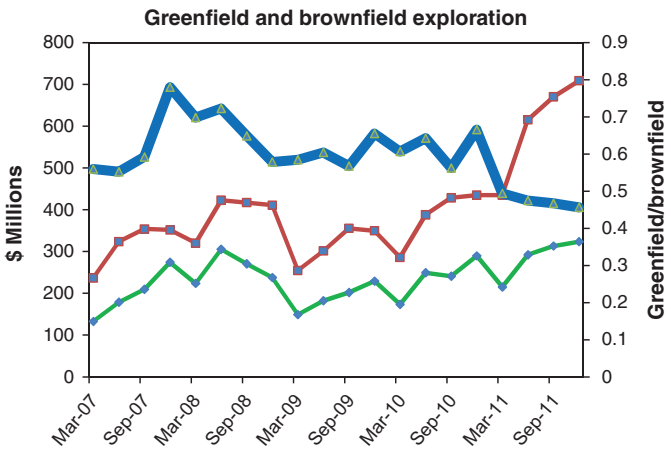

Fig. 2. *Change in emphasis in greenfield (new deposits – green curve) and brownfield (existing deposits – brown curve) exploration (left axis). Notice the large change in the greenfield/brownfield parameter (blue curve) from the end of 2007 (right axis).*

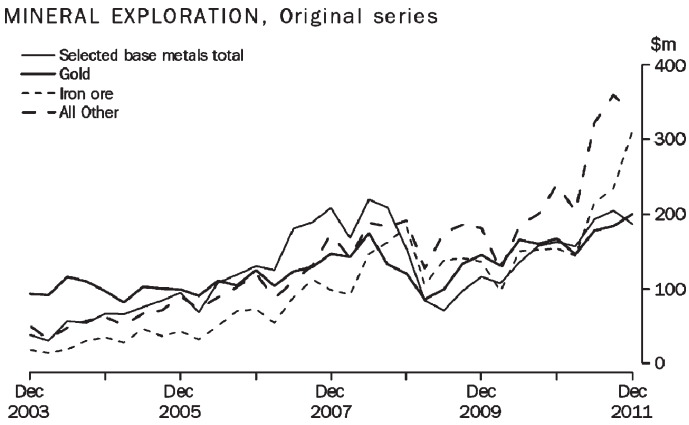

Fig. 3. *Trends in exploration expenditure for selected commodities (from the Australian Bureau of Statistics Report 8412.0, December Quarter 2011).*

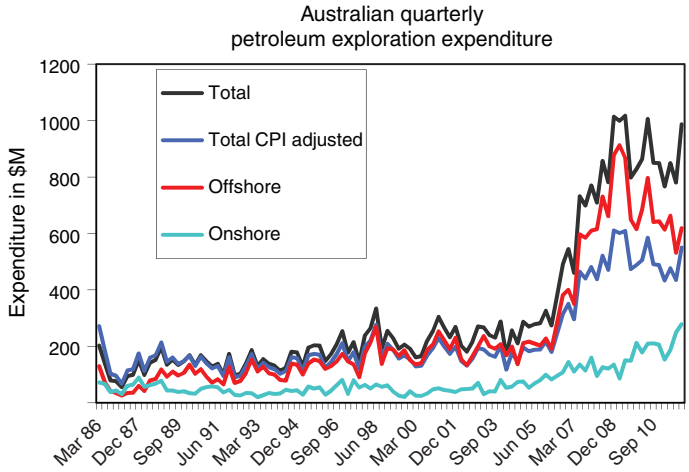

Fig. 4. *Quarterly petroleum expenditure from March 1986 through December 2011. The individual offshore and onshore numbers are actual numbers spent at the time, not CPI adjusted. The black line shows the contemporary dollars spent and the blue curve shows the CPI adjusted number to 1989/90 dollars for the total expenditure.*

at the top of the heap with $312 million in the December quarter (see Figure 3). It was followed by $218 million for coal, with gold in third place at $200 million.

Petroleum exploration stays steady

Petroleum exploration expenditure rose by $117 million from the previous quarter to $897 million. However, because of the scatter in the data set (see Figure 4), the total expenditure has remained approximately constant at approximately $900 million a quarter for the past three years.

Western Australia was the dominant state. It attracted a substantial 68% of the total Australian expenditure for the December quarter. One interesting trend is the gradual increase in onshore exploration expenditure. As shown in Figure 4 it has been gradually climbing since 2003.

In summary, a very healthy situation for both the mineral and the petroleum resource sectors.

David Denham

CSIRO Earth Science and Resource Engineering Magnetics and Gravity Team

Clive Foss[1,3] and Phil Schmidt[1,2*]

[1]*CSIRO Earth Science & Resource Engineering, North Ryde, NSW*
[2]*MagneticEarth, NSW (www.magneticearth.com.au)*
[3]*Email: clive.foss@csiro.au*
**Phil Schmidt is now at MagneticEarth (see Business Directory in this issue).*

CSIRO Earth Science and Resource Engineering (CESRE) has a research team in North Ryde, NSW focussed on magnetic and gravity methods, and one in Perth, WA focussed on electromagnetic (EM) capabilities. The Magnetics and Gravity Team consists of Phil Schmidt and Clive Foss, together with three post docs – James Austin, Majid Beiki and Dean Hillan – and also has input from Dave Clark, Peter Warren and Xiaolin Luo. This article reports on current research in the CESRE Magnetics and Gravity Team. A future article will profile the research being undertaken by the CESRE EM team.

CSIRO recognised the need to invest in and strengthen its geophysics capability and decided that a major focus should be on improved interpretation of magnetic, gravity and EM data. Magnetic field data form the most complete and detailed geophysical coverage across Australia. They are also the most widely used geophysical data for greenfields mineral exploration, location and design of mineral exploration drill holes, and geological mapping, and importantly are available for free download from Geoscience Australia's GADDS facility. The value of these data can be enhanced considerably by upgrading our ability to recover geological information from it.

We have concentrated on several research topics, including:

- improved interpretation of remanent magnetisation;
- better treatment of self-demagnetisation results;
- recognition of the geophysical signature of mineral systems; and
- new automated interpretation of source depth.

The Magnetics and Gravity Team wants to ensure the reliability and wide application of its research through extensive cooperation with external groups. The team has ties with Geoscience Australia on multiple research projects, with several of the state and territory geological surveys, with Sydney and Macquarie Universities, and with Intrepid Geophysics and Tensor Research. Another major focus of the group, funded through CSIRO's involvement in the Deep Exploration Technologies Cooperative Research Centre (the DET CRC), is down-hole magnetic tensor gradiometry being developed in close collaboration with CSIRO Materials Science and Engineering (CMSE) at Lindfield.

Brief information on the Magnetics and Gravity Team's research projects is given below – further details are available on the Team's website at www.magresearch.org. As the research projects progress, the results, publications and any software developed will be posted on this site.

Palaeomagnetic and rock magnetic studies

CSIRO has for many years run a palaeomagnetic and rock magnetic laboratory in North Ryde which both undertakes research projects and provides a sample measurement service to industry. The laboratory shares facilities with Macquarie University, and is linked in a LIEF (Linkage Infrastructure, Equipment and Facilities) grant with ANU. Direct measurement of magnetisation and magnetic properties of rock samples is essential to understand the connection of magnetisation to the mineralogy, petrology and geological history of the rock.

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Down-hole magnetic tensor gradiometry

For deep magnetic targets, aeromagnetic and ground magnetic data represent distal samples of the magnetic field. A borehole provides access for measurements much closer to the source. To compensate for the limited spatial distribution of down-hole measurements we have chosen to measure the gradient tensor, which has superior targeting capabilities. This work, undertaken as part of the DET CRC, includes both instrument manufacture and development of interpretation software. The instrument is in large part based on previous CSIRO airborne SQUID magnetic tensor gradiometry research and development, but the current project uses AMR (anisotropic magnetoresistive) sensors.

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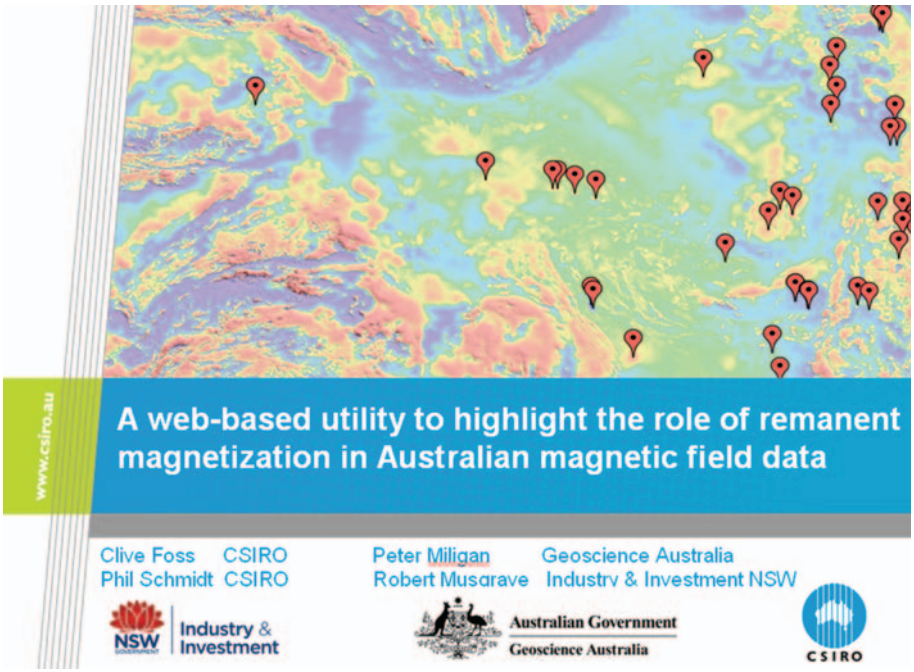

Fig. 1. *Talk given at the 2012 ASEG conference on the remanent anomaly database.*

Remanent anomalies database

Knowledge about the distribution of magnetisation across Australia is available from direct measurement in palaeomagnetic and rock magnetic studies, and also from various magnetisation direction analyses and inversions of magnetic field data. At present these results are not readily available in any one location. The Remanent Anomalies Database is a collaborative project between CSIRO, Geoscience Australia, and various state and territory geological surveys, to collect this information and make it available via a web delivery service through the AuScope web portal. When geoscientists start work in a new area, they will be able to utilise this facility to determine what remanence magnetisations have been previously recognised in the area, and thus recognise the characteristic expression of that remanence in the magnetic field data. Figure 1 is the title slide from a talk on the database given at the 2012 ASEG Conference in Brisbane, which can be downloaded from www.anomalydatabase.magresearch.org.

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Recovery of magnetisation direction from magnetic field data

To support remanent magnetisation studies and help build the remanent magnetic anomalies database we are undertaking research into many means of recovering magnetisation direction from magnetic field data. The objective of this study is to produce a suite of software tools that can be applied in magnetic field interpretation. These tools range from rapid automatic scanning of magnetic field grids to provide a first-pass detection and analysis of remanent magnetisation, through to intensive study of an anomaly to define the best-estimated location, geometry and magnetisation parameters of the source body. Considerable progress has already been made in tensor-based magnetic moment analysis, and in a wide range of automated methods to scan various magnetisation directions (or perform down-hill searches through magnetisation direction space) to select optimum magnetisation direction estimates as defined by various chosen statistics defined from reduction to pole (RTP) and reduction to equator (RTE) transforms using trial magnetisation directions.

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Self-demagnetisation studies

There is an increasing interest in strongly magnetised ore bodies, in particular magnetite deposits, for which standard forward modelling codes provide an inaccurate representation of the source body through failure to account for the substantial internal secondary fields (self-demagnetisation). Exact analytic solutions for self-demagnetisation only exist for ellipsoidal sources, and beyond using this geometric approximation for a geological source body, existing commercial software packages invoke simple approximation methods that break down at susceptibilities far less than 1 SI. We have developed a much improved forward modelling code for self-demagnetisation effects, and have wrapped this in a Monte-Carlo inversion process. Ongoing research aims to link this voxel-based forward modelling of self-demagnetisation to more powerful, better guided inversion processes. Figure 2 shows the first vertical derivative of total magnetic intensity over the Hawsons Deposit south of Broken Hill being developed by Carpentaria Exploration (www.carpentariaex.com.au) where we are ground-truthing the software.

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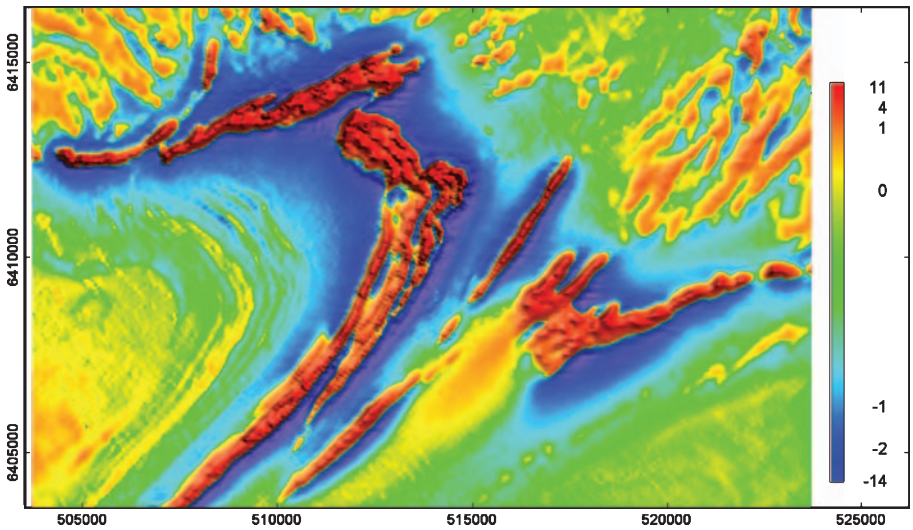

Fig. 2. *First vertical derivative of total magnetic intensity over Carpentaria Exploration's Hawsons Deposit south of Broken Hill.*

Geophysical signatures of iron-oxide copper-gold (IOGC) and other selected Australian mineral deposits

The search for new mineral deposits beneath cover benefits considerably from understanding the geophysical signatures of those deposits already found, as well as learning from misinterpretation of what proved to be un-mineralised drill targets. IOGCs are a particularly rich and popular exploration target, but they have very variable, and in some cases enigmatic geophysical signatures. We are attempting to better understand the geophysical signatures of these bodies by measurement and collation of physical property information, forward modelling of synthetic source models, development of structural models, and understanding the processes that link mineralisation to physical property. Of particular importance is incorporation in these studies of remanent magnetisation, which has rarely been considered before, but which in some cases has a profound influence on the magnetic field signature of the mineralised system.

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Inversion of magnetic and gravity field data

Our research at CESRE Magnetics and Gravity team is focussed on:

- developing new inversion methods and optimisation tools for inversion of magnetic and gravity field data;
- joint inversion of magnetic and gravity gradient tensor components for a better interpretation of short wavelength

anomalies using regularised focusing inversion method;
- joint inversion or parallel inversion of magnetic gradient tensor and electromagnetic data for mineral exploration.

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Quantification of uncertainty in potential field inversion

Inversion of potential field data is inherently non-unique – therefore it is not possible to assign true confidence limits to the results. This reduces the value of those results in, for instance, quantitative risk analysis of decisions such as whether or not to drill a selected target. In lieu of full confidence estimates we are undertaking a statistical study of the justified complexity of a model. Results obtained to date relate to the required complexity in cross-sectional shape for a 2D model to explain a gravity or magnetic profile. Studies to extend this analysis to joint inversion (gravity field and gravity gradient, magnetic field and magnetic gradient, or gravity and magnetic) are near complete, and we are now extending this analysis to the complexity of 3D sources.

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Automated magnetic depth to source mapping

One of the most common quantitative objectives of magnetic field interpretation in Australian mineral exploration projects is the mapping of depth to source (most commonly the mapping of crystalline basement beneath cover). We are investigating a novel, semi-automated multi-stage process of magnetic source depth estimation. This research is being performed in collaboration with Simon Williams of Sydney University, and provisional arrangements have been made with Geoscience Australia to utilise this research in development of a new national depth of cover investigation as recommended in 'Searching the deep Earth: the future of Australian resource discovery and utilisation' proceedings published by the Australian Academy of Science: http://www.science.org.au/events/thinktank/thinktank2010/documents/thinktankproceedings.pdf. Figure 3 illustrates the close relationships between the magnetic field and geology in one of our test areas in the Northern Territory.

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Investigation of multi-scale edge mapping ('worming')

CSIRO was at the forefront of developing multi-scale edge detection analysis ('worming'), which combines wavelet analysis, edge detection and upward continuation in an attempt to resolve a gravity or magnetic grid into responses attributed to a series of physical property contrast interfaces at different depths. We have created an improved implementation of the original code and are currently testing this in an investigation, in conjunction with the NSW Geological Survey, of part of the Lachlan Fold Belt. At the same time we are mapping capabilities and limitations of the method using both synthetic forward computed grids derived from detailed 3D models, and data grids from selected test areas.

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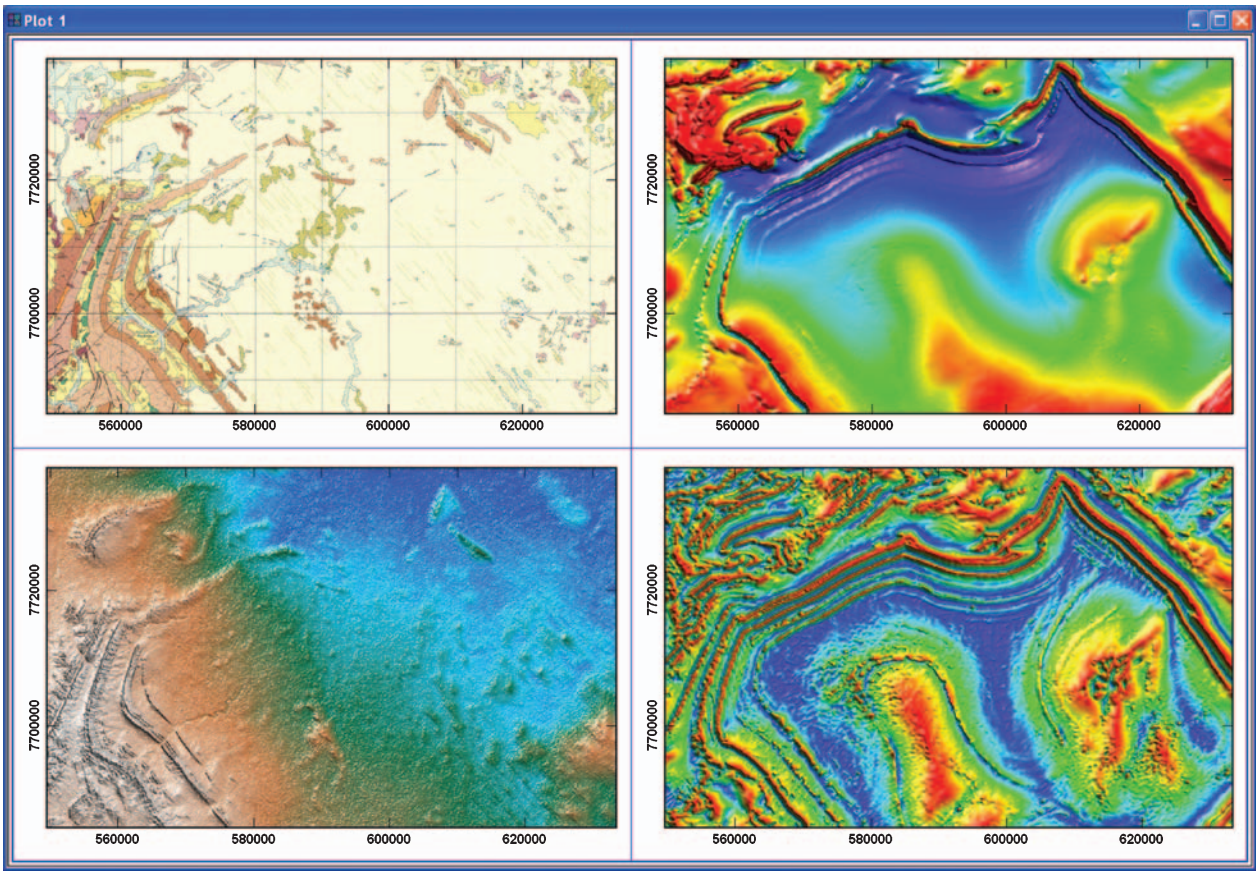


Fig. 3. *Relationships between geology and the magnetic field in the Frew River area of the Northern Territory, one of the test areas for testing new magnetic source depth estimation techniques.*

News

TESEP update – a continuing success story and now an award-winning program

The following TESEP update mainly comprises material summarised from a review published in the PESA News Resources, No. 115 Dec 2011/Jan 2012.

How it all started

The Teacher Earth Science Education Programme (TESEP) began as an idea in 2007, and developed with the help of seed funding from the Petroleum Exploration Society of Australia (PESA) and under the guidance of ExxonMobil geologist, Jill Stevens. By 2008 the idea had blossomed into a major educational initiative, with the aim of raising the capacity of middle school (Years 7–10) teachers to teach the Earth Science components of the curriculum through the development and delivery of teacher orientated professional development workshops.

When TESEP was first proposed in 2007, Earth Science WA (ESWA) was already underway and running classroom Earth Science workshops for primary and secondary students and teachers. These workshops informed and enabled teachers and resulted in increased Earth and Environmental Science student numbers. As the ESWA program runs only in WA there was a need for teacher education in the other states, and it was with this need in mind that TESEP was created, albeit using a different model to ESWA.

By 2008, TESEP had gathered a team of teacher-educators, surveyed teachers to identify high priority workshop needs, commenced workshop development and by mid-2008 was in a position to deliver the first of eight workshops in the 'Challenging Earth' series. TESEP had also assembled an advisory board comprising key personnel from all sectors of the Earth Science community, and had attracted several industry, university and government partners to assist with funding and logistics (including the ASEG and AIG). The final key to the initial success of the program was the inclusion of the Australian Science Teachers Association (ASTA), to provide administrative and financial management of TESEP, and to provide the quality endorsement and accreditation that teachers look for when choosing professional development workshops.

Since 2008, TESEP has developed eight workshops on earth science topics, and has also had input into the development of the new Australian Curriculum for Science. TESEP is now considered a key stakeholder in discussions about Earth Science education in Australia. TESEP has also delivered over 77 workshops to more than 945 teachers in 23 locations across all states and territories other than Western Australia. Teachers report very high levels of satisfaction with the entire workshop delivery program, and it is estimated that each satisfied teacher shares their learning, the support materials and the enthusiasm for teaching the subject, with at least 2 or 3 other teachers.

TESEP's success recognised

In recognition of her outstanding efforts in initiating, nurturing and promoting TESEP, Jill Stevens, the founder and chairperson of TESEP, has been awarded the prestigious American Association of Petroleum Geologists (AAPG) Harrison Schmitt Award, further adding to the recognition she received for TESEP with the PESA Meritorious Service Award in 2008. The AAPG citation states it is in recognition of outstanding accomplishment in Teacher Education outreach work.

Following her nomination for the award, Jill advised AAPG that the founding members of the TESEP team were a talented, dedicated group of educators/geologists, who had developed and presented the material at face-to-face workshops and were collectively the reason for the success of the workshop series. In response to Jill's representations, the AAPG awards committee have re-conferred the award to 'Jill Stevens and TESEP'.

The Harrison Schmitt Award will be presented to Jill at the AAPG Awards Ceremony during the AAPG Conference in Los Angeles in April this year.

Teachers in action with TESEP Executive Officer, Greg McNamara (image courtesy of TESEP).

The program continues

In 2012 TESEP continues to progress, delivering workshops across many more locations, developing the ASTA online webinar portal, and compiling additional case study examples and new classroom support materials. The continuing success of TESEP is, however, dependent on the financial and logistical support of its partner organisations. To find out more about TESEP and how to be a partner visit: www.tesep.org.au.

Mike Smith

1st Australian Geoscience Teaching Workshop

The teaching of geosciences in Australian universities has recently been facing a number of challenges, particularly associated with a rapid increase in undergraduate student numbers. With some university classes doubling in size over the past few years, teaching practices have been required to quickly adapt, and new approaches are being adopted to improve student learning in both the classroom and the field. These changes in teaching methods and practices are vital for maintaining and improving graduate standards, despite increasing student to staff ratios.

In late January 2012, 40 geoscience lecturers from across Australia gathered in Adelaide for the inaugural **Australian Geoscience Teaching Workshop**. This workshop was the first time that Australian geoscience academics had come together for the sole purpose of discussing new teaching approaches, techniques and strategies. This workshop also represented the first event run by the newly formed Australian Geoscience Learning and Teaching Network, which involves partnerships between geoscience departments in 12 universities, spread across seven states and territories, to work together and improve geoscience teaching.

The workshop was conducted over two days and included 26 presentations, split into seven sessions, as well as dedicated time for open discussion on key teaching issues. A diverse range of topics were covered, including the development of field work and geophysical skills, methods for improving 3D visualisation, smoothing the transition from school to university, online teaching, and assessment practices. Furthermore, the workshop also extensively discussed major strategic aspects, such as improvements in teaching facilities and the development of nation-wide learning and teaching academic standards in the earth sciences. Particular highlights from the workshop included:

- Marion Anderson's presentations on Monash's urban field work exercises, which involves analysis of modern 'trace fossils' in concrete;
- Michael Roach's use of cameras attached to remote controlled helicopters to build three dimensional photogrammetric models for outcrops on University of Tasmania fieldtrips; and,
- Ian Clarke (University of South Australia) laying the foundations for identifying fundamental 'threshold concepts' in earth science education.

Overall, the participants of the workshop unanimously agreed that the workshop had been extremely beneficial in learning and sharing of teaching experiences and approaches, and there are plans for a second workshop to take place in 2013. The workshop has also led to the formation of ongoing working parties on core issues, such as improving first year teaching and the development of national teaching standards in earth sciences. The proceedings of the workshop have been published as volume 100 of the Geological Society of Australia Abstracts series.

The workshop could not have taken place without the generous sponsorship and support of the Geological Society of Australia, Australian Society of Exploration Geophysicists, the Minerals Tertiary Education Council, the Australian Institute of Mining and Metallurgy and the Australian Geoscience Information Association.

Mark Tingay

The workshop included presentations on new laboratory facilities in several institutions that are being used to revolutionise hands-on teaching. This included a tour of the new teaching spaces in the Mawson Laboratory, University of Adelaide.

Several attendees stayed on for the weekend after the workshop and took part in a field trip to the Hallett Cove Conservation Park south of Adelaide. Hallett Cove is famous for its excellent exposures of pre-Cambrian sequences folded during the Delamerian Orogeny and glaciated during the Permian.

Update on Geophysical Survey Progress from the Geological Surveys of Queensland, Western Australia and New South Wales (information current at 16 March 2012)

Tables 1 and 2 show the continuing acquisition by the States, the Northern Territory and Geoscience Australia of new gravity, airborne magnetic and radiometric data over the Australian continent. All surveys are being managed by Geoscience Australia.

There is one new airborne magnetic and radiometric survey in this issue. Figure 1 shows the survey boundary for the Thomson North survey in Queensland. This survey adds to the previously reported surveys – Thomson East and Thomson West. Thomson North will cover an area of 21 900 km^2 with 400 m E–W lines collecting a total of 7543 line km.

Poor weather conditions and standing water on the survey blocks have delayed both the Thomson and Galilee surveys in central and south-west Queensland. No flying was possible in the Thomson survey area from 21 January to 12 March. Similarly the Galilee survey has been on hold since 25 February. As a consequence of the poor weather the release date for the data has been pushed back and is now expected in July, weather permitting.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km^2)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
South Officer 1 (Jubilee)	GSWA	Thomson	1 Jun 10	180 000	200 m 50 m N–S	32 380	100% complete @ 22 Jun 11	TBA	148 – Oct 10 p23	QA/QC of final data in progress
South Officer 2 (Waigen – Mason)	GSWA	Thomson	28 Jun 10	113 000	400 m 60 m N–S	39 890	100% complete @ 5 Jan 11	TBA	148 – Oct 10 p24	QA/QC of final data in progress
Grafton – Tenterfield	GSNSW	GPX	16 Jun 11	100 000	250 m 60 m E–W	23 000	100% complete @ 6 Nov 11	TBA	151 – Apr 11 p16	QA/QC of final data in progress
West Kimberley	GSWA	Aeroquest	29 Jun 11	134 000	800 m 60 m N–S Charnley: 200 m 50 m N–S	42 000	100.0% complete @ 11 Dec 11	TBA	150 – Feb 11 p20	TBA
Perth Basin North (Perth Basin 1)	GSWA	Fugro	11 Jun 11	96 000	400 m 60 m E–W	30 000	100% complete @ 18 Dec 11	TBA	150 – Feb 11 p20	QA/QC of raw data in progress
Perth Basin South (Perth Basin 2)	GSWA	Fugro	22 Mar 11	88 000	400 m 60 m E–W	27 500	99% complete @ 23 Dec 11	TBA	150 – Feb 11 p20	TBA
Murgoo (Murchison 1)	GSWA	Thomson	28 Feb 11	128 000	200 m 50 m E–W	21 250	100% complete @ 16 Nov 11	TBA	150 – Feb 11 p20	TBA
Perenjori (Murchison 2)	GSWA	GPX	21 Oct 11	120 000	200 m 50 m E–W	20 000	100% complete @ 12 Jan 12	TBA	150 – Feb 11 p21	TBA
South Pilbara	GSWA	GPX	TBA	136 000	400 m 60 m N–S	42 500	TBA	TBA	150 – Feb 11 p21	Start planned for April 2012
Carnarvon Basin North (Carnarvon Basin 1)	GSWA	GPX	24 Jul 11	104 000	400 m 60 m E–W	32 500	100% complete @ 20 Oct 11	TBA	150 – Feb 11 p21	Data released via GADDS on 16 February 2012
Carnarvon Basin South (Carnarvon Basin 2)	GSWA	GPX	TBA	128 000	400 m 60 m E–W	40 000	TBA	TBA	150 – Feb 11 p21	Commenced 21 March 2012
Moora (South West 1)	GSWA	Aeroquest	13 Jun 11	128 000	200 m 50 m E–W	21 250	84.2% complete @ 11 Dec 11	TBA	150 – Feb 11 p22	QA/QC of final data in progress

Table 1. *Continued*

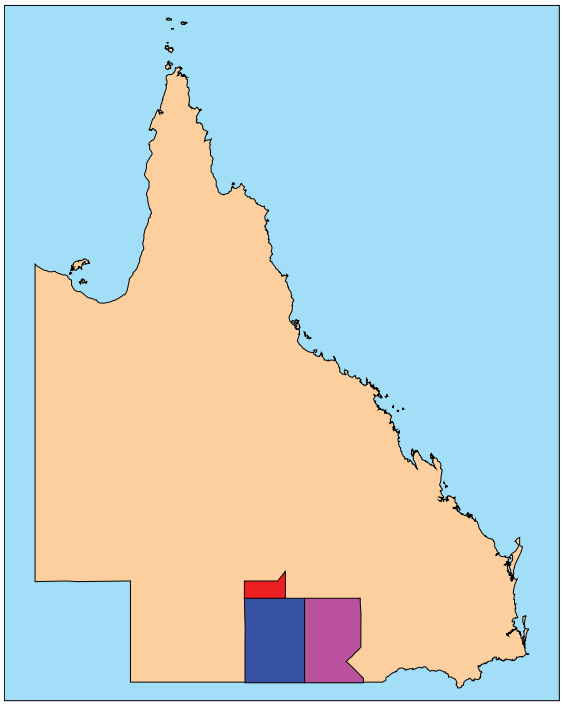
Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Corrigin (South West 2)	GSWA	GPX	12 Jan 12	120 000	200 m 50 m E–W	20 000	90.6% complete @ 11 Mar 12	TBA	150 – Feb 11 p22	TBA
Cape Leeuwin – Collie (South West 3)	GSWA	Fugro	25 Mar 11	105 000	200/400 m 50/60 m E–W	25 000	100% complete @ 23 Dec 11	TBA	150 – Feb 11 p22	TBA
Mt Barker (South West 4)	GSWA	GPX	24 Apr 11	120 000	200 m 50 m N–S	20 000	22.2% complete @ 11 Mar 12	TBA	150 – Feb 11 p22	Survey resumed 11 February 2012
Galilee	GSQ	Aeroquest	11 Aug 11	125 959	400 m 80 m E–W	44 530	50.7% complete @ 11 Dec 11	TBA	151 – Apr 11 p15	Survey suspended due to rain
Thomson West	GSQ	Thomson	14 May 11	146 000	400 m 80 m E–W	52 170	75.3% complete @ 1 Dec 11	TBA	151 – Apr 11 p15	Survey suspended due to rain
Thomson East	GSQ	Thomson	14 May 11	131 100	400 m 80 m E–W	46 730	75.3% complete @ 1 Dec 11	TBA	151 – Apr 11 p16	Survey suspended due to rain
Thomson Extension	GSQ	Aeroquest	22 June 11	47 777	400 m 80 m E–W	16 400	100% complete @ 10 Aug 11	TBA	151 – Apr 11 p16	QA/QC of final data in progress
Thomson North	GSQ	Thomson	11 Mar 12	21 900	400 m 80 m E–W	7543	TBA	TBA	This issue	Survey crew mobilised 9 March 2012

TBA, to be advised.

Table 2. Gravity surveys

Survey name	Client	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Peak Hill – Collier	GSWA	Daishsat	29 Jul 11	9100	2.5 km regular	56 140	100% complete @ 30 Nov 11	January 2012	153 – Aug 11 p18	Data released via GADDS 22 February 2012
Kimberley Road Traverses	GSWA	Daishsat	8 Aug 11	7560	400 m station spacing along 2700 km of gazetted roads	N/A	100% complete @ 26 Sep 11	January 2012	153 – Aug 11 p20	Data released via GADDS 22 February 2012
Eucla Basin SW	GSWA	Atlas Geophysics	19 Jan 12	3798	2.5 km regular	23 030	100% complete @ 9 Feb 12	TBA	154 – Oct 11 p23	TBA
Eucla Central	GSWA	Atlas Geophysics	28 Nov 11	5704	2.5 km regular	36 100	100% complete @ 18 Jan 12	TBA	154 – Oct 11 p23	TBA
Eucla Basin East	GSWA	Atlas Geophysics	31 Oct 11	5201	2.5 km regular	31 340	100% complete @ 27 Nov 11	TBA	154 – Oct 11 p23	TBA

TBA, to be advised.

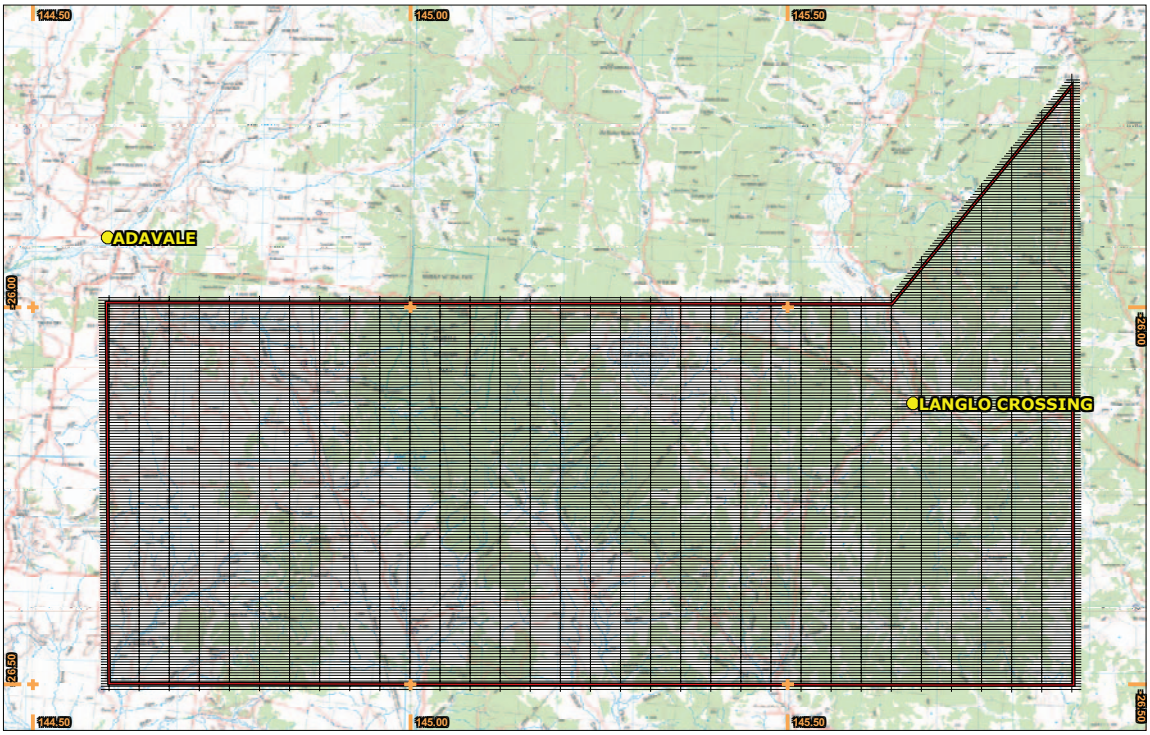


Client: Geological Survey of Queensland
Funding: Greenfields 2020 Exploration Initiative
Project Management: Geoscience Australia
Survey Area: Thomson North (Red)

Current Surveys:
Thomson West (Blue); Thomson East (Purple)

Projection: Geodetic
Datum: GDA94

500 0 500 1000 1500
Kilometres



20 0 20 40 60 80 100
Kilometres

Fig. 1. *Locality diagram for the Thomson North airborne magnetic and radiometric survey.*

New SARIG layer

Introduction

Department of Manufacturing Innovation Trade Resources and Energy (DMITRE) (formerly PIRSA) has recently developed a new layer in the SARIG 2020 Geoserver to view and download processed SEG-Y open file seismic data. This layer is called '2D lines with SEG-Y data' and is located under 'Seismic Lines' in the main Map Layer list (see Figure 1). This exciting development enables web viewing of processed seismic data not previously possible. Downloading the SEG-Y data will allow users to further manipulate the seismic data to suit individual requirements.

The SARIG Geoserver provides a wealth of geophysical, geological and ancillary information relating to South Australia to facilitate exploration.

Once the bastion of the 'oil patch', processed seismic data is now available for easy use without the need for sophisticated hardware platforms, software requirements or prior extensive knowledge and experience of the seismic recording technique.

Since 1975, there have been over 350 2D seismic surveys recorded in SA, producing more than 110 000 km of line profile data over the main onshore sedimentary basins. While much of this activity has been concentrated on the deeper parts of the basins, a percentage has encroached into areas now deemed to be prospective for other commodities and targets such as uranium, coal seam methane, base metals and geothermal energy.

Most surveys have been recorded under the 'Petroleum Acts' of the day. Under the regulations relating to these Acts, 'basic data' is made open file (public) two years after the recording of the survey. Key data sets that are covered by this requirement include line location, processed data and various operational reports.

DMITRE has collated and databased all available open file SEG-Y data and standardised the format of file presentation to assist the user. Items such as samples per trace, sample interval, line names, shot-point and CDP numbers, rectangular coordinates and time of first sample have all been entered into standard byte locations to assist with workstation applications. All coordinates are in a GDA94 format.

2D SEG-Y data availability

To date, data sets have been consolidated, edited and uploaded for the following provinces: Officer, Pedirka, Eromanga, Cooper (in part), Arckaringa, Arrowie, Otway and Murray Basin areas. It is anticipated that data for the Stansbury, Gawler Craton and Cooper Basin areas will be finalised by mid-2012.

Using the layer

Using the identify tool from the Search/ Identify menu, draw a box area to select the line(s) of interest in the map area. A Results window for the selected lines will appear with three hyperlinked fields

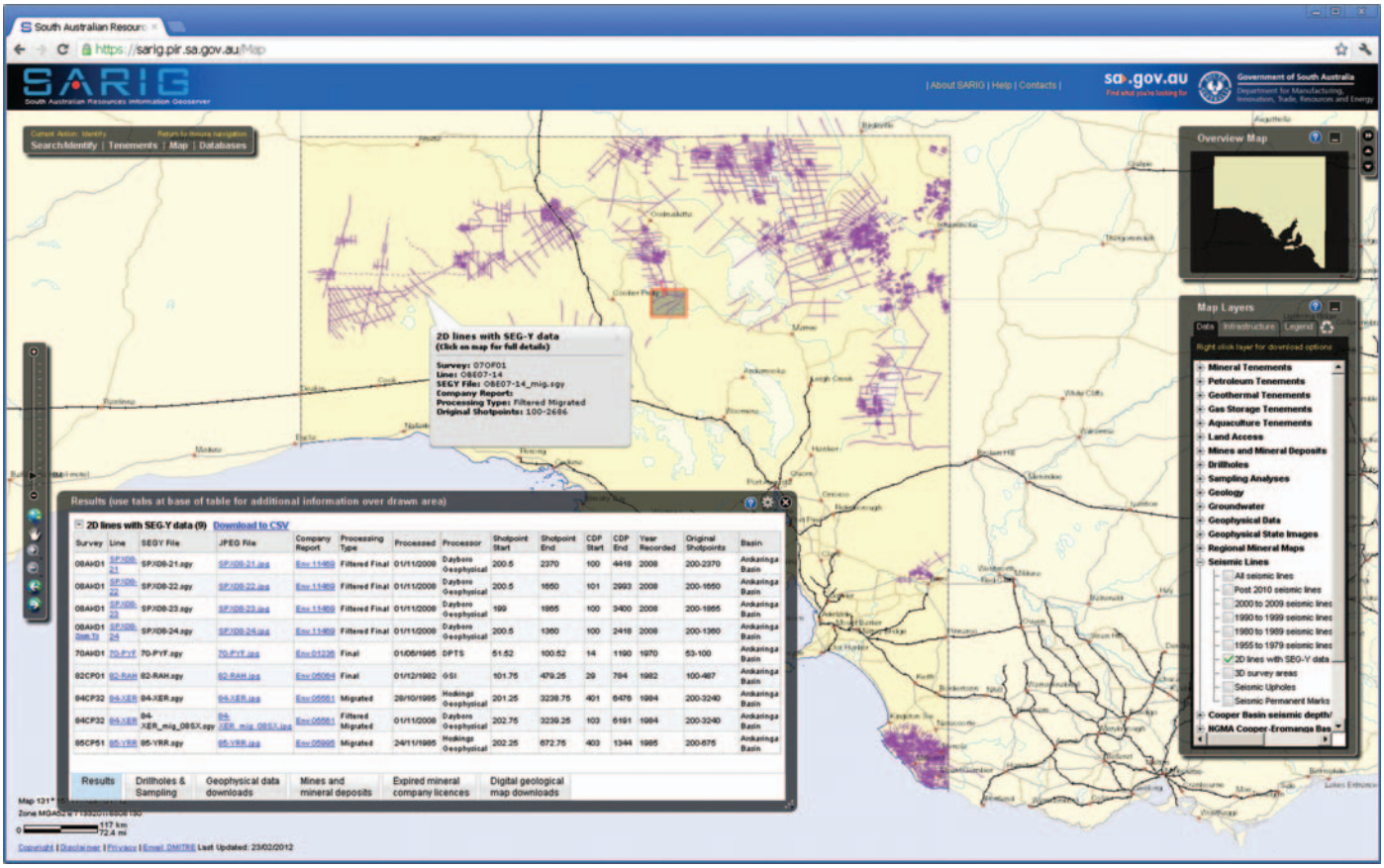


Fig. 1. *SARIG screen showing results from a selected subset (red box) of 2D lines with SEG-Y data (shown in purple).*

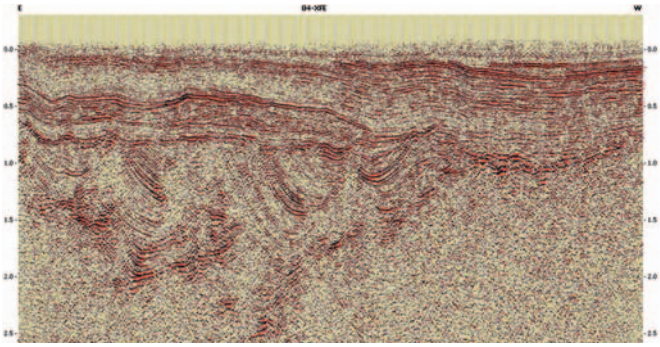


Fig. 2. *Example JPEG image of line 84-XFE, Arckaringa Basin.*

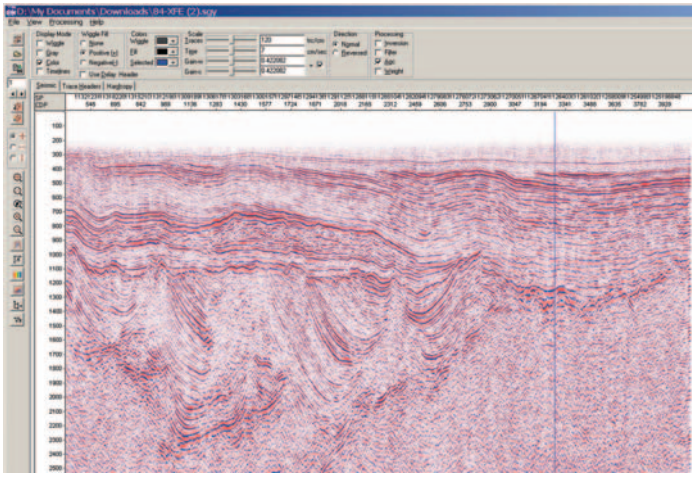


Fig. 3. *Example SEG-Y image of line 84-XFE, Arckaringa Basin.*

shown as blue underlined text (see Figure 1). DMITRE suggests using these in the following sequence to view and download the SEG-Y data:

1) **JPEG file:** this provides a quick preview option of an A4 JPG image of the seismic data without having to download the larger seismic dataset. Note: the image is representative only as the data has been adjusted to always fit an A4 page (see Figure 2).
2) **Line:** this option returns a list and file size of SEG-Y datasets for the selected line plus some other key attribute data. Note: there may be more than one version for some lines. A SEG-Y viewer is required to view the downloaded SEG-Y data file and SARIG provides links to two suggested free viewers (see Figure 3).
3) **Company report:** returns a list and direct links to all downloadable open file reports for this line and related seismic survey in PDF format.

DMITRE can also provide more comprehensive province-based SEG-Y datasets. For more information on data availability and pricing, visit: http://www.pir.sa.gov.au/petroleum/access_to_data/seismic_data/seismic_workstation_datasets

Peter Hough

The CarbonNet Project Airborne Gravity survey – Victoria

Sander Geophysics Ltd has completed an airborne gravity survey on behalf of the Victorian Department of Primary Industries (DPI). The survey was completed as part of The CarbonNet Project, which is investigating the potential for carbon capture and storage in the region. The 10 523 line km survey was flown in November and December 2011 over the near shore Gippsland Basin between Lakes Entrance and Woodside in Victoria (Figure 1). Acquisition lines approximately 140 km long were flown NE–SW at 1 km spacing with infill at the coastline to 500 m spacing, tie lines were flown NW–SE at 10 km spacing. Survey outcomes will be published on DPI's website: http://new.dpi.vic.gov.au/ccs.

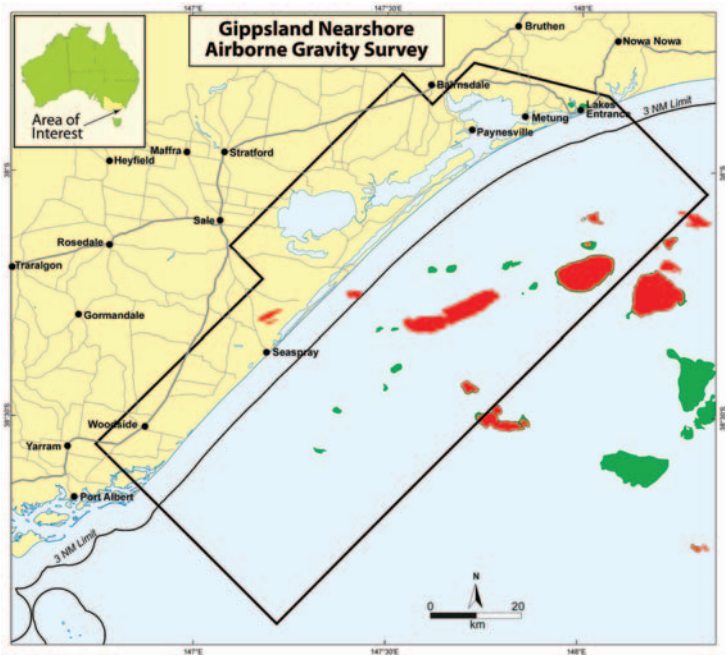


Fig. 1. *Location diagram showing survey boundary of the Gippsland Nearshore Airborne Gravity Survey. (NB: The red and green areas are existing oil and gas fields.)*

Curtin University 3rd year field geophysics students visit Abra mine site

Jayson Meyers

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Introduction

The Curtin University 3rd year field geophysics students carried out their field work experience at the Abra Mining site and camp north of Meekatharra in WA, late August 2011 (Figure 1). The project was sponsored by Abra Mining Limited and supervised by Jayson Meyers, Christian Dupuis and Dominic Howman. There were 27 students from many different countries and six supervisors (Figure 2). The field work was a logistical challenge for getting so many people, so much equipment and a large amount of food and other supplies to and from a remote area in such a short time frame. All the Curtin students and staff returned safely and without any incidents.

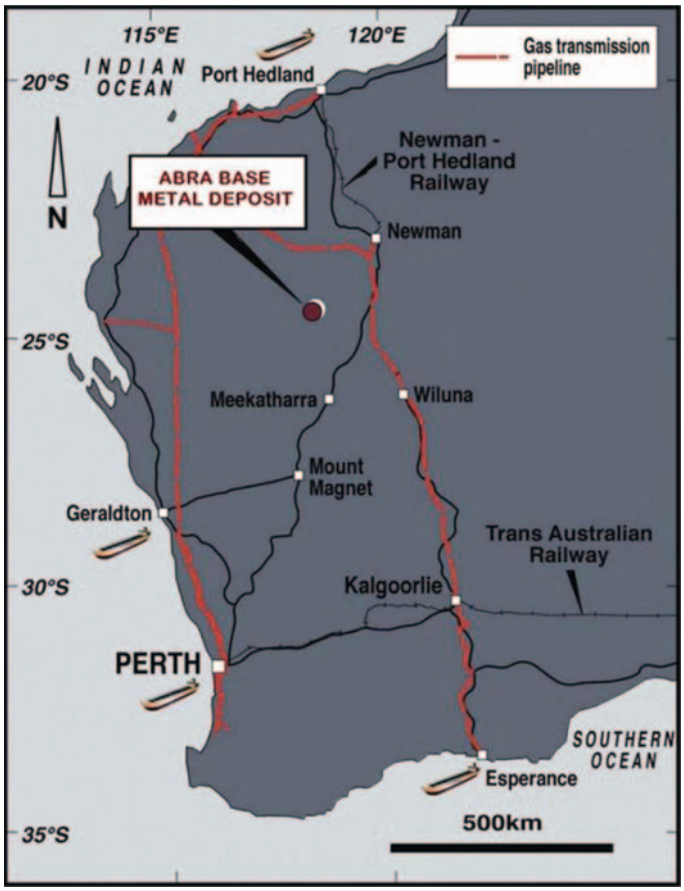

Fig. 1. *Location of the Abra polymetallic base metal deposit in WA.*

Fig. 2. *Students and staff standing in front of truck carrying seismic equipment to Abra.*

Abra geology and mineralisation

Abra is a sedimentary hosted, polymetallic base metal ore deposit system that was discovered in 1981 by drill testing a coincident, 'bull's eye' magnetic and gravity anomaly with no geochemical or outcrop evidence for mineralisation, and was later shown to have a well defined anomaly in fixed and moving loop time domain EM surveys (Vogt and Stumpfl, 1987; Mutton and McInerney, 1987). The host rocks for the deposit are siliciclastic and carbonate deposits of the middle Proterozoic Edmund Group within the Bangemall Basin. The deposit sits within the Jillawarra sub-basin, which formed as part of the long-lived Capricorn Orogen between the Pilbara and Yilgarn cratons.

Drilling has confirmed that the top of the deposit sits below 250 m depth, where barite and iron oxide alteration zones of magnetite and hematite occur as stratiform, higher grade mineralised zones underlain by a lower grade stringer zone of feeder sulphide–quartz–carbonate veins that form within a funnel shaped envelope. The lower part of the stringer zone contains higher Cu–Au concentrations than the upper part of the deposit, which is enriched in Ba–Ag–Pb, and both zones also contain Zn. The deposit remains open in all directions, especially where the ore body continues to dip towards the south. Total indicated and inferred resource estimates for the deposit stand at 93 million tons at 4.0% lead and 10 g/t silver, and 14 million tons at 0.6% copper and 0.5 g/t gold. The deposit is currently sub-economic due to ore body depth, low metal grade and current metal prices.

There are many opinions about the style and origin of the deposit which range from deposition by seafloor hydrothermal processes during and shortly after sedimentation, MVT replacement of carbonate layers during formation of the sub-basin, a hybrid form of VHMS deposit, a hybrid end member of the IOGC style of deposits, or just a unique system that does not fall into any widely accepted category. The only major thermal

event that occurred around the time of basin formation and mineralisation was a regionally extensive tholiitic basalt and dolerite sill and dyke swarm complex at ca. 1.4 Ga (Piranjo, 2004). This event is similar in age to the timing of mineralisation at Abra, which suggests that ore formation is likely at least 40 to 290 Ma younger than the host rocks (Rasmussen *et al.*, 2010).

The genesis of the Abra deposit remains a mystery, as well as the geometry of the mineralisation in relation to major structures, crystalline basement, and extensions to mineralisation surrounding the known ore zones. A recent potential field inversion study by Curtin Masters student Daniel Eden showed that the magnetic expression at Abra can be explained by the known mineralised zone, but the gravity expression is a combination of the known mineralised zone and an underlying excess mass, possibly elevated basement rocks or additional mineralisation at depth.

3rd year students' field trip

Abra and adjacent prospects provided the perfect location for students to try out magnetic, gravity and EM methods on actual mineralisation still in the ground. As an added bonus, the students, most of whom are heading into the petroleum industry, acquired a line of high resolution multi-channel seismic data

Fig. 3. *Students examining diamond drill core before carrying out geophysical surveying.*

Fig. 4. *Curtin University's accelerated weight drop seismic source at Abra.*

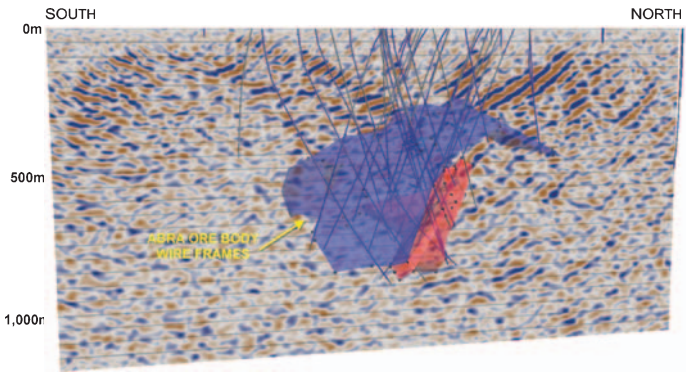

Fig. 5. *Depth migrated seismic reflection profile across the Abra deposit with drillholes and ore body wire frames. No vertical exaggeration.*

directly over the Abra deposit for the first time. The students carried out a literature review on Abra before heading to site, and on the first day at site they reviewed diamond drill core, following the usual safety and site inductions (Figure 3). The students visually saw the host rocks and ore+alteration minerals that were responsible for the geophysical anomalies.

Groups of students were cycled through different survey methods during each day, and were responsible for data download and QC during the evenings – as well as camp duties. Most hands were on the seismic data acquisition, where shots and geophones were spaced at 5 m intervals using a spread of 500 active channels, over a line that was 2.5 km long oriented in a N–S direction over the centre of the Abra deposit. An accelerated weight drop was used as a source (Figure 4), and several shots with low noise were recorded and stacked for each shotpoint. Shot and receiver locations were surveyed using a RTK DGPS system.

Results

The results of the seismic reflection surveying are presented as a depth migrated profile in Figure 5. This image shows that the stratiform Abra mineralisation is seismically chaotic and transparent, probably due to brecciation and small scale folding within the ore zone, and patchy areas of low velocity lead sulphide. The surrounding unaltered sedimentary host rocks, mostly siltstone and sandstone, show up as bright, continuous reflectors. A series of apparently N-dipping faults are observed to offset the sedimentary reflectors in the northern part of the line. There is also a bright seismic event sitting just below the stringer zone at Abra, which is the red coloured ore zone in Figure 5. This reflection event may be a horst block of crystalline basement or it could be a zone of hydrothermal alteration/mineralisation. The reflective pattern in the middle and southern part of the line appears to show an overall synclinal fold to the south of the known ore body. The axis of this synclinal structure is seismically chaotic, and this seismic character may be related to a NNE-trending fault that crosses the seismic line at a low angle, producing a wide chaotic zone in the section. Due to time constraints, the students were unable to acquire an E–W seismic line across the deposit.

Discussion

While all the seismic events in the profile are difficult to interpret, the data show encouraging results and promise for this type of surveying to provide useful information at mine scale to

depths in excess of 1 km. The ability to image seismic events and interpret complex layering and structure at Abra would be made much more reliable by carrying out 3D seismic acquisition and processing.

Another direction of geophysical surveying yet to be tried at Abra is passive electrical methods, such as AMT and MT. It is hoped that these methods will show deep zones of low resistivity corresponding to mineralisation that could be overlain on the seismic profile to follow extensions to the known mineralisation, highlight major structural features and identify deep targets.

The Abra deposit remains enigmatic and unmined. However, deep exploration targeting using innovative geophysical methods will reduce drilling risk in this environment. Work is ongoing at Abra to highlight new high grade ore zones and shallower ore bodies, and the Curtin students are fortunate to have gained experience by being part of this process.

Acknowledgements

The 3rd year student field project would not have been possible without financial and logistical support from Abra Mining, and Dr Mingyan WANG and his staff are acknowledged for their support. Resource Potentials and Atlas Geophysics donated staff helpers and state of the art magnetic and gravity survey equipment to teach the students how to collect industry quality data. HiSeis supplied seismic acquisition equipment. Milovan Urosevic and his team carried out the seismic data processing at Curtin University.

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Land seismic: the 'quiet' revolution

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Introduction

The combination of several recently introduced technologies suggests that land seismic acquisition is undergoing a quiet, but profound, revolution. This revolution is driven by the need to better characterise existing reservoirs as well as quickly identify new, more challenging, unconventional, and even, non-hydrocarbon, exploration targets. In addition, data needs to be acquired more quickly and at a lower cost, both environmental and economic. In this paper I describe these new technologies in the same order in which they are applied in the field, namely survey planning, positioning, recording systems, seismic sources and techniques to improve productivity. Some of these technologies are now being used in Australia.

Survey planning

Assessment of the geophysical objectives of a survey ultimately leads to the determination of the survey geometry, i.e. the source and receiver station and line spacing. The survey is thus designed as a regular grid (e.g. Figure 1a), a requirement for the data processing algorithms that will later be applied. Unfortunately occupying these exact source and receiver positions is rarely possible, particularly in areas with significant obstacles. Thus, points need to be offset (e.g. Figure 1b), a time-consuming process that introduces offset and azimuthal discontinuities in the sub-surface coverage.

The development of data-processing algorithms that do not require surface positions to conform to a rectilinear grid, instead being actual-location driven, allows the survey to be designed so that it efficiently follows paths of least resistance around obstacles (identified from high-resolution satellite images) while retaining smooth variations in offset and azimuth (e.g. Figure 1c). These new non-grid-based algorithms also improve the processed data as the actual positions of the sensors can be used, rather than their planned position, which we know to be only an approximation.

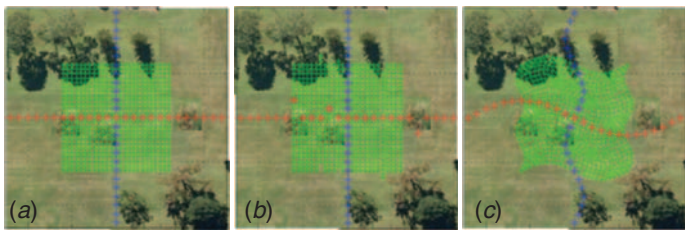

Fig. 1. *(a) An ideal regular grid layout. Source locations are in red, receiver locations in blue, and the resulting common midpoints in green. (b) The same layout after the source positions have been moved to avoid some trees. (c) A new layout made possible by recent developments in processing software. The locations do not need to conform to a grid or to any particular pattern. Provided the locations vary reasonably smoothly, the result is uniform coverage.*

Positioning

Previously, once planning was finished, surveyors using GPS would mark the receiver and source positions, either with wooden stakes, pin-flags or small photodegradable bags of sand. The layout crew would then place receivers as close as possible to the marked positions. This process is now almost entirely obsolete as the latest generation of recording systems allows *positioning-with-layout,* i.e. integrated positioning and placement of receivers.

Using GPS with satellite based augmentation systems (SBAS) allows accurate positioning (Figure 2a) without the need for the cumbersome radio infrastructure associated with other GPS-based surveying methods. In WesternGeco's UniQ system, the layout crew use GPS to navigate to the planned position before planting the sensor and programming its position into the sensor using an RFID system (Figure 2b). If the planned position cannot be achieved then the sensor can be offset and, as its actual position is recorded, time-consuming re-surveying is not required. Most cable-less systems (discussed later) incorporate

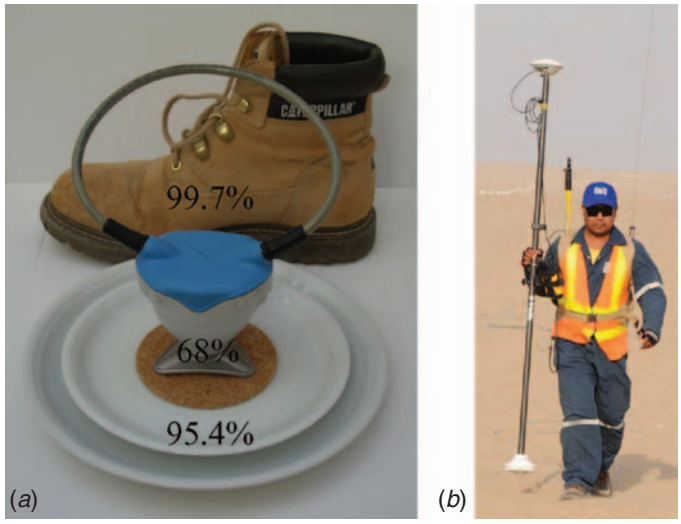

Fig. 2. *(a) Accuracy of SBAS positioning. The probability that the measured position of an object will be within its true position is shown for objects of varied size relative to the size of a sensor. For example: boot or plate 99.7%, coaster 68%, saucer 95.4%. (b) UniQ positioning-with-layout equipment in use. A GPS antenna is at the top of the pole and the RFID system at the bottom. (Image courtesy of WesternGeco.)*

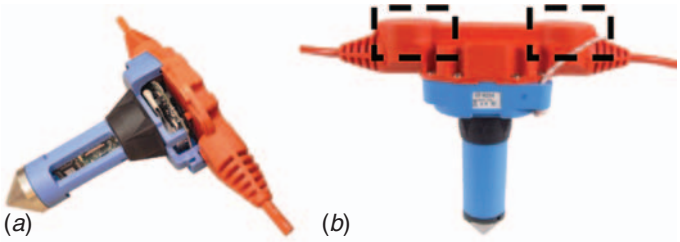

Fig. 3. *Sercel DSU3 3-component MEMS sensor (left) and DSU3GPS sensor (right). The latter includes a pair of GPS antennas, highlighted by the dashed black boxes, to record the position and orientation of the sensor. (Image courtesy of Sercel.)*

Fig. 4. *Screenshot of stake-less navigation, the planned source positions are shown by the circles at the centre of the screen with the current positions of three vibrators (shown as arrowheads) to the right. (Image courtesy of INOVA.)*

GPS positioning while Sercel's new DSUGPS sensors are unique among cabled systems as they incorporate a pair of GPS sensors (Figure 3). The GPS antennas add little weight and increase the cost by 15% but become redundant once the position of the sensors is recorded.

Source positioning has also been revolutionised. Inside the vibrator driver's cab, the source point and vibrator positions appear on a screen, allowing accurate placement without the need for a survey (Figure 4).

Recording systems

The basic building block of a land seismic acquisition system is the sensor, usually a geophone, which is a magnet surrounding a coil attached to a spring. Vibrations in the ground cause the magnet to move, generating a small electric signal in the coil. The design principle of the geophone has remained practically unchanged since the 1930s, although its size, at least for exploration purposes, has been reduced considerably.

The amplitude response of geophones varies with frequency, limiting their ability to record low frequencies. The response of the geophone peaks at the natural frequency, and although this can be reduced to record lower frequencies, this makes the sensor larger and more susceptible to errors if not placed exactly vertically. Recently two alternative acceleration sensors have been introduced: the geophone accelerometer (GAC) and micro-electro-mechanical-systems (MEMS). The GAC utilises geophone elements and advanced active circuitry. Its improved frequency response compared with a standard geophone is

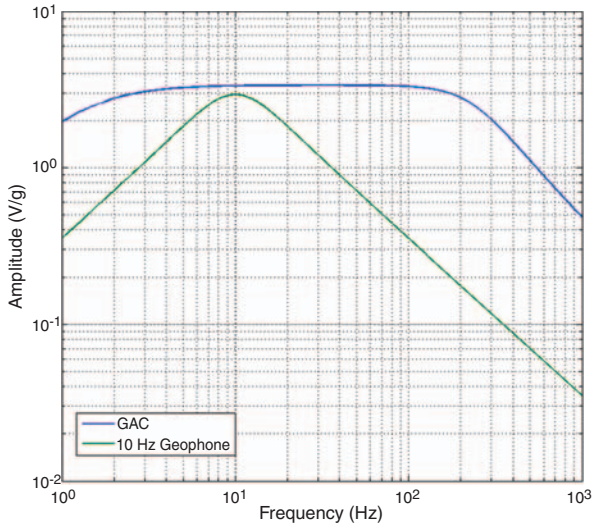

Fig. 5. *Amplitude response curve for a geophone (in green) and a GAC (in blue). (Image courtesy of WesternGeco.)*

shown in Figure 5. MEMS sensors are tiny chips (smaller than a coin), as used in electronics such as smart phones. Although MEMS sensors are much smaller than geophone elements their associated electronics and housing considerably increases their size.

Geophones have been traditionally wired together and placed in an areal pattern to reduce both coherent and random noise. These analogue arrays are good at attenuating noise at the wavenumbers for which they have been designed but have drawbacks in terms of flexibility (noise at other wavenumbers is not fully attenuated) and spatial aliasing. In practice the ideal response of an array is easily weakened by small errors in the positioning (x, y, and z) of individual geophones.

A dramatic increase in the recording capacity of acquisition systems, with 100 000+ channels now available from a number of suppliers, has allowed the output from large spreads of individual sensors to be recorded and noise digitally removed. As digital filtering is more effective at removing noise than the use of analogue arrays, superior noise-removal results can be achieved using a much smaller number of sensors (typically 10–20% as many). This improvement reduces the logistic overheads and allows the deployment of much larger spreads, albeit at the expense of deferring the noise attenuation from acquisition to processing.

Recently a growing number of cable-less (also known as nodal) recording systems have become available, although most (95%) recording systems being sold are still cable based (Mougenot, 2010). There are various different systems (Figure 6), but they typically consist of a sensor that is either attached to the recording unit by a small cable or, less commonly, integrated within the recording unit. The recording unit contains a GPS clock for timing synchronisation and flash memory to record the data. Some units are autonomous; others can send quality control information or even data via radio or wireless links, either in real-time or via intermittent 'harvesting'.

Cable-less systems offer increased flexibility and freedom from cables, which in turn makes recording free from interruptions due to cut cables, although modern systems guard against this by having multiple transmission paths between each sensor and the recording truck (Figure 7). On the other hand, if the spacing

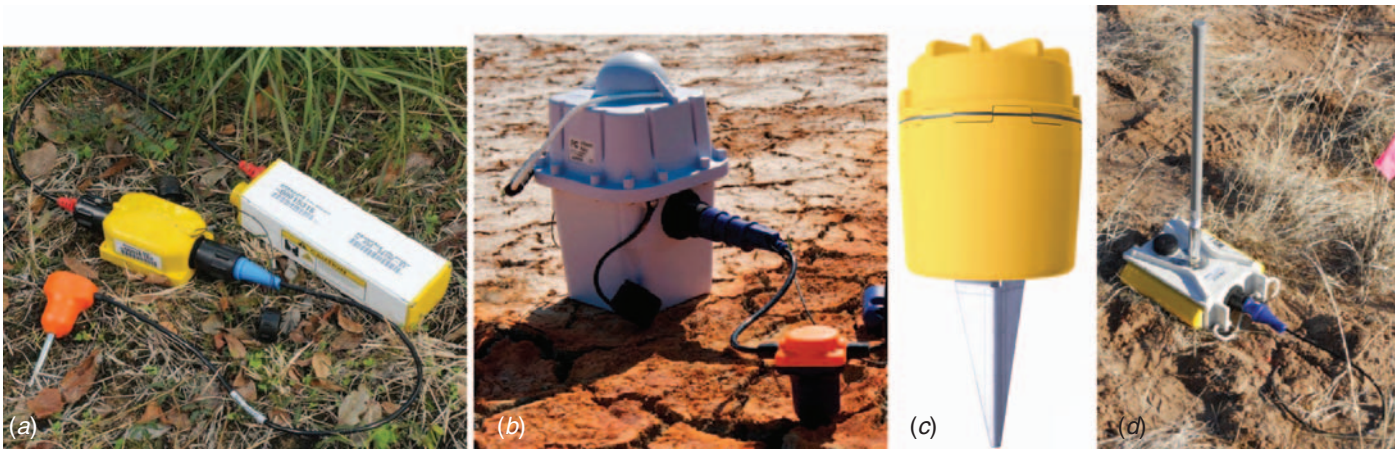

Fig. 6. *Examples of cable-less recording systems. (a) OYO Geospace GSR with separate geophone, recording unit, and battery (image courtesy of OYO Geospace), (b) Sercel UNITE node with an internal battery and separate geophone string (image courtesy of Sercel), (c) ZLand with all components integrated, the unit is 15.9 cm high without the spike (image courtesy of FairfieldNodal), (d) Wireless Seismic RT 1000 unit, capable of sending data in real-time via a radio network. (Image courtesy of Wireless Seismic.)*

of receivers is less than about 50 m apart (spacing of ~10 m is required to protect against spatial aliasing in most areas), the weight of batteries needed can be more than the weight of cables they have replaced (Lansley *et al.*, 2008).

Although the choice of either a cabled or cable-less system is usually clear, sometimes a combination of both offers advantages (Lansley, 2012). For example, the hundreds of thousands of channels required for a very large area (Figure 8) is unlikely to be balanced by improvements in batteries, wireless communication and data harvesting. Thus cabled systems are likely to be preferred, with cable-less systems reserved for survey areas with restricted access.

Sources

Vibroseis continues to be the predominant land seismic source and seems unlikely to be replaced (not that a replacement is needed). The development of vibrators continues to be incremental, primarily driven by increases in the hold-down weight with 80 000 lb units and even 90 000 lb units available. These increases have allowed fewer vibrators to be used in surveys, and sometimes a single vibrator is sufficient. The introduction of rubber tracked vibrators (Figure 9) has improved their mobility, allowing them to reach previously inaccessible areas and reduced the need for line clearance. The much reduced ground pressure of these vehicles also ensures that deep ruts are not created.

Data with enhanced low frequency content has various benefits such as overcoming attenuation, improving vertical resolution and enhancing inversion results. Although modern vibrators are capable of emitting low frequencies with reduced force, specialised sweeps, such as the Maximum Displacement Sweep (Bagaini, 2008), are required to ensure that the sweep does not attempt to exceed the performance limitations of the vibrator.

Productivity

Conventional sequential vibroseis acquisition requires that the time between consecutive sweeps be at least equal to the sum of the sweep length and listen time, typically around 14 to 20 seconds. Once crews became equipped with sufficient fleets this became the ceiling on productivity. Techniques to overcome this limit have existed since the mid-1990s but have been little used due to concerns about noise contamination. Recently the advantages of acquiring additional source points with less source energy ('Fold vs. Force') have become commonly accepted. Although improvements in vibrators have allowed fleet sizes to be reduced, and thus the number of fleets to be increased, such that these extra source points could be acquired, to achieve them

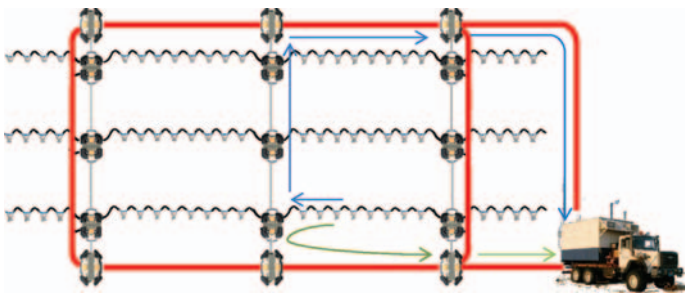

Fig. 7. *Diagrammatic representation of a WesternGeco UniQ system layout, strings of point receivers can be joined (only a single 10-receiver string is shown but 15 contiguous strings (~1800 m) are supported), removing the need for line cables. The red lines are fibre-optic cables. Multiple paths from each sensor to the recording system ensure that recording can continue even if some of the cables are cut. Two examples are shown by the coloured arrows but many others are possible. (Image courtesy of WesternGeco.)*

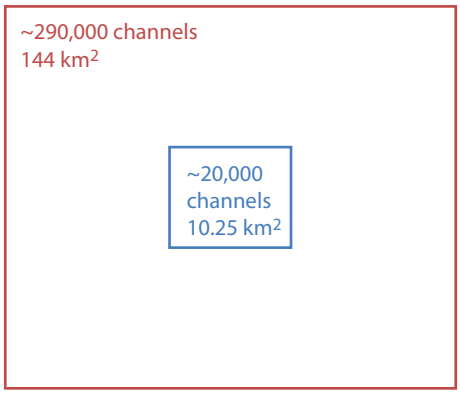

Fig. 8. *Areas and channels for surveys in Kuwait during 2004 (10.25 km^2, 20 000 channels) and one proposed in 2010 (144 km^2, 290 000 channels).*

Fig. 9. *Rubber tracked DX80 80 000 lb vibrators. (Image courtesy of WesternGeco.)*

in a timely manner requires overcoming conventional productivity limitations. To do this various high productivity techniques have been introduced including overlapping sweeps (slip–sweep; Rozemond, 1996); separating the fleets so they interfere below the horizon of interest (distance separated simultaneous source; Bouska, 2010); and even allowing vibrators to sweep autonomously (independent simultaneous sweeping; Howe *et al.*, 2008). The current acquisition record is over 45 000 source points in a single day (Pecholcs *et al.*, 2010), although a sustainable figure is ~20 000/day, an order of magnitude higher than that achieved just five years ago. Many of these high productivity methods are enabled by continuous recording with the recorder and sources synchronised using GPS timing.

Conclusion

Land seismic data acquisition is undergoing a quiet revolution. This revolution is driven by the need to map more demanding geological targets at lower economic and environmental cost. The data needs to be uncompromised by its own acquisition so that it can be used as an input for advanced seismic imaging and inversion processes. Survey planning is no longer based on rigid grids but follows paths of least resistance around obstacles identified from remote sensing images. Teams of surveyors operating in advance of the layout teams are no longer required because receivers are now being located and their actual positions recorded by the layout teams. Vibrators proceed directly to their source positions using their own navigation systems. High productivity acquisition techniques allow tens of thousands of source points to be acquired each day, into spreads covering tens of square kilometres containing over a hundred thousand individually recorded accelerometers, generating terabytes of data.

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The constrained magnetic modelling of the Wallaby gold deposit, Western Australia

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This article reports on Sasha Banaszczyk's Honours project, which was sponsored by the ASEG Research Foundation. Sasha's project was supervised by Mike Dentith at The University of Western Australia and Yvonne Wallace and Lee Sampson at Barrick (Australia Pacific).

Project summary

With minerals exploration becoming reliant on understanding the deeper subsurface in detail, the development of 3D geophysical inversion is becoming essential. Due to the non-uniqueness of inversion an infinite number of solutions can be found to fit original potential field data; however, this can be overcome by applying geological and mathematical constraints within an inversion.

A Sparse Constraint Model Builder (Model Builder) developed for use with the University British Columbia – Geophysical Inversion Facility code (UBC-GIF) aims to facilitate the supply of direct constraints to mediate the inversion process (Williams, 2008). The Model Builder can be used to create factual 3D physical property models from surface sample measurements, drilling property measurements and outcrop or basement geology maps. Buffers are also applied to the physical property model to allow measurements to be extrapolated into surrounding regions where there are less or no constraints. This physical property model then provides a reference model or bounds model for a UBC-GIF inversion to use as a constraint, therefore incorporating a degree of geological knowledge during the model building process.

The Wallaby gold deposit is located 25 km southwest of Laverton in the Eastern Goldfields Superterrane, Western Australia, and is a satellite deposit within Barrick Gold Limited's Granny Smith mine property. Gold mineralisation at Wallaby is hosted within a mafic conglomerate, intruded by a south plunging (50°) magnetite-actinolite altered syenite pipe. Features of the magnetic Wallaby anomaly are the amplitude (910 nT) and twin peaks central to the broad 'bullseye' anomaly. Gold mineralisation at Wallaby is associated with zones of lower to moderate magnetic susceptibility (Coggon, 2003; Neilson, 2005). This relationship can be modelled using magnetic data to infer further regions of mineralisation. The Model Builder was used to create a 3D physical property model of the magnetic susceptibility distribution from measurements taken along diamond drill core. Utilising this as a constraint enabled a UBC-GIF inversion to resolve detail laterally away from the alteration pipe, and below the known depth (1200 m) of the Wallaby deposit.

The aims of this research were:

- to test whether inversion methods constrained by a physical property model built using the Model Builder can improve on previous magnetic modelling and create a reliable and geologically realistic magnetic inversion from aeromagnetic data;
- to use these improved models of magnetic susceptibility to better understand the internal structure of the Wallaby system, and to identify areas of low magnetic susceptibility as a proxy for Au lodes.

The process for creating the physical property model and constrained inversions of the Wallaby deposit was iterative, reliant on visual assessment of the model and forward/residual calculations. These were used to determine the most realistic representation of the magnetic susceptibility distribution within the alteration pipe that showed the characteristic central low and outer high magnetic susceptible zones (Coggon, 2003).

It was found that the physical property model itself provided a very useful exploration tool, defining the magnetic susceptibility distribution within the alteration pipe. Interpretation of this model found zones of mineralisation that correlated with low to moderate zones of magnetic susceptibility, and the plunge of the alteration pipe and major structural features were clearly defined (Figure 1(b)).

In the initial stages of the constrained inversions a coarse mesh was used to enable refinement of the physical property model and inversion parameters (Figure 1(c) and (d)). Once a realistic model, based on the known geology of the Wallaby deposit was resolved, the final physical property model and inversions were built using a fine mesh (Figure 1(e) and (f)).

The constrained inversions of the Wallaby gold deposit were useful in accurately identifying extensions of known gold lodes in shallow regions of the models (Figure 1(e) and (f)). At depth and in regions with limited constraints, however, the resolution of detail decreased. The southward plunge of the alteration pipe and detail within the central low and outer high magnetic susceptible zones were resolved. Similar low magnetic susceptible features were identified in the bounds model inversion, also seen in the reference model inversion (Figure 1(e) and (f)).

The bounds model inversion resolves a large zone of high magnetic susceptibility on the northern edge of the Wallaby pipe that is not resolved in the coarse mesh inversions. The main magnetic alteration within the Wallaby deposit is known to be contained within the alteration pipe (Coggon, 2003; Miller, 2010), so it is unlikely that a large intense region of alteration extends to depth on the northern side of the deposit. The constraining physical property model is not accurately representing the magnetic response of the magnetic alteration, so the inversion is compensating by resolving a northern high magnetic susceptible zone where limited constraints are available. The reference model inversion, however, produces a more realistic model consistent with the known geology of the area, where the outer magnetic high susceptibility on the northern and southern edges of the pipe is clearly resolved. A magnetic source is also defined at depth which constrains deeper zones of mineralisation.

Project outcomes

1. The Model Builder provides a useful tool for creating geologically realistic constrained potential field inversions from the UBC-GIF inversion code. The constrained magnetic inversion of the Wallaby gold deposit was useful in confirming further regions of gold mineralisation outside the Wallaby alteration pipe.

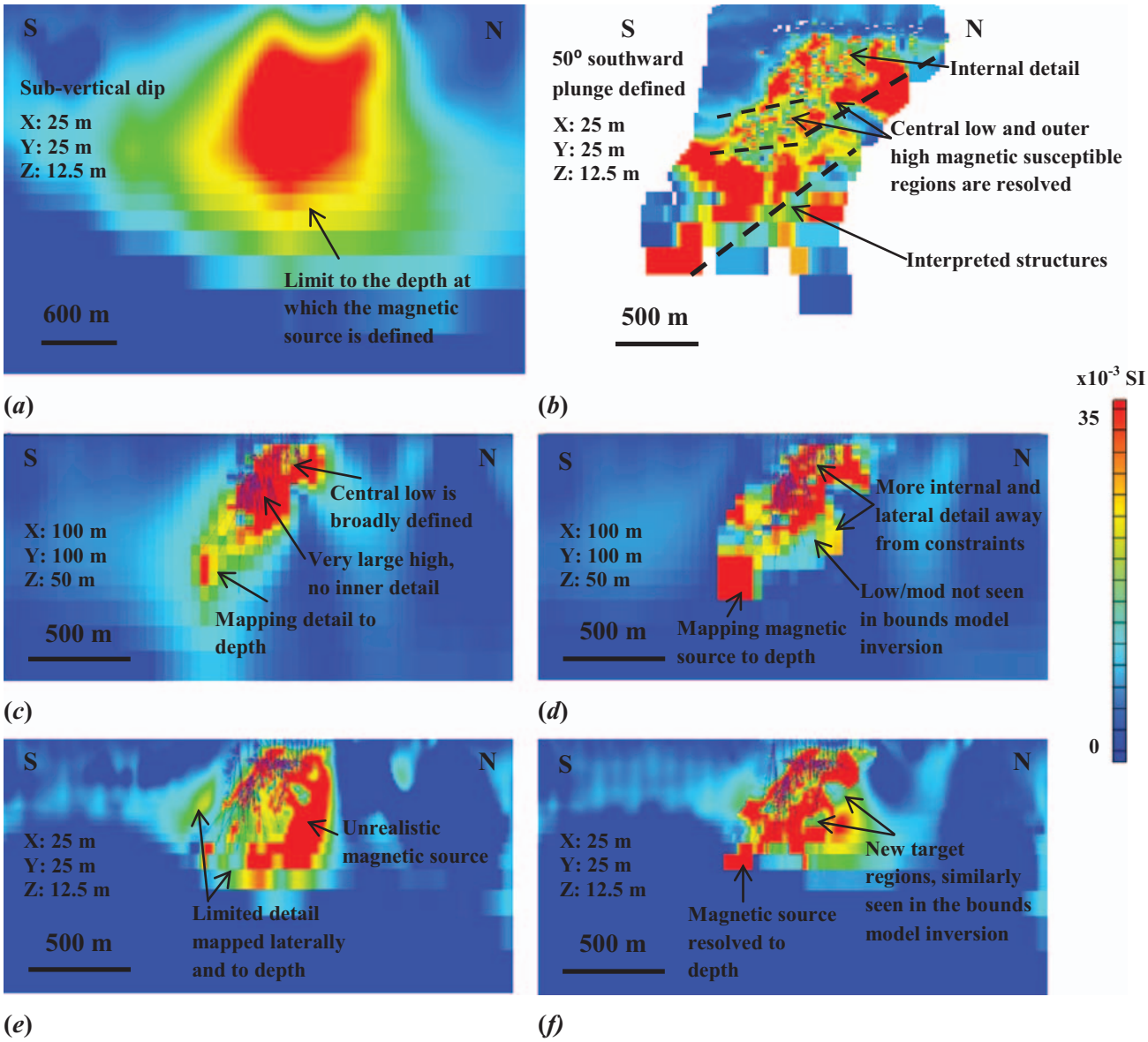

Fig. 1. *Comparisons between (a) an unconstrained UBC-GIF inversion of the Wallaby gold deposit; (b) Model Builder fine mesh physical property model (buffered) showing the magnetic susceptibility distribution within the alteration pipe; (c) UBC-GIF coarse mesh inversion constrained with a coarse physical property model applied as a bounds model; (d) UBC-GIF coarse mesh inversion constrained with a coarse physical property model applied as a reference model; (e) UBC-GIF fine mesh inversion constrained with (b) applied as a bounds model; and, (f) UBC-GIF fine mesh inversion constrained with (b) applied as a reference model.*

2. Higher resolution detail can be resolved when more constraints are available for creating a physical property model.
3. A compromise needs to be made dependent on the number of physical property measurements available, the number of cells in the inversion mesh, and the level of detail required from the inversion. A relatively large cell size provides an efficient model for defining large features and may be all that is needed depending on the exploration requirements.
4. The bounds model inversion and reference model inversion show some similarities and ideally, should be interpreted in conjunction to provide a more accurate exploration tool than using one model over the other.
5. It is recommended that the dynamic range from forward/residual calculations of the physical property model be very close to the original aeromagnetic data before attempting to use the physical property model to constrain an inversion.

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Clean Energy, Climate and Carbon

by Peter J Cook
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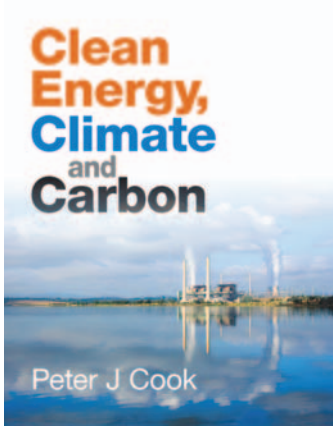

2010 was a record year for CO_2 emissions from burning fossil fuels and making cement. Globally, the equivalent of over 33.5 billion tonnes of CO_2 was added to the atmosphere. This was nearly 6% higher than the 2009 global estimate, and with the economies of countries like China and India powering ahead the current trend is likely to continue.

As a result, the earth's atmosphere will continue to warm; sea level will rise faster than it has in the last 2000 years; millions of people now living on low lying land will be forced to move; the oceans will become more acidic; there will be more extreme weather events as the atmosphere becomes more energetic; and the fossil fuels currently being consumed at record rates will become more expensive.

This is not a happy scenario, but it did not deter Peter Cook from arguing that Carbon Capture and Storage (CCS) can be a major weapon to decrease the current rate of CO_2 being added to the atmosphere.

Clean Energy, Climate and Carbon is an easy-to-read thorough analysis of all the main issues, and the diagrams are really good if you just have time to skim-read. It cuts to the core of the challenges humans face on planet earth as a result of climate change and increasing energy demands, including the science, engineering, economics, population (the elephant in the room) and of course the politics.

The book starts with a very good review of the evidence for human-caused global warming and why we are producing so much CO_2. It then goes on to discuss some of the technological options for decreasing CO_2 emissions and concludes that even with a mix of solar, wind, geothermal, nuclear and other 'renewables' it will be very difficult to reduce these emissions because of our huge reliance on fossil fuels.

This leads to CCS; where and how it is captured; how it is transported; where and how it can be stored; how the captured CO_2 can be monitored; and above all how much it is likely to cost. Of course the overall cost is very difficult to estimate because there are so many variables, and above all, because there is a dearth of examples of CCS in action. If you want to take a punt at the cost then $80–$140 per tonne of CO_2 avoided is suggested, but each case will have to be calculated on its own merit. To take one example: how should the CO_2 be transported from the source to its storage place? By ship or pipeline? Or another: how should the storage site be monitored and for how long?

In spite of these complexities it is argued that CCS can play a significant role in reducing the level of CO_2 in the atmosphere.

Finally, the technology and politics of clean energy are discussed – and if you think the science and engineering of CCS are complex, try the politics of clean energy!

It is pleasing to note that a lot of the research into CCS has been and still is being carried out in Australia and this is in no small measure as a result of the work of Peter Cook who established the CO2CRC and was its CEO from 2003 until 2011. I would highly recommend this book for anyone with a science background from year 12 and upwards. Furthermore, in Australia we can look forward to 2015 when the Gorgon gas project in Western Australia will start storing 3–4 million tonnes of CO_2 per year under Barrow Island – not long to wait and a real test of the technology.

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Too much of a good thing

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Can you remember several years back to the introduction of those great little USB connected hard disks that allowed people to send data sets between companies with ease? Man – these things were a great boost to productivity. No more tape drives, no more burning DVDs, just plug and play and get on with things.

The guy at the other end could plug it in, drag and drop his data onto his machine and then if he was sneaky – take the disk home and put a heap of music on it, videos, and family photos – and maybe even then send that to someone else to use to get a copy of his music collection.

It didn't take long until volumes of these disks began to pile up filled with valuable data, breaching security and antivirus systems everywhere, and creating an impossible archive situation where no one knew what disks had what data on them. The one labelled 'Mt Isa Located Magnetics and Gravity Data', actually had Barbra Streisand's Greatest Hits music collection and a nice array of photos of a previous exploration manager's kids on it. The one labelled 'North West Venture 3D Seismic' had a small collection of seismic data on it, but also included a 'Stuff' folder that had 2 Gb of porn, a second copy of Barbra Streisand's Greatest Hits, and the recently updated resume for the exploration manager that just left.

The great USB connected disk pool (or black hole) got larger and larger. The disks started to change shape. Some very small, others standing on their edge in a neat little stand, some with cool blue lights, others just a subtle stainless steel case complete with a total lack of cooling and anti-vibration systems that rendered them useless after 12 hours of continuous use. And let's not forget about all of the cables and plugs … yes … the snake drawer!

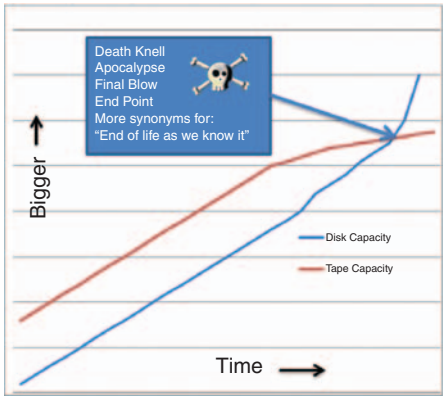
I remember reading the warranty on one hard disk that said something about the disk being perfect for home use and data storage, anytime and anywhere. In reading the fine print, it actually said something about 'anytime and anywhere' being less than 4 hours in any one 24 hour period in a cool, clean, and dust free environment. I'm not sure about most of your own homes, but my house operates 24/7, and with five kids it is never cool or clean.

Two years ago as this data management issue started getting worse, one major oil company declared that all USB connected HDDs will be used only once and were to be disposed of to avoid data loss – so all data was to be transferred to the network server for archiving as soon as the data arrives. Network administrators and backup engineers all took a deep breath and quietly went about crapping themselves wondering how their backup systems would cope with terra-bytes of unexpected data coming onto the network every few days.

Last year, the largest manufacturer of disk drives shipped 200 million disks. Rumour has it that almost 40% of these went into USB 'disposable' disks. That is only about 80 million USBs … nothing to worry about. Okay network administrators – you can go change your underwear now.

This trend is not going to stop. Disk manufacturers are trying to build hard disks that store more than tapes and they are getting closer. Once they do – the trend of USB connected disks will be more than just a fad – it will be the way of the future.

The following graph shows the race between these two technologies.



I do a bit of reading on this stuff (because I am a nerd) and no one from my point of view has a very good feel for where this will end up.

So how do we cope?

Well – you are going to continue using these very convenient disks aren't you … so you might as well use:

1. A server grade hard disk like a Hitachi Ultra Star. Not the cheapest, but it is a good quality disk that will last. The old adage of 'you pay for what you get' rings true in this situation without a doubt.
2. A good enclosure for the disk. Good ventilation, built in fan and a redundant power supply if possible.
3. A spreadsheet/database of files that are on it so you can locate them easily. No one wants to get a hankering for Barbra Streisand and not be able to find her.

And work with your IT manager to help you back this stuff up. Don't screw up his incremental backups with 2 Tb's of extra stuff when he least expects it.

As per the graph above, the two curves will meet, and when they do, someone will become very rich and someone named Barbra Streisand will go platinum posthumously as the most distributed artist of all time. The rest of us meanwhile will be searching for that critical data set on one of those disks.

May			2012
14–18 May	GeoConvention 2012: Vision http://www.geoconvention.com	Calgary	Canada
27–29 May	3rd International Conference: Geosciences and Environment http://www.agserbia.com	Belgrade	Serbia
29–31	3rd International Geosciences Student Conference http://www.3igsc.com	Belgrade	Serbia
June			**2012**
4–7 Jun	Copenhagen 2012: 74th EAGE Conference & Exhibition incorporating SPE EUROPEC 2012 http://www.eage.org	Copenhagen	Denmark
4–8 Jun	GPR 2012: 14th International Conference on Ground Penetrating Radar http://www.gpr2012.org	Shanghai	China
15–18 Jun	5th International Conference on Environmental and Engineering Geophysics http://www.iceeg.cn/english/index.htm	Changsha	China
July			**2012**
25–31 Jul	21st EM Induction Workshop http://www.21emiw.com	Darwin	Australia
22–27 Jul	IEEE International Geoscience and Remote Sensing Symposium: Remote Sensing for a Dynamic Earth http://www.igarss2012.org	Munich	Germany
August			**2012**
5–10 Aug	34th International Geological Congress http://www.34igc.org	Brisbane	Australia
20–24 Aug	Geobaikal 2012: Electromagnetic Research Methods and Integrated Geophysical Data Interpretation http://www.eage.org	Irkutsk	Russia
September			**2012**
3–5 Sep	Near Surface Geoscience 2012: 18th European Meeting of Environmental and Engineering Geophysics http://www.eage.org	Paris	France
10–14 Sep	EABS IV – Eastern Australasian Basins Symposium http://www.EABS2012.com.au	Brisbane	Australia
17–19 Sep	Istanbul 2012: Istanbul International Geophysical Conference and Oil & Gas Exhibition http://www.igcistanbul.com	Istanbul	Turkey
19–21 Sep	KSEG International Symposium: Geophysics for Discovery and Exploration http://2012symp.seg.or.kr	Jeju	Republic of Korea
November			**2012**
4–9 Nov	SEG International Exposition and 82nd Annual Meeting http://www.seg.org	Las Vegas	USA
December			**2012**
6–10 Dec	AGU Fall Meeting 2012 http://www.agu.org/meetings	San Francisco	USA

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