Preview

Australian Society of Exploration Geophysicists

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More resources for GA

In one of the best good news stories of the year, Geoscience Australia has been provided with an additional $135 million over five years to encourage resource exploration, particularly where this relates to energy. Eristicus provides more details of the new funding elsewhere in this issue.

The allocation of this new money provides an excellent example of how the political process works in Canberra (and probably in most other governments).

In previous years there have been an Action Agenda report, a House of Representatives Inquiry into Resources Exploration (Prosser Report 2002) and other well reasoned documents, arguing that more Commonwealth money should be provided to increase continent-wide geoscience programs.

In the normal budget process these recommendations got nowhere, probably because of the heavy hand of the Treasurer and bureaucrats in his department. However, as soon as the electorate started squealing about petrol prices, the whole issue became critical, the Prime Minister's political acumen came to the fore, and all the annual budget processes were quickly bypassed.

Anyway, apart from expanding the frontier offshore petroleum program, the new money will enable GA to expand its onshore geoscience programs, which were previously devolved to the States and the Northern Territory by the Australian Government, and it provides a long overdue contribution by the Commonwealth in this important national issue.

More on Melbourne Convention

In this issue of Preview I have included more on the very successful convention held with the GSA in Melbourne during July this year. We have a somewhat random collection of photographs taken at the meeting and also some presentations adapted especially for Preview as Feature Articles.

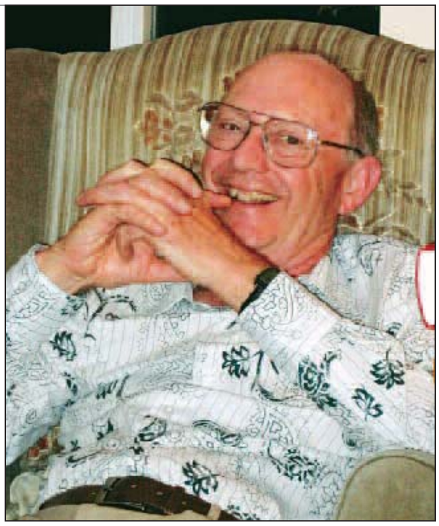
The meeting was reported in the EAGE First Break magazine (September 2006, No 24, 14-15) and also in The Leading Edge produced by the SEG (August 2006, 920). Each society was represented in Melbourne by their Presidents, Terry K Young from the SEG and Theo Kortekaas from the EAGE. They both gave very complementary descriptions of the meeting and made strong pleas for their members to go to Perth in 2007.

I have asked for these articles to be placed on our website, so if you can't find them in hard copy they should be soon available on our website.

Leadership

I was fortunate to hear Peter Lilly's Presidential address: *If you can't laugh you can't lead: a personal perspective on leadership in the minerals sector.* Peter is currently the President of the AusIMM and has recently been appointed to lead the CSIRO Division of Exploration and Mining in Perth.

His talk was based on the book: *The Seven Heavenly Virtues of Leadership*, published by the Australian Institute of Management.



David Denham

The seven virtues, or attributes, are: Humility, Compassion, Wisdom, Integrity, Passion, Courage and Humour.

Very fine characteristics to develop and nurture, but how do our top leaders in the real world measure up?

ASEG Christmas Wines

Finally, I refer readers to page 40 of this issue. Once again the South Australian Branch has worked hard to provide us with some excellent choices to accompany our Christmas fair. If these wines maintain the quality of their earlier selections they are highly recommended.

Get your orders in now.

David Denham

James Reid

On a personal note, the last couple of months have been extremely busy. I left my position at the University of Tasmania at the end of August and 'emigrated' to Perth, where I am now employed in the private sector by Geoforce Pty. Ltd. My new contact email address is given below.

Potential merger between ASEG, GSA and AIG?

Many ASEG members will already be aware that the Geological Society of Australia and the Australian Institute of Geoscientists are very seriously discussing a merger. Both societies are keen for the ASEG to be included, with the objective of forming a major geoscientific entity. A merger of societies was discussed at length at the GSA Council Meeting immediately before the AESC2006 Conference in Melbourne in July. I attended the Council Meeting along with Rick Rogerson, President of AIG. The ASEG was also represented at the meeting by Koya Suto, David Denham and Michael Roach. At the meeting, it became apparent that merger discussions between GSA and AIG were quite advanced. As yet, there has been little formal discussion of the idea within the ASEG, either at the Federal Executive level or within the general membership, and as a consequence the ASEG has made no commitment to a merger at this stage. However, it was agreed at the meeting that the three societies will form a working group (yet to be constituted) to scope out the possible structure and organisation of a combined society.

Proponents of the merger argue that a single large society would provide increased political lobbying power for Australian geoscience, and would be a means of combating declining or stagnating membership numbers (particularly within GSA and ASEG). Other potential outcomes would be an improved (i.e. less cluttered) conference schedule, and savings in administration and publication costs.

These potential advantages would however be offset by a loss of identity for our society. Our flagship journal, Exploration Geophysics has a strong recognition within the geophysical community worldwide, and is the only local geophysical technical journal. It is also important to consider that approximately half of ASEG members are employed within the Oil and Gas sector, which is more weakly represented in the GSA and AIG. Any future merged society would have to adequately represent the interests of all of our members. An alternative is that a formal merger may not be required, and that many of the benefits of a merger could be achieved through other means - for example, the problem of there being too many competing annual conferences could be addressed by holding a joint ASEG/PESA/GSA conference on a more regular basis.

Our society must carefully weigh the pros and cons of a merger before we decide our future course of action. The Federal Executive would be very keen to hear the views of ASEG members on the issue.

Keep your email address current!

I would like to remind members to keep their online membership details, and particularly email addresses, current. This is very important in the current boom times, when there is a lot of mobility within our industry. A correct email address is extremely important for access to the members section of the website (including the membership directory). If your contact details change and you can't remember your username and password, then the automatic reminder email will be sent to your old email address! If you are unable to log in, please contact the ASEG secretariat (secretary@aseg.org.au).

Member details can be updated by logging in to the Members section of the web page (www.aseg.org.au).

To date there have been some problems with processing of feedback regarding the new website. These should now have been resolved. If you report a problem with the new website and you do not receive any confirmation within a day or so, please contact the ASEG secretariat.

James Reid
james@geoforce.com.au

Calendar of Events

2006

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

6-12 November
Assoc. of Exploration Geoscientists of India (AEG)
3rd International Seminar and Exhibition
Hyderabad, India
Website: www.aegindia.org

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

30 November- 1 December
SEEGrid III : Computation Modelling and Decision Support in the Solid Earth and Environmental Community
CSIRO Discovery Centre, Black Mountain, Canberra
Website: https://www.seegrid.csiro.au/

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

2007

1-5 April
20th Environmental and Engineering Geophysical Society, Annual Meeting (SAGEEP 2007)
Marriott City Center, Denver, Colorado
Website: http://www.eegs.org/sageep/index.html
Email: john_nicholl@urscorp.com

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

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

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

9-12 September
5th Decennial International Conference on Mineral Exploration (Exploration 07)
Theme: Exploration in the new millennium.
Exploration 07 will review the current state of the art in geophysics, geochemistry, remote sensing, data processing and integration.
Venue: Toronto, Canada
Website: www.exploration07.com

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

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

Exploration and Beyond in Perth 2007

The **19th International Geophysical Conference and Exhibition** will be held from 18-22 November, 2007 at the Perth Convention and Exhibition Centre. The Conference has the theme of 'Exploration & Beyond', and we invite you to come and join us to celebrate the 50th Anniversary of the International Geophysical Year in this outstanding venue in Perth's Central Business District.

We welcome you to Perth, the 'heart of Australia's resources industry'. The conference is being held jointly with the Petroleum Exploration Society of Australia, with five concurrent session streams planned at present. It is also possible that the FESWA may operate a stream, while the SEG is expected to have an involvement through the provision of a number of international key-note speakers.

The conference will start on Sunday 18 November with a number of workshops followed by the ice-breaker and, after three days of technology discussion, finish with more workshops and possibly the ASEG/PESA golf day on 22 November.

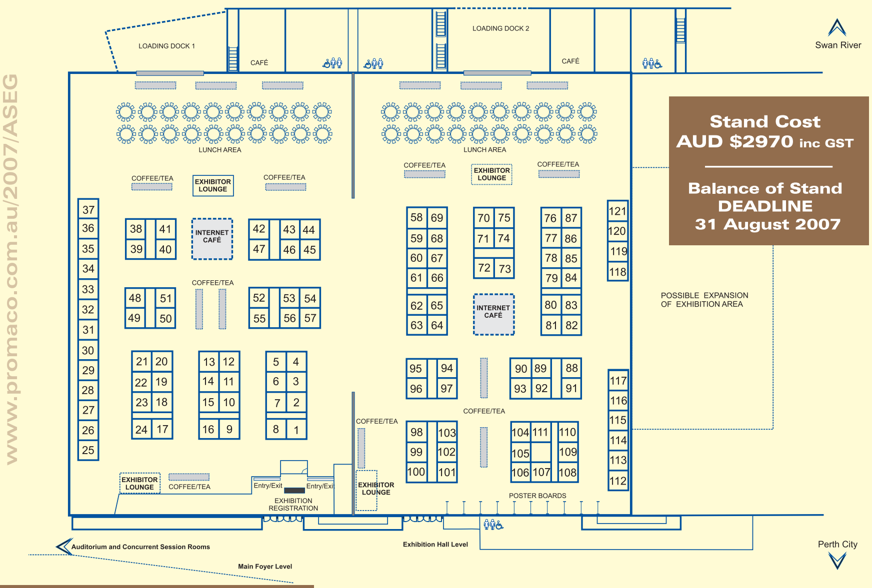
A special movie was presented at the closing ceremony of the Melbourne conference. The video is also scheduled for presentation at a number of other conferences (eg. SEGJ in November, EAGE Seismicity workshop in December). We expect to have a large number of international guests attend the conference, and we are confident that all delegates will have an enjoyable time at this beautiful time of the year in Perth.

At the latest count, 49 industry display booths have been reserved, so don't miss out on ordering your booth. Please check the booth map in this issue of Preview and book rapidly diminishing space soon. Information on sponsorship will be distributed in the coming months. The first call for papers will be issued around the end of January 2007.

Brian Evans and Howard Golden
Co-Chairs

19TH INTERNATIONAL GEOPHYSICAL CONFERENCE & EXHIBITION

www.promaco.com.au/2007/ASEG



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3rd .... 6th ....

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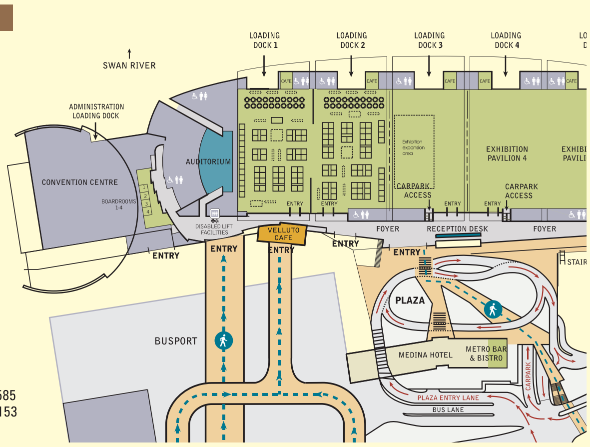

I/We understand that stand(s) preference will be given to corporate members, previous exhibitors and then in order of receipt of application. Any conflicts will be resolved by ASEG guidelines and the committee decision will be final. Should the exhibition floor plan require expansion or retraction, the committee have the right to make the necessary changes.
Note: Payment of 50% deposit of the total must accompany this form.
CANCELLATION POLICY - In the event of cancellation of the stand(s), please note that unless the stand is able to be resold, there will be no refund of monies paid. If the balance of the stand is not received by the due date of 31 August 2007, the allocated stand(s) will be cancelled and the deposit forfeited.

Signed .... Date ....
(for and on behalf of the above listed company)

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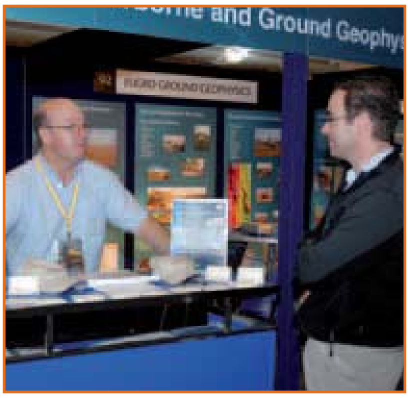
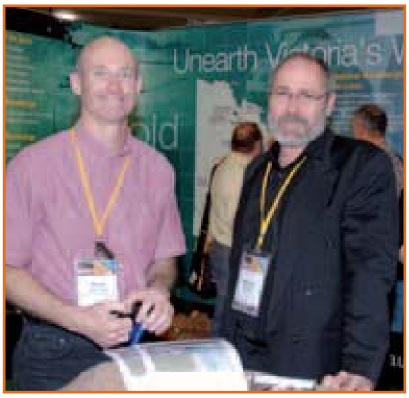



Pictures from Melbourne





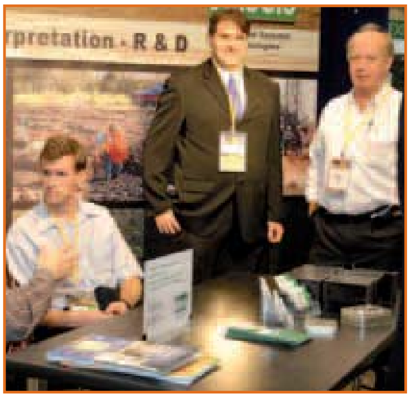


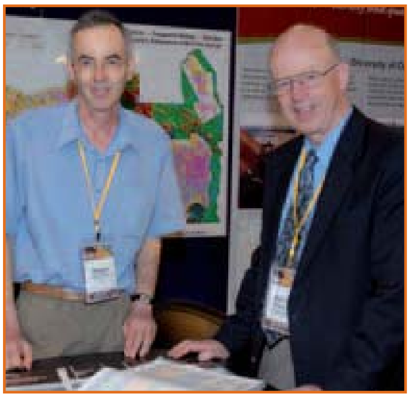






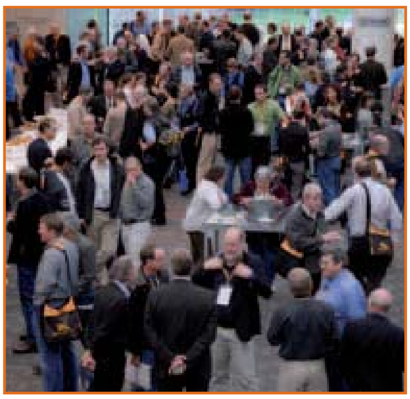










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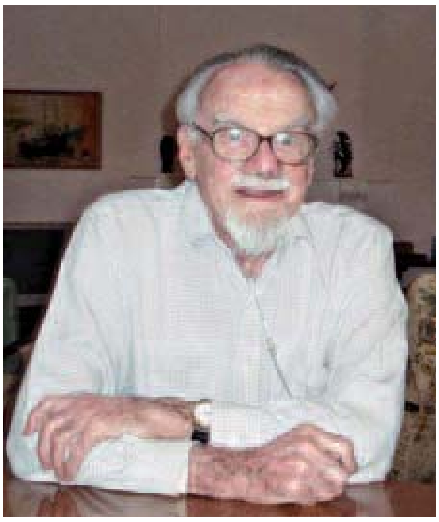
New Members

The ASEG welcomes the following new members to the Society. Their membership was approved at the Federal Executive meetings held on 25 July and 25 August 2006.

Name	Affiliation	State
Monika Cogoini	Fugro Jason Australia	WA
Robert Dean	PGS Australia Pty Ltd	WA
Marcos Hexse Grochaul	Curtin University	WA
Claire Grubb	PGS Geophysical	WA
Roberto Guerini	PGS Geophysical	WA
David Grant Hutchins	Nambia Geological Survey	Nambia
Cameron Blair Jones	Finder Exploration	WA
Dave Mellors	PGS Australia Pty Ltd	WA
Steve Parry	Robertson Geologging	Hong Kong

Name	Affiliation	State
Paull Victor Parker	Independence Group NL	WA
April Lee Pickard	PGS Australia Pty Ltd	WA
Robert John William Singh	Schlumberger	Vic
Camilla Sorensen	Monash University	Vic
Kim Sukhyoun	Adelaide University	SA
King Seong Tan	WesternGeco	WA
Ray Van Rensburg	Geotron	Africa
Rainer Wackerle	Geological Survey	Nambia



Desmond Lauder Rowston

Born Northam, 8 September 1923
Died Perth, 11 July 2006

Des Rowston was born in Northam, WA in 1923. His father was a Postmaster and had many different appointments around the country, mostly in the south of WA and it was at Bunbury High School in about 1938 that he met Margaret Forrest, who would later become his wife.

Progression from high school to university was not in those days a usual process and Des left school to be a trainee telephone mechanic (nowadays a technician!) in 1940 for the PMG Department. His training was interrupted by war service in 1942, when he joined the Army in the Signals Corps.

In very short order he was dispatched to Milne Bay in New Guinea to play his part in the repelling of the attempted Japanese landing there. At the time this success was a morale booster for Australia, as it was the first time that a Japanese invasion had been defeated. After Milne Bay he served in other parts of New Guinea mostly to install carrier telephone systems.

When the war ended Des returned to his technical duties with the PMG until 1948, when he enrolled at the University of WA (UWA) in the Faculty of Science under the Commonwealth Reconstruction Training Scheme (CRTS). He graduated in 1950 with the unusual majors combination of Physics and Geology (Structural & Economic). He had also married Margaret in 1948 and had two children. It would not have been easy for him.

In 1953 he was appointed as a geophysicist in the Bureau of Mineral Resources, Geology and Geophysics (BMR), the fore-runner of Geoscience Australia. In the Melbourne-based BMR he worked mainly in the Metalliferous Section and this included surveys in the west ("Sunshine") coast of Tasmania using the TURAM method. It is of interest to note that in some of this work he was associated with Sep Horvath, one of the few exploration geophysicists of that time who had worked in Australia before WWII. In 1960 Des was transferred to the Darwin office and worked there until 1962, when he accepted an appointment as a geophysicist with Geological Survey of WA (GSWA).

If we exclude observatory activities, this was the first official appointment of an exploration geophysicist in WA. As the mining industry prospered Des' work became less involved with mineral exploration and more concerned with civil engineering projects and water resources.

In the early seventies he was active in the formation of the WA Branch of the ASEG in association with the late Joe Williams. When the Branch was formed Des was elected to be its first Chairman. In recognition of his efforts in the ASEG he was awarded Honorary Membership in 1983.

Des Rowston retired in 1982, but continued some limited geophysical activities as a consultant on small scale projects.

He led an active life with his beloved golf, bridge and camping trips. Unfortunately he fell victim to emphysema (possibly from war service), which virtually immobilised him in his home on oxygen support from about 1998, and eventually killed him.

He died in Hollywood Repatriation Hospital on July 11, 2006.

He is survived by his wife, Margaret, his children Jenny, Kim, Deborah and Graham and their descendants.

To them we offer our sympathy.

Stewart Gunson

For the Record

We unfortunately published the wrong picture for Edward Burnside in the August 2006 Preview. We apologise to his family and friends for this error. The correct picture is shown below:

Edward Burnside

Born, 29 May 1919, died 28 April 2006

ACT – by Matthew Purss

Firstly, the ACT Branch would like to thank the Victoria Branch, in conjunction with the GSA, for their very successful and professional organisation and running of the 2006 Australian Earth Sciences Convention at the Melbourne Convention Centre from 2-6 July.

Since the May issue of *Preview* we have held two meetings; one in June and one in August. The June meeting was a held as a joint meeting between the ASEG ACT Branch and the AusIMM Canberra and Central West NSW Branch. At this meeting James Johnson (the new Chief of the Minerals Division at Geoscience Australia) presented a seminar entitled: *WHEN THE BOOM BUSTS: Geoscience Australia's response to declining discovery rates*. In this seminar he presented an analysis of the current minerals boom in Australia and the disturbing revelation that this boom is based on high commodity prices and increasing production rates rather than a surge in the discovery of new ore deposits. He then went on to outline Geoscience Australia's response to this looming crisis. That being a new program of geodynamic analysis with a mineral systems overlay, to supply predictive products to the Australian minerals sector. Dr. Johnston's talk was received with much interest by the audience.

At our August meeting, John Rayner, National Centre for the Public Awareness of Science, ANU, presented a seminar entitled: *A Journey with my Father: A Personal History of Geophysics in Australia*. John traced the professional life of his father Jack Rayner and of the origins of geophysics in Australia. Jack Rayner, was arguably the first full-time professional geophysicist in Australia. His geophysical career had its origins in the Physics Department of Sydney University in the 1920s where he worked on geomagnetism for his honours project. He then progressed to his first job with the Imperial Geophysical Experimental Survey which investigated the applicability to Australian conditions of newly emerging geophysical exploration techniques including magnetic, gravity, electrical, electromagnetic and seismic surveys. He was also involved in research into cosmic rays, the Henbury meteorite craters, the degaussing of ships and creation of magnetic declination maps for the Pacific campaign during WWII.

John also traced the development of these geophysical techniques, and their use in Australia, through the many historical photographs, maps, diagrams and extracts from his fathers original documents. Of particular historical interested to many ACT members was the evolution of geophysics in the Bureau of Mineral Resources, to AGSO and presently to Geoscience Australia, and the fact that Jack Rayner was the director of BMR through the 1960s.

New members and visitors who may wish to participate in branch activities are always welcome. Please contact Matthew Purss (02-6249 9383, matthew.purss@ga.gov.au) or Adrian Hitchman (02-6249 9800, adrian.hitchman@ga.gov.au) with enquiries.

New South Wales – by Glenn Wilson

In August, Salah Mehanee presented a review of 3D magnetotelluric modelling and inversion with case studies from Canada and the USA. Salah is a new recruit to Macquarie University's Department of Mathematics from prior academic appointments at Cairo University and the University of Utah.

In September, David Pratt led an interactive presentation on Encom's 3D software environment for the 3D integrated analysis of geological and geophysical data. This involved live demonstrations from Broken Hill, Copper Hill, and Ernest Henry in Australia, San Nicolas in Mexico and groundwater exploration in Botswana. The meeting was very well attended, and held in conjunction with the Sydney Mineral Exploration Discussion Group and the NSW Branch of PESA. The Branch is most appreciative for Encom's sponsorship of the evening.

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

Queensland – by Emma Brand

The Queensland Branch is on fire again this month with an excellent talk from the ASEG's own Koya Suto. Koya spoke on: *Multichannel Analysis of Surface Waves (MASW): a new tool for investigation of ground competence.* MASW is a seismic method which analyses surface waves to estimate the underground S-wave velocity structure. The S-wave velocity is closely related to other elastic parameters important in describing ground strength, such as Poisson's ratio and Young's modulus. MASW is mostly applied in shallow Engineering-style situations. However its extension to minerals or petroleum exploration problems, such as defining shallow velocity structure for statics problems, piqued the interest of those present. The Qld Branch has two more Technical Meetings organised for the year, and will hold a students' night in December. This will be an opportunity for Geophysics Honours Students to present the results of their year-long Honours Research Projects.

South Australia – by Selina Donnelley

The SA Branch has had a quiet few months with technical meetings, but has a number of plans in the pipeline for the rest of 2006. On Thursday 3rd August, Jim Davies gave a presentation entitled *Australian Science & Mathematics School – Innovative Learning in Adelaide*. Jim Davies is currently principal of the Australian Science & Mathematics school, which is a public school recently established in Adelaide, in partnership with Flinders University. The school is for students in years 10, 11 & 12 who have an interest in science, and currently there are just fewer than 400 students at the school. The school offers a very different knowledge and experiential environment based in specially designed facilities and opportunities for learning with industry and the tertiary sector. As such, it provides direct, appropriate and guided pathways into the world of work and higher learning. In this specialist public school, which is open to a wide range of applicants, student experiences in science, mathematics and related technologies are fully developed so they can pursue issues of compelling interest and value. Students take part in project-based and interdisciplinary activities, promoting authentic, vigorous and applied learning. (from: www.asms.sa.edu.au). Jim gave an excellent and interesting talk about his role in developing enthusiasm in young people for science and mathematics – of particular interest to geophysicists! We can only hope more Australian schools see the value in teaching and encouraging mathematics and science as excellent options for students.

The wine tasting dinner was held on August 25th at the Apothecary 1878, in a fabulous private upstairs room. 3 luxurious courses of food were consumed to compliment the 19 white wines and 29 red wines which we tasted over the course of the evening. Taste-off's were required for both the white and red wines, and the red wine was a very close call for a winner! Thanks to Luke Gardiner (Beach Petroleum) and Benn Hansen (Santos) for organising an excellent wine tasting evening.

On September 14th we are holding our annual industry night, which this year is concentrating on a topic very popular in SA at the moment - Geothermal Energy. And on October 19th we will be holding a Schlumberger sponsored lunch at the Sebel Playford Hotel, featuring John Kaldi who will be presenting an update on Geosequestration. John is the Professor (Chair) of Geosequestration at the University of Adelaide and Program Manager, CRC for Greenhouse Gas Technologies (CO2CRC).

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

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

Maps and images from the web

Since the release of Google Earth in 2005, online maps and satellite photos have begun to add a new strength to the internet via the direct connection with real-world topography and satellite imagery. Satellite image grids can now zoom you in close enough to the world that you can see your car parked in front of your own home. The geospatial community has become electronically motivated, much to our short-term benefit, with new downloadable software, BETA systems and APIs quickly following suit.

Maps allow you to navigate through continents to cities and function in real time. Geologically, the aerial views of grasslands, mountain ranges, and isolated landscapes, which provide a new perspective of the planet and the trends that exist within the Earth's layers.

There is a multitude of web sites providing various applications to view relevant features of personal interest, just like the various types of differing search engines available on the web, there are generic web mapping systems that are competing for our spatial perspective and these mapping facilities are been provided by both big and small web providers.

Google Earth

(earth.google.com)

Google Earth has been the instigator of great progress with the geo-spatial community.

New unique features recently released include the ability to activate 3D terrains to create new varied perspectives of the topography as well as the interaction among users to create new annotations that can be shared.

Those users interested in a GIS capabilities Google has created Google Earth Plus ($20/year) which advertises advanced mapping potentials and GPS compatibility with data imports and annotation. Profit-making users, e.g. geologists/geophysicists, would likely opt for the premium choice of Google Earth Pro ($400/year), which offers high-resolution printing and GIS data import capabilities.

Creative users can utilize Google's open code to create 'mash-ups' mapping that includes creations such as UFO landing sites to the best cheesecake locations in New York City.

(www.motherplanet.com)

This website puts forward varying software packages that are managed for young students to a professional level. The series functions on both Mac OS X and Windows operating systems. Once the program is downloaded the website states that you will no longer require an internet connection to access the data from the database. System upgrades are free.

Spatial vantages include a 'Topographic View', 'Satellite View' and an overlay of the two datasets. Resolution is advertised as being 1km grid datasets. The developers of this site work closely with GIS efficiency in mind. Optimum data correlation and navigation are the key to this software's processing.

YAHOO! DEVELOPER NETWORK

(developer.yahoo.com/maps)

Yahoo Beta offers more customization of map features compared to Google Earth. This new version tenders simple navigation with a more in-depth amount of mouse control functionality.

A unique feature of this site is the simplistic approach available for non-technical members of the public who can now utilize an Excel plug-in to manage webpage integration of data from a spreadsheet.

Yahoo also has just released APIs 'that allow developers that opportunity to create software that integrates with the service'.

Ask.com

(maps.ask.com/maps)

The site will automatically pick what it thinks is the most reasonable choice, and still provides a little list of alternatives. The interface was more pronounced with eye-catching fonts and colour depths. The zoom was easier to control and the overall maneuverability of the site was exceptional. To date there is not API services and the imagery is slightly less detailed when you zoom in too closely to a target.

(www.microsoft.com/virtualearth/default.mspx)

The recently released MapPoint 2006, advertises the inclusion of an 'updated geographic and demographic data, advanced GPS operability, text and voice-prompted vehicle guidance' for Windows XP users (nothing is available for the Mac-lovers).

This site presents excellent data trend visualization and analysis of data by geographical plots of the results. The new version includes quick response to command requests without the long gap time between zooming into image frames.

MAPQUEST

(www.mapquest.com)

This is an interesting site that offers excellent correlation between database information and API programming. However, it was the only website that did not offer satellite imagery.

One slight annoyance was the amount of adverts that interrupted all processing requests.

The interface is easy to work through and there were no issues locating the datasets I requested. The site also retained the information from my past searches which was not available with the other sites. It is a very durable and stable search engine but it does not offer the same well-rounded functionality of the other websites (e.g. birds-eye view and multi-dimensional views).

$135 million to boost resource exploration for GA

What the Prime Minister said

On 14 August the Prime Minister announced "a series of practical steps that will give Australians cheaper fuel options, further develop our energy resources and help to underpin the nation's long-term energy security. This total expenditure on these measures will be $1.576 billion over the next eight years."

As part of this package Geoscience Australia will be allocated an additional $135 million over five years to encourage resource exploration.

The driver for this new funding was the rise in fuel prices at the bowser due to increased global demand and a falling global rate of new discoveries.

In his statement the Prime Minister gave a welcome commitment to his government's role in encouraging exploration.

"While known oil reserves are declining, much of Australia has been explored only at a shallow level and large areas of remote frontier provinces remain under explored. Current exploration activity is largely 'brownfields' exploration rather than the higher risk, 'greenfields' exploration that is aimed at identifying new resource provinces.

Australia has some 40 offshore basins that display signs of oil potential and half of them remain unexplored. Encouraging further exploration could see the discovery and development of resources the size of those in Bass Strait.

In a high-cost, high-risk field, where global investment competition is fierce, governments have an important role to play in providing good geo-science information. Identifying and assessing Australia's resources is the first step in developing them.

To this end, the Government will expand Geoscience Australia's current programme of seismic acquisition, data enhancement and access. At a cost of an additional $76.4 million over the next five years, this expanded programme will focus on new frontier offshore areas to be chosen in consultation with the industry.

The Government will also commit an extra $59 million over five years to identify potential on-shore energy sources such as petroleum and geothermal energy. Using the latest geophysical imaging and mapping techniques, this information will help attract companies to explore in new areas by enhancing the chances of discovery and reducing the risks to investors."

A very realistic and positive statement.

What the Minister said

The Federal Resources Minister, Ian Macfarlane is to be congratulated on obtaining this additional funding. In his media release he stated that:

"$76.4 million of the package will expand Geoscience Australia's "Big New Oil" program through pre-competitive data acquisition. Over the next five years, data will be acquired from offshore areas that span up to two million square kilometres, more than three times the area covered by the last program.

The acquired geological data will be enhanced to meet evolving global exploration industry standards. The improved data will be extensively promoted to the exploration industry decision-makers in Australia and abroad.

Additionally, we will take serious steps to reduce the red-tape burden on the petroleum exploration industry. The current legislation has been re-written, but we can go further to make frontier exploration more attractive."

The package includes $58.9 million to enable Geoscience Australia to pioneer innovative, integrated geoscientific research to better understand the geological potential of onshore Australia for both minerals and petroleum. This will be done through the application of the latest geophysical imaging and mapping technologies."

What are the action plans?

GA is currently developing detailed plans to maximise the benefits of these initiatives.

"The new funding will supplement and enhance our existing work programs, so we are expanding our acquisition of information to assist in identifying potential sources of petroleum and energy related minerals," said Geoscience Australia Chief Executive Officer, Dr Neil Williams.

"At a cost of $75 million over the next five years, we will be expanding the Big New Oil program of pre-competitive seismic data acquisition, enhancement and access. This program has proved successful in attracting new exploration to frontier offshore areas such as the Bremer Sub-basin.," he said.

"There is an urgency to acquire new information and make regional pre-competitive data available for evaluation and acreage uptake because on average it takes six years from discovery to production in an offshore area. This means new teams will work concurrently with the existing program," said Dr Williams.

"The package also includes $59 million to enable Geoscience Australia to pioneer innovative, integrated geoscientific research to better understand the geological potential of onshore Australia for new energy resources, including petroleum, uranium, thorium and geothermal energy," said Dr Williams.

Chief of Geoscience Australia's Petroleum and Marine Division, Dr Clinton Foster, anticipates the collection of up to four times the amount of commercially acquired 2D seismic data to evaluate deep water and shallow water opportunities.

"This will assist us in identifying working petroleum system/s in under-explored and remote areas, using a range of tools including satellite remote sensing and sea-bed coring. Initial studies developed in consultation with industry will target offshore south-western Australia," said Dr Foster.

"Access to information in formats used by industry will see innovation in online and near online delivery of seismic and other data," said Dr Foster.

Chief of Geoscience Australia's Mineral Division, Dr James Johnson, said the new funding would see the organisation's onshore program delivering more than 7,000 km of new seismic data, around 190,000 km of airborne electromagnetic data and about 140,000 km of new magnetic and radiometric data.

“Initially, Geoscience Australia will be working in areas around the Gawler region in South Australia and the Mount Isa/Georgetown region in North Queensland with similar programs being prepared for other States and the Northern Territory.

“Deployment of resources will be based on project merit and materiality rather than on the aerial extent of the jurisdiction. One of the key considerations will be that projects have national or strategic importance in terms of energy potential. Projects will also need to produce outputs aimed at promoting investment in exploration for energy-related resources, especially in greenfields areas; and project outputs will need to be aimed at improving discovery rates for energy-related resources,” said Dr Johnson.

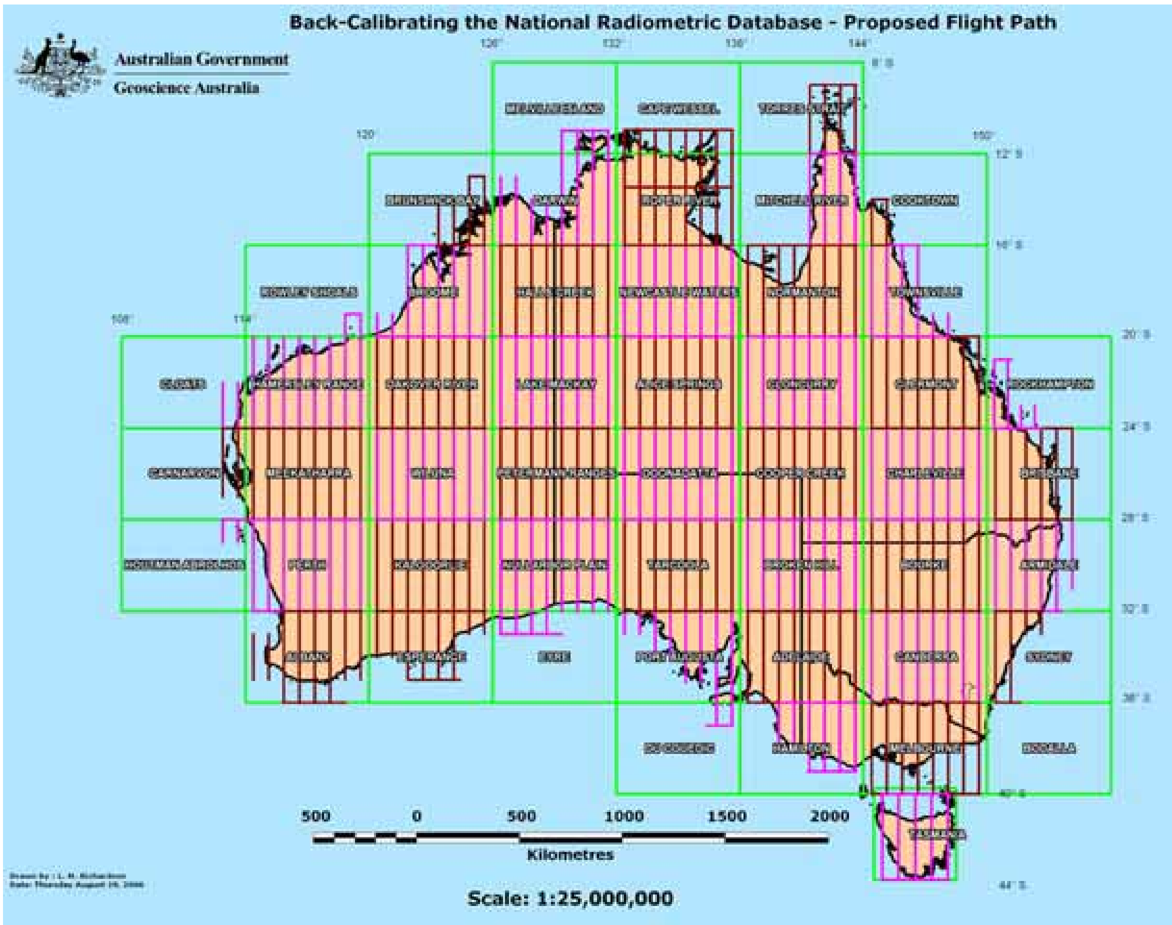
“As a by-product of data acquisition for energy commodities, we expect the same data types will also prove very beneficial to explorers for a broad range of non-energy mineral commodities. These synergies will provide maximum benefit for the government funds invested.

“We have already begun the initial phase of face to face consultation with State Geological Surveys with the aim of agreeing on projects that are consistent with the energy mandate and that supplement the programs currently being undertaken,” said Dr Johnson.

"For example, the major uranium deposits mined to date in Australia occur within geological terranes of a restricted age range in a variety of settings. It is proposed to acquire and integrate diverse datasets across the terranes within this age range in order to highlight new areas of uranium potential. Similar approaches in other aged terranes will reveal which of those have uranium potential and potentially lead industry to new provinces," said Dr Johnson.

One of the major projects will be to establish a **National baseline database of Australian gamma-ray spectrometric data** that is consistent with the global radioelement baseline established by the International Atomic Energy Agency. This will be achieved by: (a) ensuring consistency in the calibration and processing of new gamma-ray spectrometric data through the use of standard processing procedures and calibration facilities that are tied to the global datum, and; (b) adjusting surveys to the global datum through back-calibration and automatic grid merging. A consistent national database will greatly increase the usefulness of these data.

The diagram below indicates the proposed flight-plan to achieve the continent-wide calibration. More information on the program will be published when it becomes available.



Flight plan (in brown and purple) to establish an Australian radioelement baseline database. The named areas correspond to the 1:1 million map sheet areas. Magnetic measurements will also be obtained at the same time so that both magnetic and radiometric anomalies can be ‘accurately stitched together’ over the entire continent. Flight lines are spaced at 75 km and the ground clearance will be 80 m.

Preliminary AVO results from the Caswell Sub-basin NW Australia

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Geoscience Australia has reprocessed parts of 2 lines crossing into the 2006 Acreage Release area W06-7 to determine if modern Amplitude Versus Offset (AVO) compliant processing can identify potential hydrocarbon anomalies. The preliminary results from this reprocessing are presented here. An identified preliminary AVO anomaly occurs on public domain seismic reflection data that was collected on the 2D Plumhead Seismic Survey over the Caswell Sub-basin in 1998. The data analysed are over one of the exploration areas that was released by the Australian Government in May 2006. Bidding for the block closes on 9 November 2006. These preliminary results were released in poster form at the Earth 2006 Conference in Melbourne to allow time for interested companies to carry out their own studies. The AVO anomaly is a high amplitude event at far offsets. The location of the anomaly is shown in Figure 1.

The Plumhead Survey is one of a number of commercially collected long-cable seismic surveys that are publicly available under the normal release provisions for exploration data under the Petroleum (Submerged Lands) Act. The preliminary AVO analyses were carried out to investigate if processing of publicly available long-cable data sets could yield AVO anomalies that may relate to the presence of hydrocarbons. Similar analyses have previously been applied to data collected by Geoscience Australia in the Bremer Basin off south western Australia (Kroh and Williamson, 2005), as part of the Australian Government's Big New Oil program, and over the Exmouth Plateau in area W06-11 (Kroh and Williamson, 2006) that was also released in May 2006.

The Caswell Sub-basin is a Palaeozioc to Cenozoic depocentre of the Browse Basin located on the north western Australian margin (Struckmeyer et al., 1998). Supergiant gas fields have been discovered in the Sub-basin in the Early to Middle Jurassic Plover Formation sediments. Scott Reef was discovered in 1971, Brecknock in 1979 and Brecknock South in 2000 (Figure 1). With increased demand for LNG for export, these fields are now being considered for development. Consequently, the Caswell Sub-basin is receiving considerable attention.

Results of this study by Geoscience Australia are publicly available. Seismic data from the Plumhead Survey are available from Geoscience Australia for the cost of transfer. Common Depth Point (CDP) Pre-Stack Time Migrated (PreSTM) gathers plus near, middle and far trace angle stacks derived from this AVO processing are also available.

Geology

The Caswell Sub-basin of the Browse Basin occurs on the rifted northwest margin of Australia.

The Caswell Sub-basin, where the anomaly occurs, is the northernmost major depocentre of the Browse Basin (Figure 2), containing up to 15 km of Palaeozoic to Cenozoic sediments (Struckmeyer et al., 1998). The outer margin of the Caswell Sub-basin is marked by

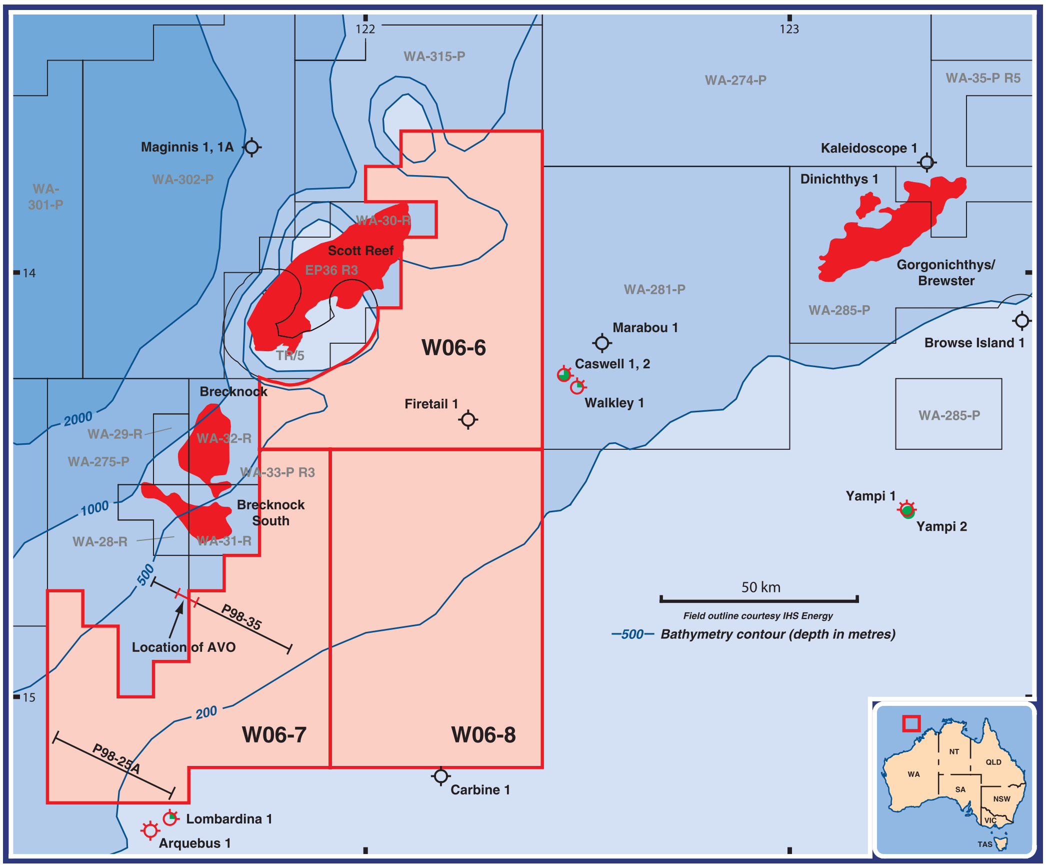


Fig. 1. Block W06-7 in the 2006 Acreage Release showing the location of seismic line P98-035 in the Caswell Sub-basin. Highlighted on P98-035 is the location of the Amplitude Versus Offset (AVO) anomaly seen during the preliminary investigation of the Pre-Stack Time Migrated angle stacks and NMO corrected gathers.

an arcuate Triassic structurally high anticlinal trend containing the Scott Reef and Brecknock gas fields.

The AVO anomaly occurs at far offsets as a strong event conformable with strata. The seismic expressions of the AVO anomaly suggest a structural closure. A seismic line tie suggests the geological setting of strata relating to the AVO bright spot (Figures 3, 4, 5 and 6) correlates closely to the "Jearly" horizon as defined in Struckmeyer et al. (1998) (A. Barrett, pers. comm.). This is within the Early to Middle Jurassic Plover Formation (Figure 2) that forms the reservoir at Brecknock and Brecknock South 20 km to the north (Figure 1).

AVO Processing

The processing sequence used was designed to eliminate multiple contamination, while preserving amplitudes for subsequent AVO and petrophysical analyses.

Data were processed at a 4 ms sample interval, with multiple attenuation achieved using Surface Related Multiple Elimination and High Resolution Radon Demultiple prior to Pre-Stack Time Migration (PreSTM). A High Resolution Residual Radon Demultiple was performed after PreSTM using 4th Order NMO with Eta corrections derived from the final 0.5 km spaced velocity analyses.

A Curved Ray Kirchhoff Pre Stack Time Migration algorithm was used to ensure the optimal AVO response from the near, middle and far angle stacks, with 0-15, 15-30 and 30-45 degree angle mutes being applied. A statistical zero phase filter and Db Scalar has been applied prior to angle stack, and a filter applied post stack prior to outputting SEG-Y data. Line P98-35 is currently available through the Geoscience Australia Data Repository by emailing ausgeodata@ga.gov.au and includes near, middle and far angle stacks, final stack with scaling, CMP gathers with 4th Order NMO + Eta correction, CMP gathers, Velocities + Eta correction, zero phase filter and navigation data.

Results

Basic analysis of the stacks and gather datasets has been undertaken for Line P98-35 (Plumhead Survey). Initial results show a high amplitude AVO anomaly, which is at least

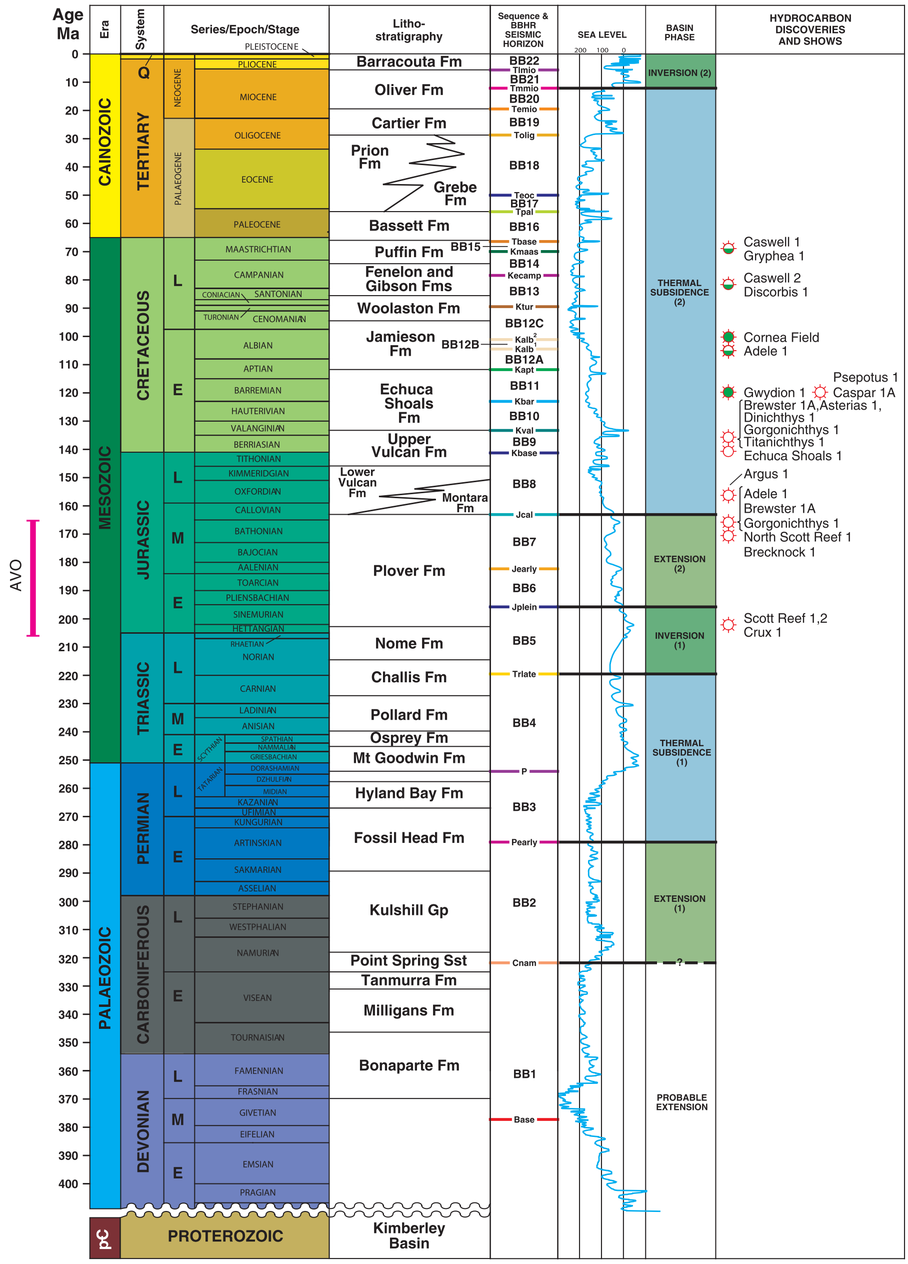


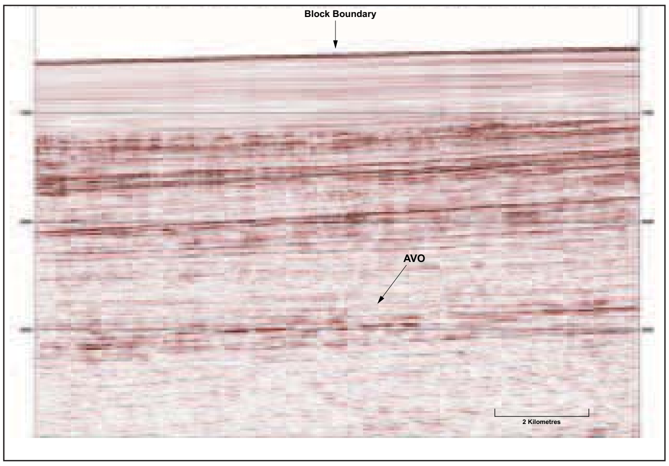
Fig. 2. Tectonostratigraphic summary and hydrocarbon discoveries for the Browse Basin (after Blevin et al., 1998; Struckmeyer et al., 1998).

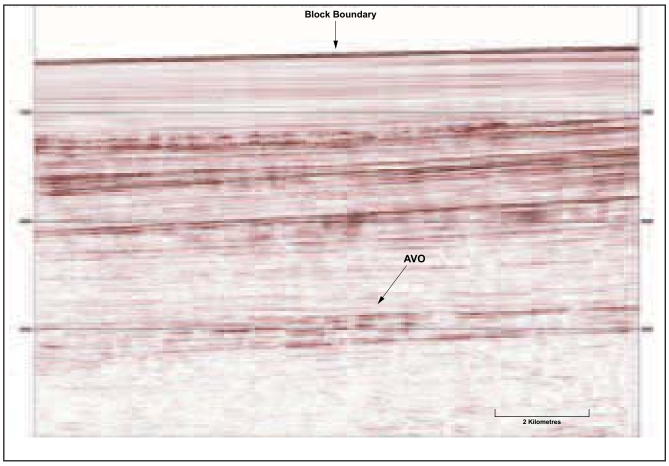
4 km long on this seismic line and warrants further investigation.

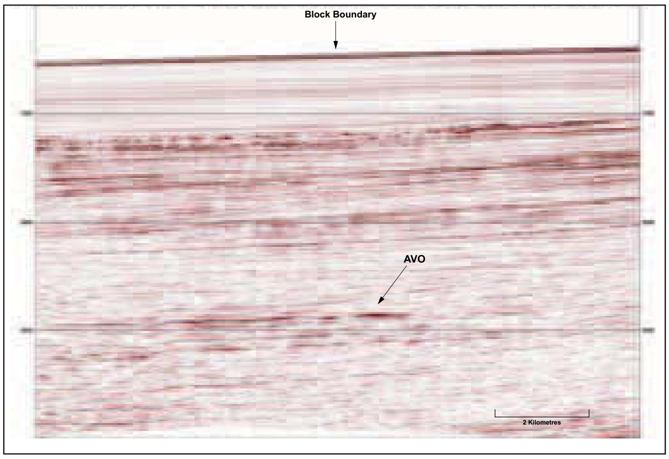
The AVO anomaly appears to have a 'soft response' on the far offsets. It appears to change phase with offset and has a strong amplitude increase with offset. A statistically derived zero phase filter has been applied to the data, and will be supplied with the data package to allow its removal if a more accurate well derived zero phase filter is required. No Q compensation has been applied to the data as it was felt that this should be done by those further analysing the data.

Because of the importance of making preliminary results available on current release acreage, time did not permit the area containing the feature to be mapped. It has also not been possible to map the anomaly to investigate whether down dip terminations are consistent with their mapped extent. This would be expected for a fluid contact such as a gas/water contact.

Regional discoveries and data at Scott Reef 1, Brecknock 1 and Brecknock South 1 support the possibility of the AVO feature being associated with a gas accumulation. Well







Figs. 3, 4 & 5 show the near, middle and far angle PreSTM stacks. The location on the seismic section corresponding to the boundary between areas W06-7 and WA-275-P is shown in Figure 5.

data on the strata that could be associated with the AVO anomaly are available from those discoveries. Such information may assist modelling geological features with associated fluids to provide insights into the cause of the anomaly.

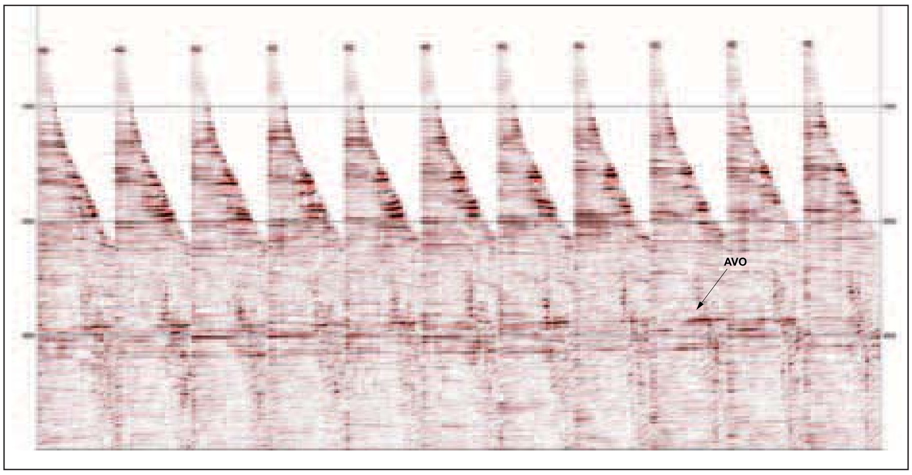


Fig. 6. NMO + Eta corrected Common Mid-Point gathers around the AVO anomaly.

Conclusion

This preliminary presentation of an AVO anomaly crossing into the Caswell Sub-basin release area W06-7 suggests that the AVO technique may have value there in evaluating the exploration potential of the area. Further processing, more detailed AVO evaluation, structural and stratigraphic evaluations, and AVO modelling are required to establish greater confidence in the validity of the AVO anomaly as indicating potential exploration targets.

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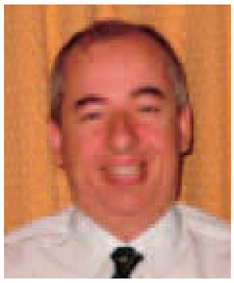
Fibre Optic Seismic Technology[1]





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Summary

Fibre optic seismic sensor systems have been under development for many years at PGS, who have produced several generations of prototype seismic equipment to demonstrate the technology. Ongoing projects include applications to 4C seafloor systems, streamers and near-field airgun recording.

An optical 4C seafloor cable was successfully demonstrated during field operations in the North Sea during late 2003. These data have proven that the prototype optical system meets the performance required for deepwater seismic operation. The PGS optical seismic technology is an excellent fit for conventional 4C seismic operations, and would also be the preferred solution for permanently installed reservoir monitoring systems. The dense wavelength division multiplexing (DWDM) technology used by PGS offers significant flexibility in terms of large dynamic range, the use of a very small number of optical fibres to record from several thousand channels, no in-sea electronics, light weight, reduced cost per channel, improved safety, and great reliability and durability.

Permanent Monitoring

Four dimensional (4D) monitoring by time-lapse seismic used to optimize the management of producing reservoirs will reduce well costs and improve recovery. With the availability of timely information, accurate reservoir models can be constructed, and successful wells can be planned. In the best case, quantitative inversion of elastic seismic properties and production data can be used to measure and differentiate between changes in pressure and saturation. History matching and reservoir prediction will thus be improved. Such ambitions are only achievable with a combination of very good seismic data and a reservoir state that elastically deforms in response to small amounts of production.

A strong interest has developed recently in permanently installed reservoir monitoring systems, led by BP's Valhall Field in the North Sea. An array of four component (4C) receivers is typically trenched at 1 to 2 m depth in the seafloor, thus providing unmatched repeatability in terms of receiver position and coupling (see Figure 1). Such a system will ideally operate without physical intervention over a period as long as twenty years, unaffected by corrosion, electrical leakage, or sensor degeneration. Optical seismic technology presents the perfect match to such requirements! As described below, an optical system is entirely passive at the "wet end", using Michelson micro-interferometers to convert strain from the seismic wavefield into a phase change of the carrier light signal. There are no electronics at the wet end.

Introduction to Optical Systems

Traditional seismic acquisition hardware relies upon sensors that produce an output voltage that is digitized, multiplexed and transmitted up a cable to the recording system. The electronics required to perform this operation are both expensive and unreliable. The passive nature of the optical telemetry system described here eliminates the need for costly in-sea electronics, and the problems associated with them, yielding a system that is more reliable, less expensive, and safer to deploy and operate. Optical sensor-based systems are beginning to replace the traditional technology in the oil field, especially in low channel count high stress environments. The telemetry architecture utilized by PGS provides a system that is expandable beyond the capabilities of current seismic systems.

Optical sensors used in acquiring seismic data are typically constructed from optical interferometers. Many establishments have demonstrated the performance of optical sensors, with the US Naval Research Laboratory leading the technology in the late 70s and early 80s (Giallorenzi, 1987; Dandridge et al., 1991). Since then, the widespread availability of fibre optic components and subsystems has helped the optical sensor system evolve into a reality (e.g., Bostick, 2000).

Optical Seismic Technology

Dense wavelength division multiplexing (DWDM) is utilized in the PGS telemetry scheme to optically power the seismic sensors. This scheme uses an optoelectronic cabinet comprised of several cardfiles (see Figure 2). Each cardfile contains eight laser diodes, each of

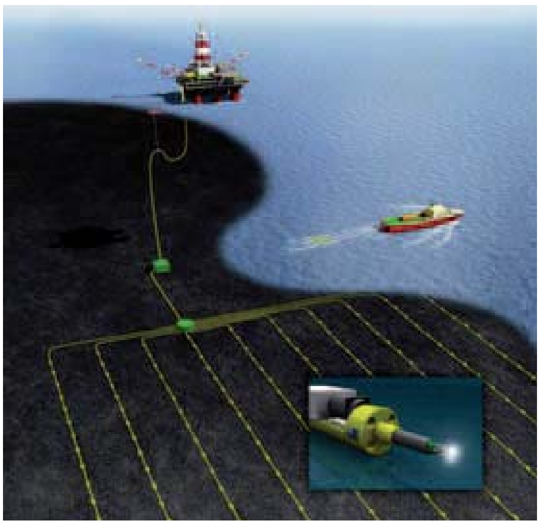

Fig. 1. Schematic illustration of a permanently-installed seafloor monitoring installation. The hardware is typically trenched into the seafloor, and must be capable of operating in large water depths for potentially as long as twenty years. The PGS solution uses all-optical sensor stations.

[1] This article is based on the paper (Optical sensor and accelerometer revolution fro seismic monitoring and acquisition) presented by Andrew Long in the New Geophysical Methods Symposium at the Australian Earth Sciences Convention 2006, held in Melbourne in July this year.

Fig. 2. Optoelectronic system cardfile and rack.

which produces a discrete carrier frequency of modulated light separated by about 1 THz. Each cardfile in turn outputs unique wavelengths separated by 100 GHz around the reference frequencies produced by the other cardfiles in the cabinet. The net benefit is that a very small number of carrier fibres (typically eight) can be used to take a unique light signal to as many as 2000 channels (both hydrophone and 3-axis accelerometer), and 2000 unique modified light signals will be returned to the optoelectronic cabinet by a small number of fibres (typically twelve) also. At each sensor the seismic wavefield applies a strain to the interferometer, thus causing a phase shift in the light signal. The degree of phase shift in units of radians is linearly proportional to the amount of strain. Each modified light signal is demultiplexed and demodulated in the optoelectronic cabinet, converted to a 32 bit digital word, and written to tape via a conventional recording system. The entire system is thus entirely passive at the wet end, with no in-sea electronics. Extensive field experience over several years demonstrates that the optical seismic data are identical to conventional seismic data, and can in fact be recorded with better dynamic range and sensitivity given an appropriate system architecture.

We have developed optical sensors for acoustic pressure and shear wave measurements (see Figure 3), including an optical hydrophone that has been qualified to operate in 3000 m depths without degradation in performance. The unit was tested to have a scale factor of -140 dB re rad/μPa ±1dB over all operational pressures and temperatures. This translates into a noise floor below 1 μB. A 3-axis optical accelerometer has become the preferred sensor at PGS for shear wave measurements. The 3-axis design measures 30 mm x 50 mm x 75

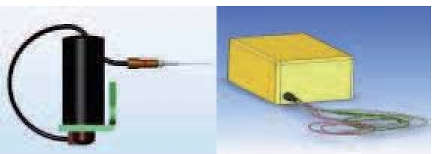

Fig. 3. Optical hydrophone and accelerometer.

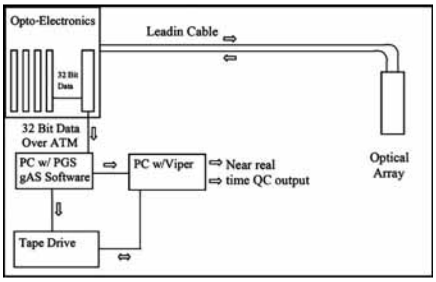

Fig. 4. Optoelectronic recording system.

mm. The accelerometer also has very good uniformity and performance. When mounted inside a pressure vessel it is also capable of operating in 3000 m of water.

The optoelectronic system generates the optical power for the array, and processes the returned optical signals to extract the seismic information. Light returning from the array is routed to a select group of demodulation boards to process the optical data, and outputs a 32-bit digital word equal to the seismic data. The data are then sent to a network interface card, where it is put into data packets, and sent to the recording system over an ATM network. Figure 4 shows the basic optical recording system architecture.

The prototype optoelectronic cabinet with 960 channel capability was assembled in cardfiles, where each cardfile contains four laser boards (2 lasers each), 6 demodulators, one clock reference generator and a network interface card. This is one wavelength's worth of processing, or 96 optical channels. Each additional cardfile adds another 96 channels of capability (on a new wavelength). The prototype optoelectronic system included ten

Fig. 5. Sensor pad assembly, side view of geophone housing on sensor pad base, end- on photo with protective housing shows hydrophone mounted in pad.

Fig. 6. Optical seabed array being prepared in warehouse, on deployment reel and during deployed.

cardfiles. Only four cardfiles were used in the reduced channel rack used for the field test described below.

Seafloor Array Cable

An array was designed to be used by a 4C exploration crew, being continuously deployed and retrieved in deepwater applications. A steel armoured optical cable with the optical fibres inside gel-filled stainless steel tubes was used in the construction. A 4C sensor pad was attached to the optical cable every 25 m. The optical fibres in the cable were extracted and fusion spliced to the sensors in the pad. A protective cover and bending strain relief was attached to the entire assembly. 2400 m of array cable plus 4 km of lead-in cable were thus assembled for a field test. Mechanical stress tests proved that the cable assemble can be deployed and retrieved thousands of times without damage to the optical fibre over loads that exceed deepwater deployments of 3000 m. Figure 5 shows the prototype sensor pad assembly.

Field Testing

The field test of the prototype seafloor array was performed onboard the Bergen Surveyor during late 2003. The optical array was deployed parallel to a PGS FOURcE seabed cable in 300 m of water, 32 km NW of Marstein, in the Norwegian Trench.

The array separation was 50 m, and the locations of the arrays were monitored using external acoustic transponders. Figures 7 and 8 show the optical array during the

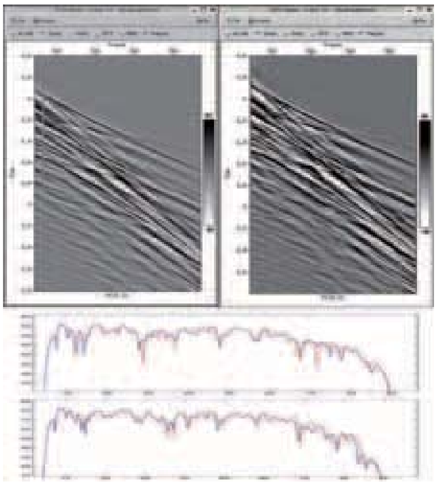

Fig. 7. Real field comparison of electrical vs. optical hydrophones. Shot gather for 96 electrical channels (top left), shot gather for 96 optical channels (top right), superimposed amplitude spectra for two of the channels from the FOURcE electrical cable (middle), and superimposed amplitude spectra for two of the optical channels (lower).

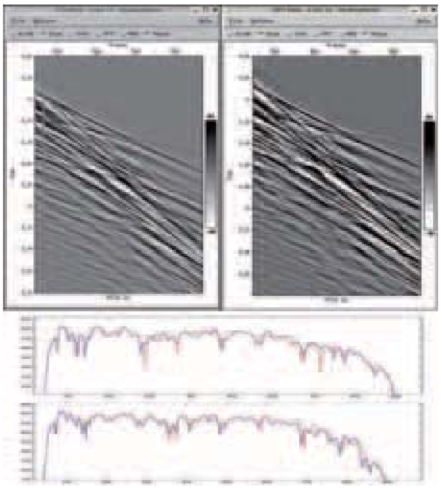

Fig. 8. Real field comparison of electrical vertical geophones vs optical vertical geophones. Shot gathers and the average signal output. Red is FOURcE and green is optical. The prototype optical geophones have since been superseded by optical accelerometers.

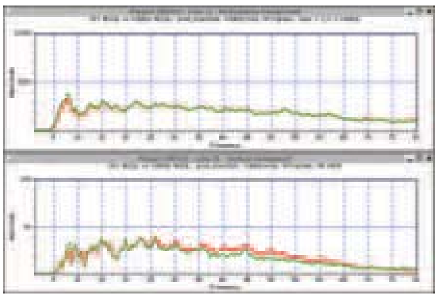

Fig. 9. Real field comparison of electrical (red) vs. optical (green) noise data. The upper comparison is for hydrophones, and the lower comparison is for geophones.

checkout and deployment stages. The data were acquired while the gun boat travelled along the arrays firing every 25 m, and again while traversing perpendicularly across the centre of the arrays. The data show excellent correlation with that of the electrical system. Figure 7 is a comparison of the hydrophones in the arrays. The data presented show the corresponding 96 hydrophone channels for the electrical and optical arrays for equivalent shot-gathers, and the averaged signals from a hydrophone channel. The red trace is the electrical channel and the green trace is the optical channel. The low frequency spike seen in the optical channel is not present in the electrical data because of the roll off filter used in the electrical acquisition system. Finally, the noise response from the two systems is shown at the bottom of Figure 7. Figure 8 provides the same data for the vertical geophones. Figure 9 is a noise comparison of the hydrophones and geophone groups summed over an 8-second shot record.

Note that PGS has now developed much smaller sensor stations for commercial application (Figure 10). The stations are designed to be trenched into the seafloor, but can be modified with a heavy baseplate for good seafloor coupling if conventional seafloor surveys are required.

Conclusions

Fibre optic seismic sensor systems have been under development for many years at PGS, which has produced several generations of prototype seismic equipment to demonstrate the technology. The dense wavelength division multiplexing (DWDM) technology used by PGS offers significant flexibility in terms of expandability to lengths greater than 12 km with channel counts in excess of 2000 per

Fig. 10. Comparison of the prototype sensor station (Figure 5) and the new compact station.

cable, large dynamic range, the use of a very small number of optical fibres to record from several thousand channels, no in-sea electronics, light weight, reduced cost per channel, improved safety, and great reliability and durability.

We have successfully demonstrated prototype optical seismic hardware using both laboratory and field tests. The optical system has been tested alongside conventional cable technology with comparable results. Data collected from the field tests have proven the prototype optical system meets or exceeds the performance required of the deepwater seabed systems. Fibre optic technology is an excellent fit for seismic operations and a preferred solution for permanently installed reservoir monitoring systems.

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Optimised Gravity Survey Design[1]

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[1] This contribution is based on Michael's presentation at the AESC 2006 meeting in Melbourne, which shared the Western Geco best Paper Award with Roger Clifton's talk to be published in the December edition of *Preview*.

Summary

An automated technique for optimised placement of gravity stations is presented that takes into account both the spatial distribution of pre-existing data and also variations in the form of the gravity surface. The new method involves calculation of a weighted normalised grid incorporating a point-distance function, a point-density function and information on horizontal gravity gradients determined from pre-existing data. The maximum in the normalised grid is taken as the optimum position for a new gravity station. The positions for multiple new stations can then be generated from successive maxima following iterative recalculation of the point-distance and point-density functions. Gravity grids generated from optimised data distributions require significantly less new data points to achieve the same relative accuracy when compared to regular, systematic infill patterns. Although other factors, such as difficult access, may in some cases limit the application of this technique, there are many circumstances where significant reductions in survey costs can be achieved by application of this new method.

Introduction

When a gravity survey is conducted in an area with little or no pre-existing data at a suitable station density then the main aim of the survey is to detect anomalous features, and the most appropriate sampling schemes involve regular grids of gravity stations. In this case, the minimum wavelength of features that can be detected is dictated by the sample spacing in accordance with the sampling theorem.

However, gravity surveys are often carried out in areas with significant existing data coverage. In these cases, the major features of the gravity image have already been detected and the emphasis is on delineation of particular features to highlight higher frequency components. This can be achieved by systematic regular infill of the existing gravity coverage but this approach is not necessarily the most efficient as it does not take into account the characteristics of the gravity field based on pre-existing data.

Infill gravity surveys are usually subject to financial and time constraints and the main aim when planning a survey is to maximize the information that can be derived, subject to these constraints. Experienced practitioners often make subjective judgements that dictate where new data acquisition should be focused, based on the existing distribution of data and on the basis of observed gravity gradients.

The effectiveness of a gravity survey can be gauged by the degree to which it is possible to reconstruct the "true" gravity field from a distribution of samples by interpolation. This can be quantified for synthetic examples but is more difficult to assess in real situations where the form of the "true" field is not known.

A technique that provides a more objective basis for optimised infill gravity surveys is presented here. The new method takes into account both the spatial distribution of pre-existing data and also the form of the gravity surface. Tests on both synthetic datasets and existing gravity survey data indicate that the optimised infill approach can achieve comparable results with significantly fewer new stations than regular data acquisition schemes.

Method and results

The new technique for optimised placement of infill gravity stations is illustrated in Figure 1 and involves simultaneous consideration of three criteria; station spacing, station density and gravity gradients, and then generating an overall ranking by a weighted combination of these criteria.

The starting point for the optimisation algorithm is the pre-existing gravity data. The station locations are used directly to generate two grids. The distance function grid

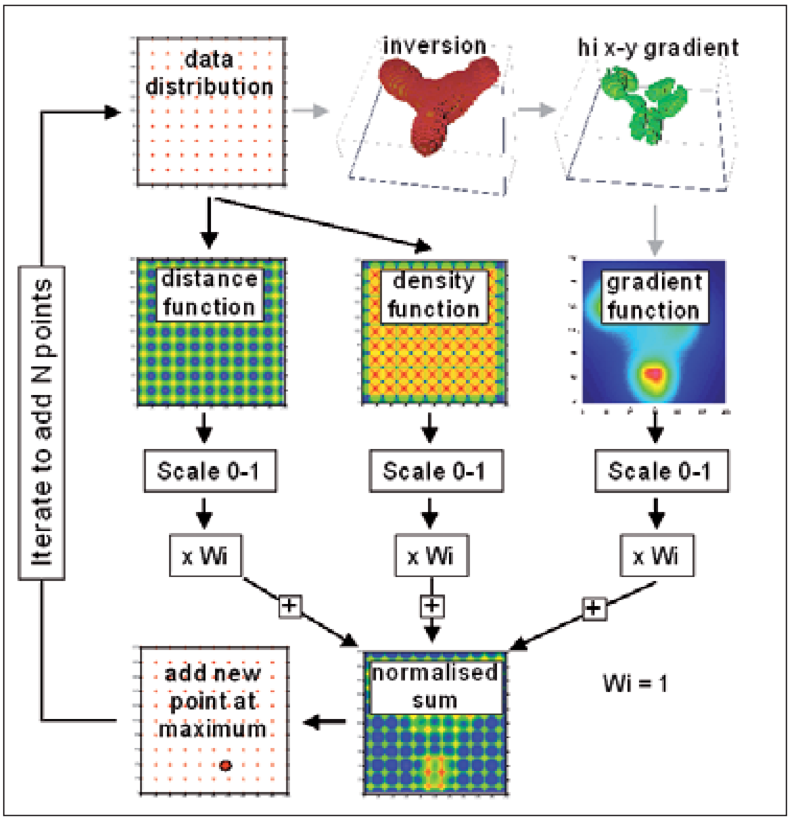

Fig. 1. Schematic diagram of the gravity station location optimisation algorithm. Black arrows show processes that are completed during each iteration. Grey arrows show processes that are completed only once.

encodes the distance to the nearest gravity station. High distance zones mark areas where new gravity acquisition is prioritised. The density function maps the local density of gravity stations and areas of low station density assigned priority.

In addition to the purely spatial criteria defined by the distance and density functions, the form of the gravity surface also needs to be considered. Gravity data acquisition should be targeted towards regions of high gradient since these zones mark lateral subsurface density contrasts. Gradient information could be incorporated directly from calculated horizontal and/or vertical gradients, and this approach has been successfully applied. However, tests on synthetic datasets suggest that a slightly more complex process involving initial unconstrained 3D inversion of the observed gravity data (using UBC-GIF code, Li and Oldenburg (1998)) produces a superior and more robust result. In this case the combined horizontal gradient of the inverted density model is first calculated and the regions of highest gradient (e.g. >90th percentile) are isolated. The gradient function in this case is then generated by forward modelling these high density-gradient zones. The gradient function created in this way reflects the region at the surface where new data will provide additional information on the most variable regions of the subsurface density distribution.

When distance, density and gradient grids have been generated, they are then combined to produce a single grid that reflects the contribution of all criteria. This is achieved by first normalising each of the input functions into the range 0-1. The relative importance of each of the input criteria to the final ranking is taken into account by weighting the normalised functions before adding them to form the final normalised sum.

The position of the maximum value in the normalised sum grid marks the highest priority location for a new gravity station. A new station is then assigned to this point and incorporated into the overall data distribution. This process can then be iterated to successively recalculate the distance and density functions and to find the desired number of new optimally positioned gravity stations. The gradient function cannot be recalculated for successive iterations because the new gravity values are not yet known.

There are a number of user-defined parameters in the optimisation algorithm that influence the final distribution of proposed gravity stations. The gradient function generated from the unconstrained inversion is affected by the choice of the threshold value applied to the horizontal gradient volume. Application of a high threshold on the density gradient will have the effect of concentrating new stations in zones that will help to resolve the most significant lateral density contrasts. Lower thresholds will tend to produce more dispersed distributions of new stations. The final normalised sum grid is produced from a weighted combination of the distance, density and gradient functions. The choice of weights determines the characteristics of this grid. High weights assigned to the distance and density functions will result in an even spread of new stations that infill the pre-existing data. If the gradient function is given a high weighting then new stations will tend to be clustered in zones of high gradients in the gravity field. Experimentation with the algorithm on synthetic data sets suggests that weightings of 0.25, 0.25 and 0.5 for the distance, density and gradient functions respectively produce data distributions that represent a reasonable compromise between widely spread and clustered data sets.

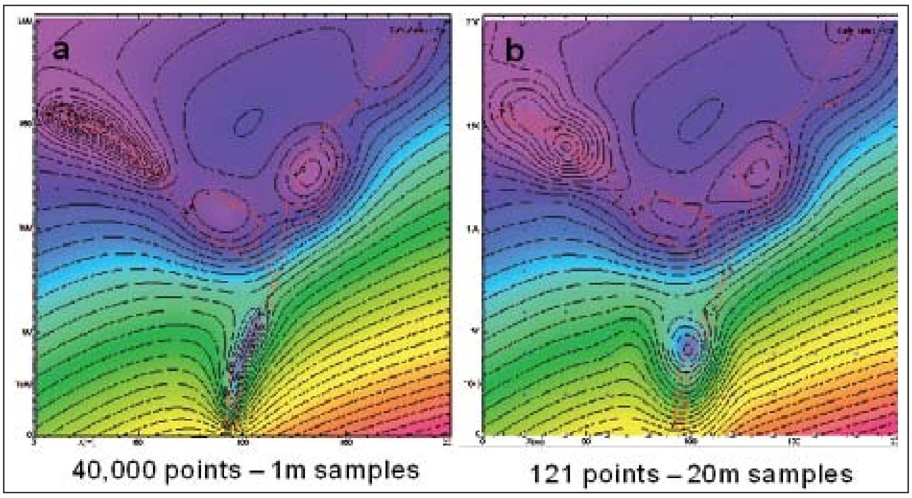

Fig. 2. Data derived from the synthetic cave network model. Red outlines show the surface projection of the model. (a) Dataset derived by forward modelling on a 1 m grid. (b) Dataset derived by gridding regular 20 m spaced samples derived from the forward model.

To test the effectiveness of the new algorithm a synthetic gravity dataset for an engineering cavity detection problem was created by forward modelling. The model for this dataset comprised a simulated cave network with chambers of various sizes and depths extending in NNE and NW directions across the study area. The surface projections of the cave network are shown as the red lines in Figure 2. A large dense body to the southeast of the survey area was also included in the model to create a regional gradient.

The response of the model was directly calculated on a one metre grid across the study area and this data set was used as the "true" response of the subsurface features (Figure 2a). The "true" response was then compared to grids derived from sub-samples of this complete dataset. An initial phase of data acquisition comprising 121 gravity stations acquired on a regular 20 m pattern across the study area was then simulated (Figure 2b). The grid derived from this initial regular phase of data acquisition successfully detects the presence of all of the major subsurface features but does not adequately define the form of the near-surface, high frequency features in the central south and northwest of the study area.

Second phase data acquisition was then simulated with grids for optimised station distributions compared to the grid derived from a regular infill pattern. The average absolute error relative to the "true" response (here referred to as the error) was calculated for each grid as a measure of quality and is presented in Figure 3. Regular infill of the pre-existing 20 m spaced samples (Figure 3a) resulted in a reduction in the error from 0.0132 mGal to 0.0113 mGal.

Three optimised station distributions are shown in Figure 3. Two of these datasets (b and c) were generated using a gradient function derived directly from the grid of the pre-existing data. The differences in the distribution of stations between b and c are due to differences in the weights applied to the distance, density and gradient functions in the optimisation algorithm. For distribution b a high weight (0.75) has been used for the gradient function and the resultant station distribution is tightly clustered in the high gradient regions. For distribution c the gradient function was assigned a weight of 0.5 and the gravity stations are more widely distributed. Distribution d was generated using a gradient function derived from an unconstrained 3D inversion with a weight of 0.5. The graph in Figure 3 shows the change in error as a function of the number of points added for each of the infill distributions. The improvement in error achieved by adding 100 additional points using a regular infill pattern (Figure 3a) could be achieved by the addition of significantly less new optimised stations. For distribution c the same average absolute error is achieved by the addition of 68 new stations and for distribution d only 63 new stations need to be recorded. For distribution b the error for addition of 100 stations is equivalent to the error for a regular infill pattern.

The measure of error used in all of these cases (the average absolute error) is calculated on a global basis for the entire grid and to some extent this underestimates the improvements to the final grid produced by the optimised datasets. The optimised distributions produce significant improvements to the grid in high gradient zones when compared to regular sampling patterns but in the error measurement these improvements are offset by the cumulative effect of a larger number of small discrepancies in the low gradient regions.

For this synthetic example the inversion optimised distribution (Figure 3d) provides the greatest degree of improvement in global error while also resulting in significant local enhancement. Tests on other synthetic and real datasets also support this observation. For this reason calculation of the gradient function by the unconstrained inversion approach is the preferred method.

Conclusions

The new technique for optimisation of the position of infill gravity stations has the potential to provide improved resolution and/or significantly reduced data acquisition costs when compared with conventional regular infill patterns. The algorithm provides an automated objective process that attempts to duplicate the survey planning approach that would be adopted by an experienced practitioner. It does so by balancing the need to place new stations in high gradient zones defined from pre-existing data where they will provide additional information on sub-surface density contrasts against the necessity to infill gaps in the data coverage.

In cases where transport or other logistic constraints impose restrictions on access, additional factors could be incorporated in the model but these would require subjective assessment of the cost/benefit of data acquisition in difficult locations. However, for local surveys or semi-regional-regional helicopter surveys these restrictions generally do not apply and with real-time DGPS navigation, acquisition of data in an irregular pattern does not represent a significant logistic constraint.

Acknowledgments

This work was completed while on study leave in 2005 at the Geophysical Inversion Facility at the University of British Columbia (UBC-GIF). I would like to thank UBC-GIF staff for initiating my interest in this topic and for many useful discussions

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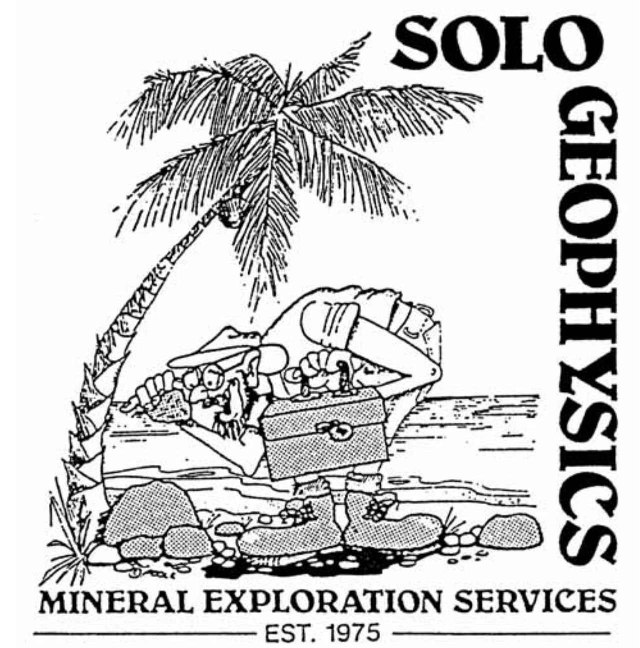


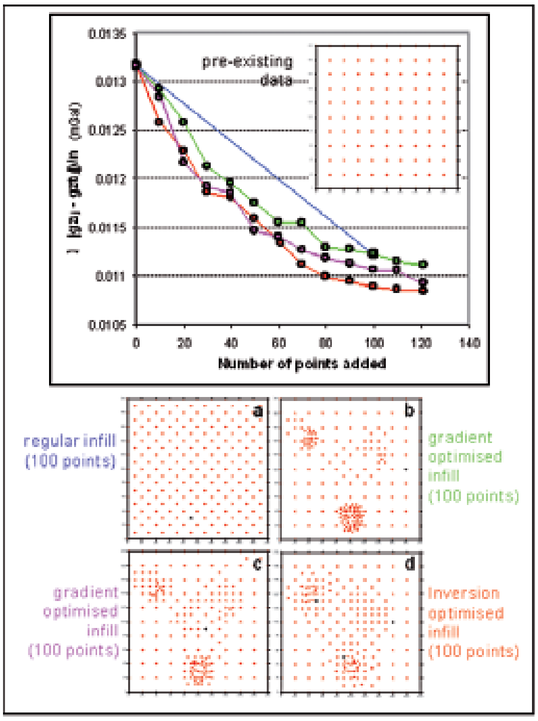
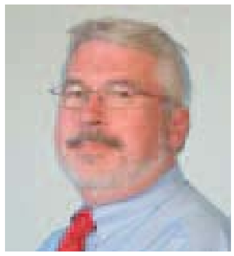


Fig. 3. Comparison of different infill schemes for the synthetic example. The upper panel shows the variation in average absolute error as a function of the number of new points added for each distribution. The lower panels illustrate the station distributions for: (a) regular infill, (b) optimisation using the measured gradient and a weight of 0.75, (c) optimisation using the measured gradient and a weight of 0.50, and (d) optimisation using a gradient function derived from an unconstrained 3D inversion using a weight of 0.5.

An electrical marine vibrator with a flextensional shell[1]

Summary

A completely new electro-mechanical marine vibroseis concept is introduced that uses a flextensional shell with a uniquely developed form. Two controllable output resonances achieve a very high efficiency and repeatability, with a typical frequency bandwidth of 6-100 Hz. The marine vibrator can be used as a standard towed acoustic source in shallow water or as a stationary source in transition zone environments. Of particular significance, the vibrator requires only an electrical power supply, cannot leak hydraulic fluids, is easily transported, and is suitable for applications requiring very low environmental impact.



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Introduction

For several decades, airgun sources have dominated the marine seismic acquisition market. Surprisingly few new source concepts have been presented to the industry during this period. During the eighties, however, developments related to marine vibrator sources took place. These sources were tested mainly for deep target marine seismic applications. These applications have since been limited, due to factors such as high cost, handling and operational difficulties, etc.

During late nineties, PGS started the development of a completely new electro-mechanical marine vibroseis concept. The objective of the project was to develop a 100 % repeatable low-cost vibrator source, with a high energy output in the frequency band of 6-100 Hz, and with a size and weight that would be easy to operate in the field. Target applications of the source are shallow water acquisition, seismic monitoring, and environmentally sensitive areas. The project can also be regarded as a first step towards a new deep target seismic source.

Prototype Development

The development of a marine vibrator for low frequency output requires a special design approach. The source uses a so-called flextensional shell with a uniquely developed form.

Important parameters in the design of flextensional transducers are primarily related to the shell itself, and the type of driver. Various properties of the transducer were simulated before the final design with tools especially developed for this purpose. These computerized models made it possible to make accurate predictions of the capability of the source, thus facilitating optimal design at an early stage of the project.

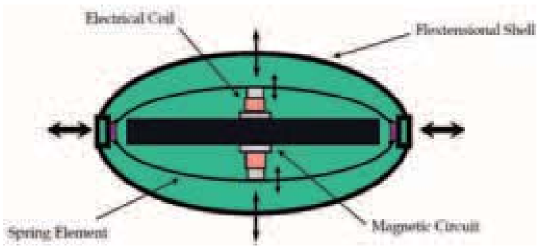

Fig. 1. Principle of the magnetic drive in the flextensional shell of the PGS marine vibrator.

All low frequency sources will face the problem of poor efficiency if a good impedance match cannot be achieved. Radiation from a piston with a radius of 0.3 m and a source level of 195 dB (relative to 1 μ Pa) would yield 0.074% efficiency at 10 Hz. The same piston would have an efficiency of 99.9% at 10 kHz. Two issues were considered in order to overcome these problems. First, the source needs to have a resonance in the frequency band of interest. Two marine vibrators were used in order to be able to provide high efficiency in the whole frequency band from 6 to 100 Hz. One vibrator is operating from 6-20 Hz and the second is operating from 20-100 Hz.

The design is based on a unique concept. Apart from having a flextensional shell, the driver is based on electrical coils operating in a magnetic field and spring elements which transfer the force from the electrical driver to the flextensional shell (see Figure 1). It has been possible by careful design to generate two resonances. The lowest resonance is from the shell interacting with the equivalent fluid mass, and the second resonance is from the spring elements. The provision of two resonances separated in the frequency band of interest makes it possible to achieve a very high efficiency. This unique concept makes it possible to generate high power, with two sources from 6-100 Hz. The anticipated frequency responses from the two marine vibrators are shown in Figure 2.

Electrical marine vibrators

As discussed, the use of two acoustic sources makes it possible to yield an overall efficiency of approximately 25%, which is extremely high. The high frequency source (20-100 Hz) is called “Triton” and the low frequency source (6-20 Hz) is called “Subtone” (see Figure 3). The combination of two sources can easily be achieved by, for example, having one sweep starting at 20 Hz and one sweep starting at 6 Hz. The signals are then correlated separately before being summed.

[1] Based on the talk presented by Andrew Long on behalf of Rune Tenghamn at the Melbourne Australian Earth Sciences Convention 2006. This paper won the Laric Hawkins Award, for the most innovative use of geophysical technique, at the Convention.

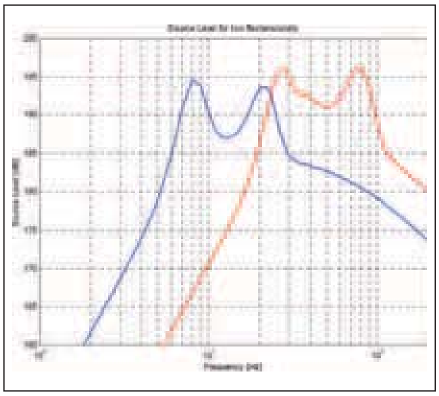

Fig. 2. The combination of the amplitude spectra for the Subtone (low frequency) and Triton (high frequency) vibrator sources.

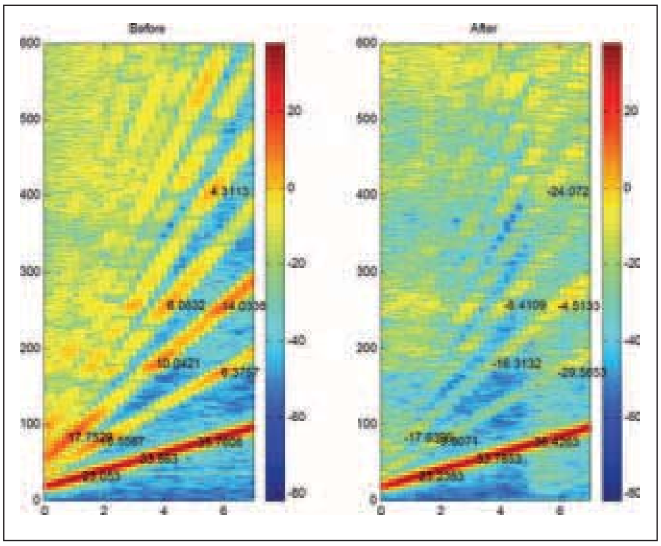

Fig. 4. Attenuation of harmonics with the marine vibrator control system.

Electrical marine vibrators have several operational advantages. There is no limitation in frequency response, except for low efficiency outside the frequency band of interest. This fact has been used to develop a control system that makes the acoustic sources repeatable over time. Having a feedback loop for control of the output means that not only can high repeatability be achieved, but the harmonics can also be attenuated. In Figure 4, the dramatic change in harmonics can be seen for a sweep generated from 20 Hz to 100 Hz. Some of the harmonics are attenuated by more than 30 dB.

2D field trial line

Several field trials were completed where the marine vibrator source characteristics were investigated and comparisons with airguns were evaluated. One comparison was made with a 2D streamer line acquired with a vibrator source consisting of a Subtone and a Triton vibrator, and a line shot with a 760 in3 airgun source.

Fig. 3. Triton and Subtone marine vibrators.

The airgun data and the vibrator data were processed through identical processing flows, except that the correlation process and an FK filter were applied to the vibrator data. Both the airgun and vibrator line were acquired with a 25 m shot interval, and a single marine streamer with 120 channels and 12.5 m group interval.

Figure 5 presents a shallow migrated section for the airgun data set and the vibrator data set. Figure 6 compares deeper part of the migrated sections of the airgun and vibrator data sets. It can be concluded from on the results presented in Figures 5 and 6 that the vibrator array, with a Subtone and Triton vibrator, has a penetration depth comparable to the 760 in3 airgun array. The penetration depths are comparable in spite of the significant difference in the output amplitudes of the airgun array (~12 barm peak-peak; 3-93 Hz) and the vibrator array (~2 barm peak-peak; 3-93 Hz).

3D field trial survey

A production 3D survey was designed for deep target objectives, and was acquired with five pound dynamite charges buried at a depth of ~10 m. As the survey was acquired in shallow water (1-2 m) it was selected as a comparison for the marine vibrator. The sources were arranged in brick-pattern to minimize the source effort. The marine vibrator used for this test had two elements; one Triton and one Subtone. These were mounted in a frame that rests at the seafloor. Both source elements vibrate simultaneously. The Triton output frequencies were 20-90 Hz with a taper on both ends, and the Subtone output frequencies were 8-20 Hz, also with a taper. Only linear sweeps were used for this test. Figure 7 is a picture of the frame with the vibrators. The Subtone is in the middle of the array, with a Triton on each side. A hydrophone that records the near-field signature is mounted close to each vibrator. The receivers used for 3D acquisition were "marsh phones". The inline receiver spacing was 50 m and the crossline receiver spacing was 400 m.

The vibrator and dynamite 3D acquisition was carried out simultaneously. The coverage for entire production 3D survey was 129 km^2, and the test area was 35.2 km^2.

The source ghost effects for a seismic source on the lower frequency component of the output frequency spectrum will be increasingly severe as the source depth decreases. For example, the 10 Hz frequency component for a source at four feet depth is attenuated by 18 dB. Therefore, it is expected that the lower frequencies from the shallower source (vibrator) will be severely attenuated due to the difference in the depth of the vibrator (1.2 m) and the dynamite (10 m). In other words, the dynamite data are expected to contain stronger lower frequencies than the vibrator. As the 10-20 Hz band constitutes the most significant part of the reflection signal beyond 2 s TWT, the comparison of dynamite and vibrator seismic data is limited to the first 2 s TWT.

Figures 8 and 9 show a time slice at 1.5 s TWT from the vibrator and dynamite migrated 3D data volumes. These figures show that the vibrator and dynamite surveys produce similar images of the subsurface. A channel imaged on these time slices has comparable appearance.

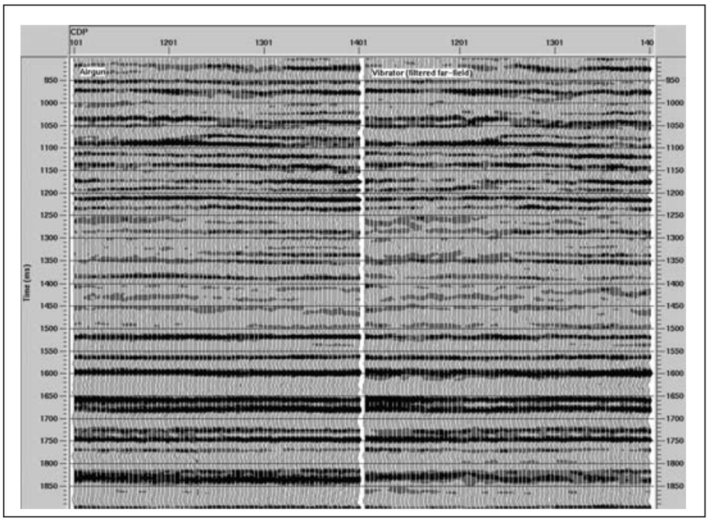

Fig. 5. Migrated sections (shallow) for an airgun source (left) and a marine vibrator source. The phase of the vibrator source section has been matched to the airgun data for comparison.

Fig. 7. The full PGS marine vibrator system.

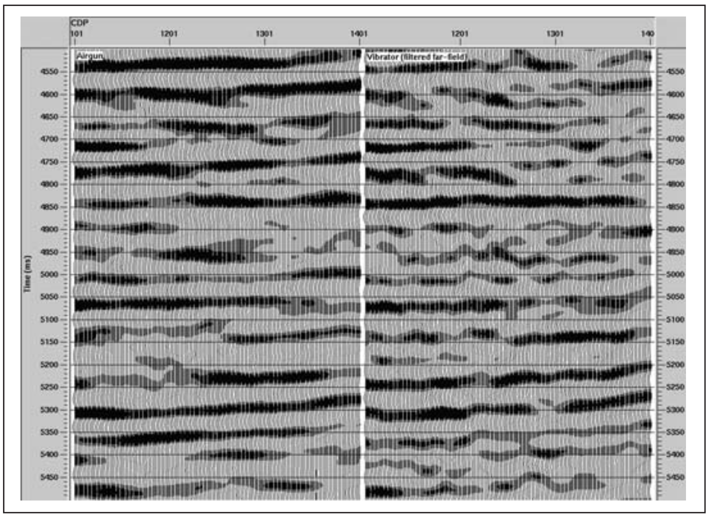

Fig. 6. Migrated sections (deep) for an airgun source (left) and a marine vibrator source. The phase of the vibrator source section has been matched to the airgun data for comparison.

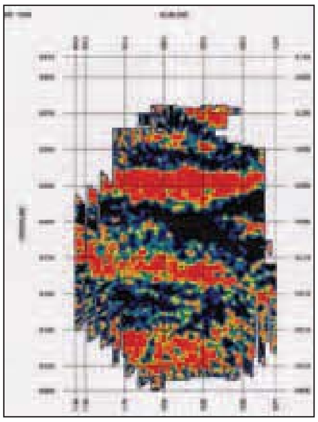

Fig. 8. Time slice at 1.5 s TWT for the marine vibrator 3D migrated volume.

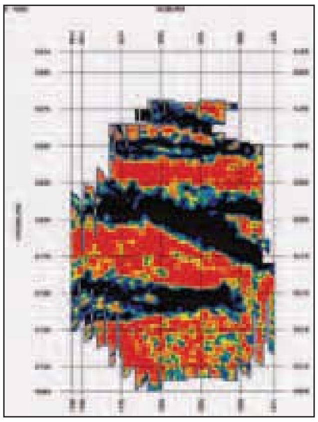

Fig. 9. Time slice at 1.5 s TWT for the dynamite 3D migrated volume.

The width of channel appears to be somewhat narrower on the vibrator data, indicating either higher resolution or higher noise content. In summary, based upon comparative migrated sections and time slices, we believe that both sources provided similar images of subsurface. Dynamite data contain stronger low frequencies (10-25 Hz), which impart more continuity to deep target reflections (~ 1.5 s TWT). These results also lead us to conclude that vibrator data contains slightly higher frequency bandwidth and resolution. Vibrator and dynamite data produce similar subsurface images.

Environmental considerations

A marine vibrator will provide several environmental advantages. Vibrator technology spreads the net source energy over a long period, reducing the acoustic power in comparison to impulsive sources. This is attractive for applications where high peak power may be problematic. This fact was established by the original hydraulic vibrators developed previously.

An electrical marine vibrator offers even more advantages than hydraulic vibrators. There is no need for heavy equipment and hydraulic systems that can cause hydraulic oil spills. As the electrical vibrator requires only an electrical power supply it can be easily transported to different vessels and locations without any costly installations and potential environmental hazards.

The fact that the electrical vibrator can generate arbitrary types of signals makes it useful for applications that can reduce the environmental impact even further.

Vibrator Applications

The marine vibrators discussed here have been tested as a standard towed acoustic source in shallow water, and as a stationary source in transition zone environments (1-2 m of water). These applications are particularly well suited for this type of source.

In order to get a strong enough acoustic output for a towed application it is probably necessary to have an array consisting of about four

Continued on page 29

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

There are now so many geophysical surveys being undertaken by the States and Territory that updates on progress will in future be shown in tabular form. A quick calculation shows that there is more than 1.2 million line-km of new magnetic and radiometric data being acquired, processed and released to the public in the period of interest. This is a huge investment of the States resources.

There has also been an increase in the number of gravity surveys being carried in key areas. In Table 2 you will notice that nearly 40,000 new stations will be acquired during 2006.

Table 1. Airborne Magnetic and Radiometric Surveys as at 15 September 2006

Survey Name	Client	Project Management	Contractor	Start Flying	Line-km	Spacing AGL Dir	Area (km²)	End Flying	Final Data to GA	Locality Diagram (Preview)	GADDS release
Paterson Central and SE	GSWA	GA	UTS	24 Jun 05	123,000	400 m 60 m E/W;N/S	42,000	30 Jun 06	24 Jul 06	115 – Apr 05 p33	15 Aug 06
Bowen – Surat North	GSQ	GA	UTS	25 Jan 06	169,800	400 m 80 m E/W	53,800	1 Aug 06	4 Sep 06	118 – Oct 05 p41	TBA
Bowen – Surat South	GSQ	GA	Fugro	26 Jan 06	170,000	400 m 80 m E/W	60,550	9 Apr 06	24 Jul 06	118 – Oct 05 p41	9 Aug 06
Isa West	GSQ	GA	Fugro	4 Feb 06	63,533	400 m 80 m E/W;N/S	22,030	2 Apr 06	17 Jul 06	118 – Oct 05 p41	9 Aug 06
Ashburton	GSWA	GA	UTS	4 Aug 06	105,840	400 m 60 m N/S	34,920	20% complete @ 10 Sep	TBA	121 – Apr 06 p35	TBA
Southern Officer Basin	GSWA	GA	GPX	15 Aug 06	105,200	400 m 60 m N/S	37,330	23% complete @ 8 Sep	TBA	121 – Apr 06 p35	TBA
Musgrave	GSWA	GA	Fugro	15 Jun 06	83,950	400 m 60 m E/W;N/S	27,920	65% complete @ 10 Sep	TBA	121 – Apr 06 p35	TBA
Isa South – West	GSQ	GA	Fugro	3 Apr 06	140,000	400 m 80 m E/W	50,100	2 Aug 06	TBA	118 – Oct 05 p41	TBA
Isa South – East	GSQ	GA	Fugro	8 Aug 06	101,200	400m 80m E/W	35,800	36% complete @ 10 Sep	TBA	118 – Oct 05 p41	TBA
Tiwi Islands	NTGS	GA	Fugro	28 Sep 06	29,300	400m 80m N/S	10,200	TBA	TBA	123 – Aug 06 p39	TBA
North – East Tasmania	MRT	GA	TBA	TBA	52,000	200m 90m E/W	8,600	TBA	TBA	123 – Aug 06 p39	TBA
Flinders Island	MRT	GA	TBA	TBA	17,900	200m 90m E/W	2,900	TBA	TBA	123 – Aug 06 p39	TBA
West King Island	MRT	GA	TBA	TBA	38,500	800m 130m E/W	27,260	TBA	TBA	123 – Aug 06 p39	TBA

Seismic Reflection Surveys

The 2006 Mt Isa Seismic Transect Project will commence in early October. The weather will need to be closely monitored and the survey suspended and completed next year if need be. The Project involves collaboration between the Geological Survey of Queensland - Queensland Department of Natural Resources and Mines, Geoscience Australia, Zinifex Limited, the pmd*CRC and ANSIR (the National Research Facility for Earth Sounding) and approximately 820 km of regional seismic reflection data will be acquired. The objectives of the project involve improving the understanding of crustal architecture which will assist in the discovery of further mineral resources, and an improved tectonic understanding of the region. Final results from the 2005 high-resolution seismic traverse collected north of Broken Hill and the reprocessed 1996-1997 regional Broken Hill seismic will be presented at the forthcoming BHEI symposium to be held in Broken Hill.

The ANSIR high frequency Minivib, in conjunction with Curtin University of Technology, is involved with several near-

Progress of Gravity Surveys as at 15 September 2006

Survey Name	Client	Project Management	Contractor	Start Survey	No. of stations	Station Spacing (km)	Area (km^2)	End Survey	Final Data to GA	Locality Diagram (Preview)	GADDS release
Isa Area A	GSQ	GA	Daishsat	10 Apr 06	6,719	2 regular	26,000	14 Jun 06	7 Jul 06	118 – Oct 05 p41	26 Jul 06
Isa Area B	GSQ	GA	Fugro	4 Jul 06	9,898	2 and 4 regular	78,000	74% complete @ 6 Sep	TBA	118 – Oct 05 p41	TBA
Jervois	NTGS	GA	Daishsat	14 Aug 06	5,500	2 regular	20,600	10 Jul 06	24 Jul 06	123 – Aug 06 p38	9 Aug 06
Webb	GSWA	GA	Daishsat	14 Aug 06	4,100	2.5 regular	24,800	13 Sep 06	TBA	123 – Aug 06 p38	TBA
Isa Area C	GSQ	GA	Fugro	October 06	9,236	2 and 4 regular	68,500	TBA	TBA	This issue	TBA
Murchison	GSWA	GA	Fugro	October 06	3,600	2.5 regular	24,800	TBA	TBA	123 – Aug 06 p39	TBA

surface high resolution seismic reflection projects. One includes the collection of mine-scale seismic reflection data around the Leinster Mine site to map the local Archaean stratigraphy and structure that hosts nickel sulphide deposits in the Wiluna Greenstone Belt, Western Australia. The second involves investigating the structure of a Southern Devonian Basin in the Argyle State Agreement Area using seismic acquisition techniques. The project aims to gain an understanding of the petrophysics, geometry, and architecture of the basin that will then provide baseline information to help design the most appropriate approaches to exploring the area for concealed diamond pipes.

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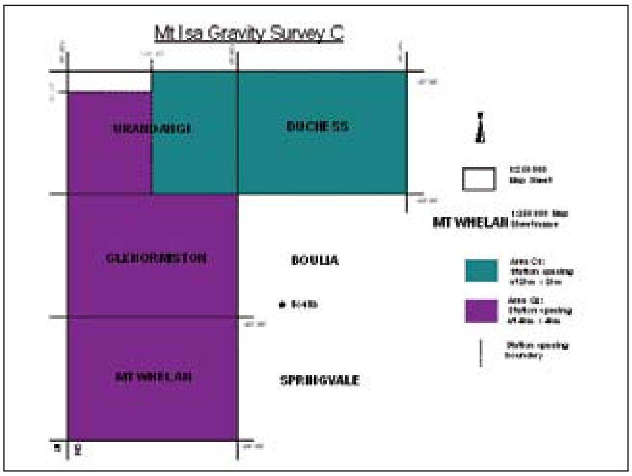

Fig. 1. Location of the Area C Mt Isa Gravity survey. The station grid is 2 km x 2 km over the green areas and 4 km x 4 km over the purple areas.

Continued from page 27

Subtone and four to six Triton sources. This is operationally feasible, and would be possible to have as a portable array deployable from any suitable vessel. In the case of very shallow water, the vibrator source can be deployed resting on its side. This makes it possible to operate in depth as shallow as 1.2 m. A number of sources can be used in this application as well. Being stationary has the advantage of the possibility to stack several sweeps. Doubling the number of sweeps will give a 3 dB improvement in the signal-to-noise ratio. Long sweeps can also be used to improve the acoustic output. The marine vibrator would be able to be a good replacement in areas where dynamite is not an option.

Other potential vibrator applications are in reservoir monitoring, where repeatable sources are of great interest. Another advantage in reservoir applications is that the source can be used at any depth. An air pressure compensation system makes it possible to get the same acoustic output at any depth.

Conclusions

All claims that are made with respect to the benefits of marine vibrators in the industry are equally valid for the PGS electrical marine vibrator. The new electrical marine vibrator developed by PGS has several operational and environmental advantages:

- Unique low frequency properties,
- Repeatable and controllable,
- Arbitrary signal coding can be used,
- Can be used for different water depths,
- No frequency limitation for the control circuit,
- Fixed reference in the middle of the source, as the membranes are symmetrically radiating, and
- The flextensional design creates a good impedance match.

Conventional hydraulic marine vibrators suffer from problems such as:

- Low efficiency at low frequencies,
- Impossible to control the low frequency, as the output signal will be in the noise floor compared to the input signal, and
- Mechanical fatigue problems because of high energy consumption and low efficiency

Acknowledgments

I thank PGS Marine Geophysical for permission to publish this paper.

Business Investment in R&D grows to record high

Business Expenditure on R&D (BERD) in Australia increased in 2004/5 by 10% over the previous year to a record $8.45 billion, according to the Australian Bureau of Statistics, which released its analysis on 28 August this year (ABS 8104.0 – BERD). This is the highest level recorded and is the sixth successive year of increase since the declines from 1995/6 to 1999/0.

There was also an increase as a share of GDP from 0.91% in 2003/4 to 0.95% in 2004/5 (see Figure 1) Notice how the mining industry (including petroleum) has powered ahead, with an annual investment of $1.2 billion in 2004/5 – more than $200 million above last year's numbers. The big companies (with more than 200 employees) dominated by accounting for 81% of the total mining R&D.

It is encouraging to note that the total human resources, in terms of people years also increased overall from 39,027 in 2003/4 to 41,656 in 2004/5. In the mining sector the numbers were surprisingly small with only a total of 1577 people years. However, this represents a huge increase over the 983 people years reported for the previous year.

To what extent these numbers represent a real increase in research activity, rather than simply representing a re-badging due to definition changes, or companies recognising the advantages of beefing-up their R&D numbers for taxation purposes, is difficult to say. Whatever, the reason it is encouraging that the numbers keep on rising.

On the global scale Australia has climbed up one place in the OECD table (see Table 1), by leapfrogging over Norway to move up one place to 14th. However, we are still well below the average for the OECD countries and more work needs to be done to encourage the business sector to increase its R & D investment. Notice that the USA has arrested its decline in the table but Canada is not looking very good at all, with a fall of investment in three consecutive years.

Mineral and Petroleum exploration both increase in June quarter

Minerals

Modest increase in 2nd quarter

Figures released by the Australian Bureau of Statistics in September 2006 showed that the trend estimate for mineral exploration expenditure increased by 2.4% to $323M in the June quarter 2006. Exploration expenditure has now risen in the past eleven quarters and is nearly 19% higher than in the June quarter 2005. However, it is still 20% less than the peak of $289 million (CPI adjusted) reached in the June quarter 1997.

Figure 2 shows the expenditure estimates from June 1998 through June 2006. Notice how the rate of increase appears to be decreasing.

Figure 3 shows the longer term trends from March 1986. It indicates that in real terms

	2000/1	2001/2	2002/3	2003/4	2004/5
Sweden	na	3.28	na	2.93	na
Finland	2.40	2.41	2.40	2.45	2.46
Japan	2.12	2.26	2.32	2.36	2.35
Korea	1.77	1.97	1.90	2.00	2.19
USA	2.05	2.00	1.86	1.87	1.88
Germany	1.73	1.72	1.72	1.76	1.75
Denmark	na*	1.64	1.73	1.77	1.69
Iceland	1.54	1.79	1.76	1.51	na
France	1.34	1.39	1.41	1.37	1.36
Belgium	1.43	1.51	1.37	1.31	1.30
United Kingdom	1.21	1.24	1.25	1.24	1.16
Canada	1.17	1.31	1.18	1.12	1.07
Netherlands	1.06	1.05	0.98	1.01	1.03
Australia	**0.72**	**0.84**	**0.89**	**0.91**	**0.95**
Norway	na	0.96	0.96	0.99	0.88
Czech Republic	0.74	0.74	0.75	0.77	0.81
Ireland	0.81	0.77	0.76	0.77	0.77
Spain	0.49	0.48	0.54	0.57	0.58
Italy	0.52	0.53	0.54	0.52	0.54
Total OECD	1.55	1.57	1.52	1.53	1.53

Table 1: BERD/GDP for most OECD countries
na not available*

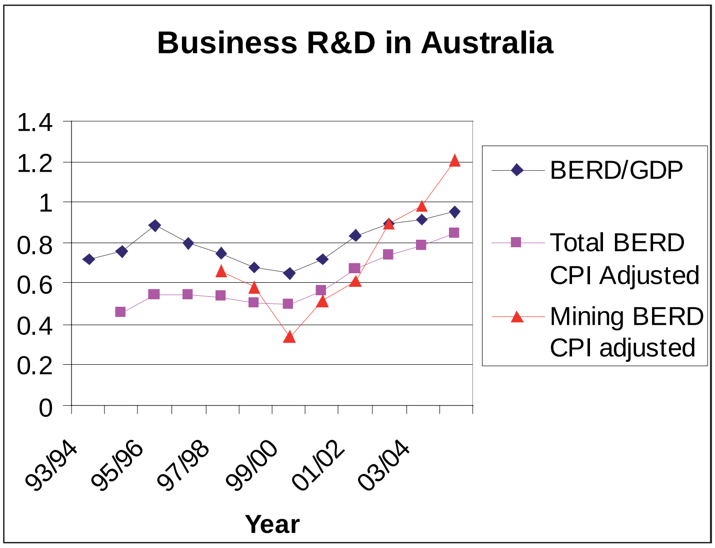

Fig. 1. Business R&D expenditure in Australia (BERD); BERD/GDP in %; total BERD in $billion/10; mining (including petroleum) BERD in $billion (both adjusted for CPI movements to 2004/5 dollars). Numbers for the mining industry before 1997/98 are not available.

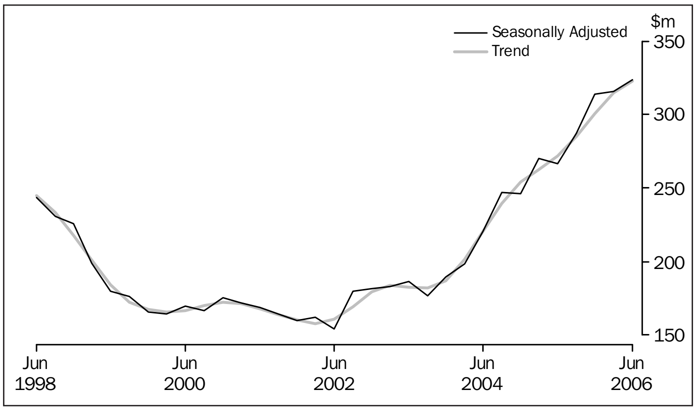

Fig. 2. Trend and seasonally adjusted quarterly mineral exploration expenditure from June 1998 through June 2006 (provided courtesy of the Australian Bureau of Statistics).

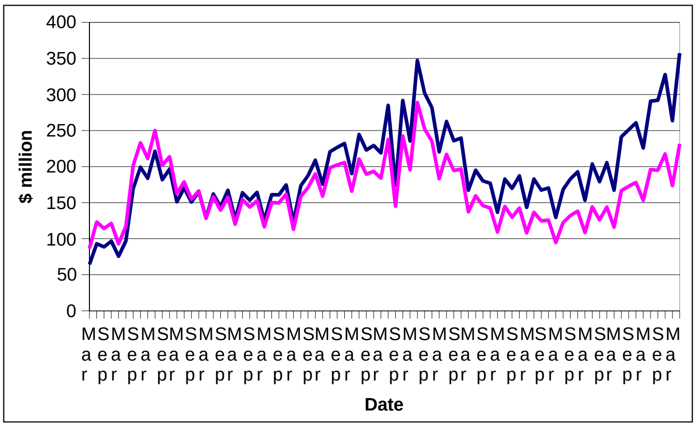

Fig. 3. Quarterly 'actual' mineral exploration expenditure from March 1986 through June 2006 (from ABS data). The black curve represents actual dollars spent and the purple curve shows the CPI adjusted number (to 1998/99, RBA data).

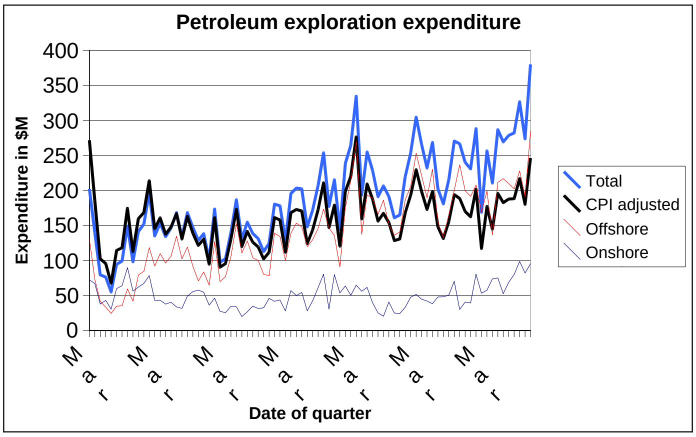

Fig. 4. Quarterly petroleum expenditure from March 1986 through June 2006. The individual offshore and onshore numbers are actual numbers spent at the time, not CPI adjusted. The black coloured graph is the Total CPI adjusted to 1998/99.

(CPI adjusted) the expenditure levels are unlikely to reach those of 1997 in the foreseeable future.

The largest contributions to the increase this quarter were in South Australia (up $4.4M or 11.1%) and Queensland (up $1.8M or 3.1%). Most states showed increasing expenditure levels this quarter, with only Western Australia showing a decrease ($0.6M or 0.4%). However, WA continues to dominate with a total expenditure of $156.3M, well above Queensland ($65.2M) and South Australia ($56.5M) which come next.

The increase of expenditure in South Australia is most impressive. In the June quarter of 2005 only $20.1M was invested.

The Greeenfields percentage of the total has increased slightly over the last year. In the June 2005 quarter the34% ($115.2M) was spent on Greenfields and in 2006 this rose to 36% ($129.7M).

Drilling activity also increased slightly in the June quarter with a total of 1916 km drilled in that period. The total comprised 1138 km on existing deposits and 778 km on new deposits. This compares with a total of 1783 km for the June quarter of 2005.

However, the trend estimate for metres drilled only increased by 0.6% this quarter and in seasonally adjusted terms, the total metres drilled decreased by 1.8% in the June quarter 2006. So it depends a little on how one uses the statistics!

Petroleum

High increase

Expenditure on petroleum exploration for the June quarter 2006 increased by $106M (39%) to $380M. The news was good for all categories of exploration. The offshore increase was $93M (48%) and onshore it increased by $13M (16%). Exploration on production leases increased by $25M (30%) and on all other areas by $81M (43%).

This last increase is particularly pleasing and indicates that the government's Big New Oil program being undertaken by Geoscience Australia is producing results in new previously un-explored areas.

All states showed increases in this quarter with the Northern Territory, up by $60M (112%) to $114M, and Western Australia, up $32M (23%) to $169M, leading the way.

Figure 4 shows a plot of the quarterly petroleum exploration expenditure from March 1986. Notice that in the last year there appears to have been a significant increase exploration expenditure.

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NEUMAYER: pioneer exploration geophysicist (Part IV)

Neumayer's magnetic map of Victoria

Filling in the gaps

In January 1863, Neumayer, riding his favourite horse Tommy, with his dog Hector at his side, spent ten days circling the Mornington Peninsula. He was accompanied by Mr. Mörlin, a newly employed observer, and Edward Brinkmann, driving the wagon. They observed at a number of places including the Schnapper Point Hotel, the Cape Schanck lighthouse and French Island in Western Port before returning to Melbourne via the hole in the ground from where the Cranbourne meteorite had been removed a year earlier.

Neumayer did not travel again until early September when, with Brinkmann (and two horses, Tommy and Jimmy, and Hector the dog) commenced a somewhat difficult journey into very rugged country. The trip was initially through Healesville, Merton, Euroa, and Benalla before turning back south to Mansfield, Jamieson and the remote Wood's Point where Neumayer engaged two aboriginal guides, Tom and Edward, employees of Mr. Green, a local missionary. Tom and Edward were to prove to be excellent guides, and they knew the value of money for Neumayer had to bargain hard to obtain their services. During the trip Tom and Edward assisted in clearing tracks and, according to Neumayer, they caught lyrebirds and wombats for food.

Brinkmann's post traumatic stress

It was very early in this trip that Neumayer, upon returning to camp, found his tea not ready, apparently Brinkmann had been reluctant to leave the camp to collect wood – he thought he would get lost. Neumayer was somewhat shocked at his bushman friend and, according to Neumayer, Tom thought it both hilarious and *very stupid* of white fellows to head into the bush if *they were so much afraid 'Why don't you take a Bible with you?'* was his comment. Brinkmann certainly must have been suffering after his lucky escape on Kosciusko.

Travel continued in very difficult and heavily timbered country and on one evening two men suddenly appeared in the camp, they were totally lost and in a terrible condition, having been without water for some days - and they were missing a companion. Neumayer did not record any more on them or the missing man's fate.

Eventually Neumayer had to abort this trip – it was just too hard and the horses were suffering from lack of feed despite the dense undergrowth. Again Neumayer never failed to note the geology as he went. Magnetic observations were measured at fifteen stations before he decided to walk directly back to Melbourne leaving Brinkmann to bring home the horses (Figure 1).

Another trip abandoned

Shortly after returning from Wood's Point (late September 1863) Neumayer had Brinkmann prepare the horses and equipment to travel to Gippsland, but poor weather continued such that, in mid-November, Neumayer decided to postpone things and make a short excursion by train and coach to Ballarat, Maryborough and some gold diggings to both check on earlier inconsistencies and to fill some holes in his network. During this trip he made a visit to the newly erected Burke and Wills monument at Castlemaine. Although this trip was of relatively short duration, and by public transport, he had travelled over 400 kilometres and observed eight more stations.

To the Gippsland bogs

On the 28th November 1863, a week after returning from Castlemaine, Neumayer started his journey to Gippsland. The weather conditions were however still very unfavourable but he just could not delay this, his last planned and important trip, any longer. He was accompanied by Edward Brinkmann and his friend, the artist Nicholas Chevalier.

Things didn't start too well when Neumayer found one of his astronomical instruments (a reflecting circle) was broken, and frustratingly, had to return it to Melbourne for repair before he could even get started. The track conditions were also found to be far too boggy to travel with the wagon, so it was decided to leave it behind, with all their travel to be, again, by horseback or by foot.

The route, over waterlogged tracks, was hilly and narrow and the bogs according to Neumayer were literally lined with horse skeletons. At times Jimmy and Tommy became stuck fast – Jimmy got bogged up to his neck at one time and after being relieved of his packs

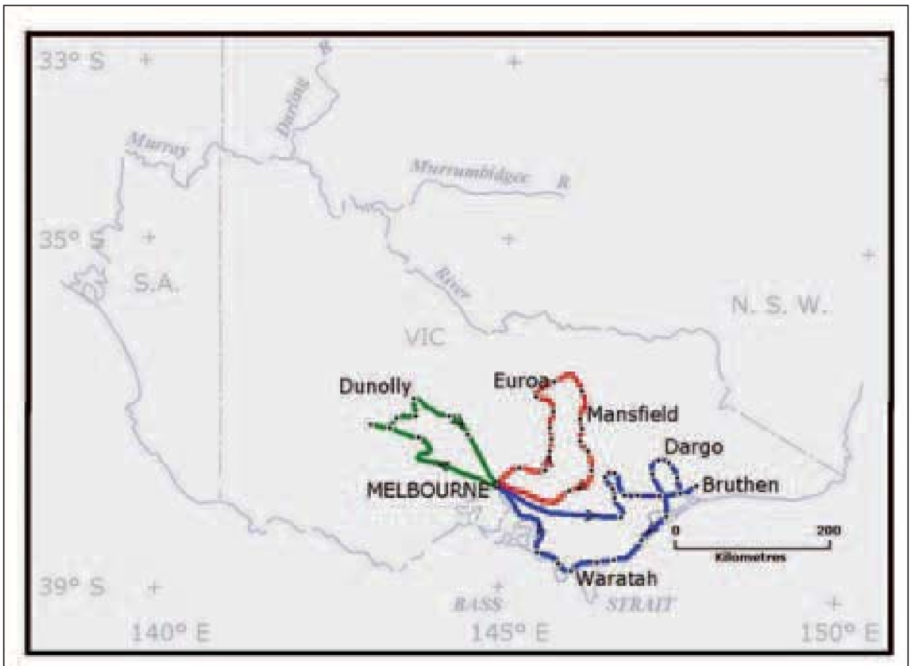


Fig. 1. Neumayer's last Victorian field trips, March-April 1863 (in red), November 1863 (in green), November 1863-February 1864 (blue). Dots represent station locations.

[1] Brinkmann pulse 63, temp under tongue 98.1°, Chevalier 70.5 and 99.0°, Neumayer 71.5 and 98.4°.

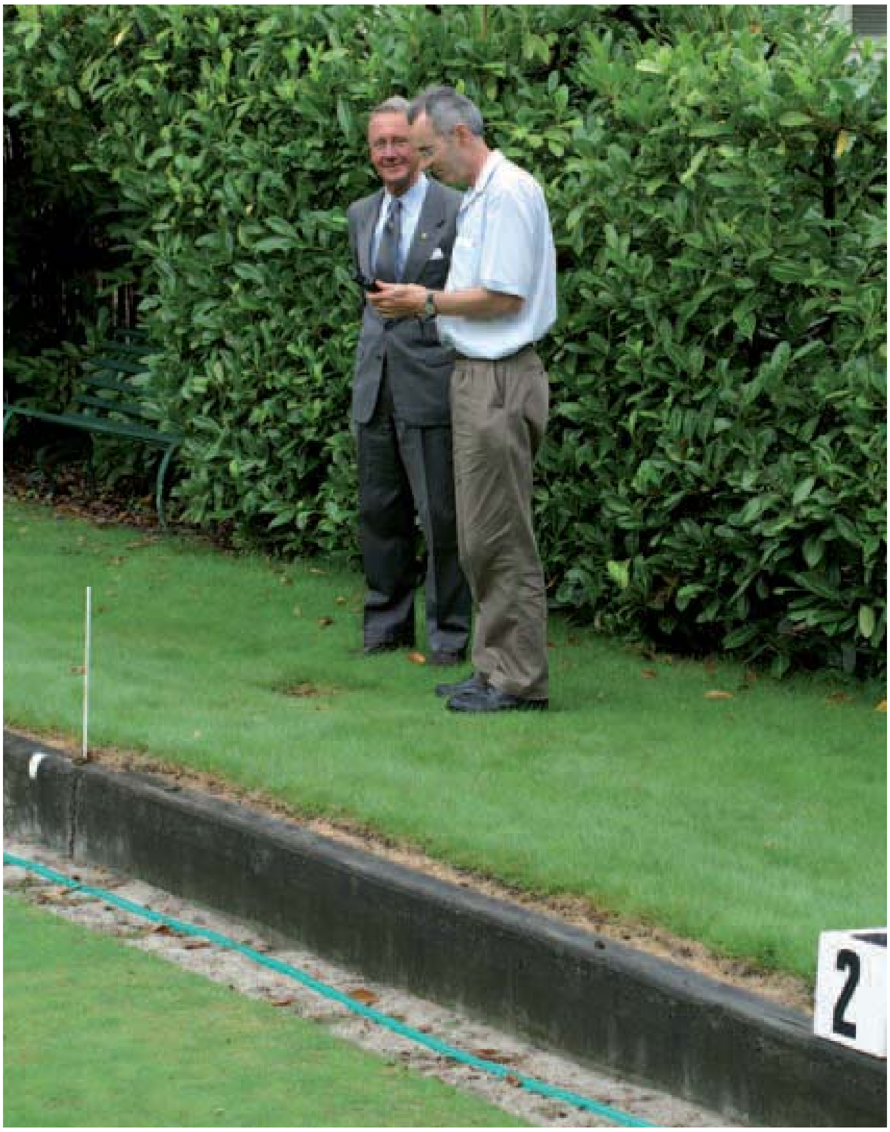


Fig. 2. Bob Richardson and John Chilcott, Secretary to the Governor, standing above the brass commemorative plaque for Rossbank Observatory pillar "D" in February 2006. The plaque was unveiled 26th May 1983 by Sir James Plimsoll the then Governor of Tasmania. Courtesy Robert Richardson.

was dragged free, it then took hours to clean the gear. As always, Neumayer never failed to note the local geology, but the weather was so poor that even after eight days, and reaching east of Traralgon, he had not been able to make a full set of physical observations at any of his planned stations. Neumayer was not happy.

Rain, fire and rotating horses

On the 13th December they crossed the Thomson River and reached the Donnelly's Creek diggings. They were to camp in tall timber, only to be caught in a dangerous night-time storm with cracking branches and falling trees. The temperature within minutes had turned freezing with everyone suffering terribly. Neumayer even went to the extent of taking and documenting everyone's pulse and temperature[1]! Despite incessant rain they were able to make a huge bonfire, bringing the horses close and turning them around from side to side for many hours giving them some warmth – even some passing travellers with their horses were to come in to take advantage of the fire.

Bushy Park, Dargo and Angus Macmillan

Mr. Chevalier, according to Neumayer was an excellent cook and was praised for a specially prepared Christmas Eve dinner, after which they visited the beautiful cascades and tall tree ferns on the Serpentine Creek (which Chevalier sketched) before travelling onto Bushy Park, the squatter's station previously held by the pioneering explorer Angus Macmillan.

At Bairnsdale, Neumayer was to rightly praise the beautiful timber and surrounding grasslands, but the travel however continued to be heavy going. In early January when Neumayer turned inland to the hills and the gold diggings, travel became impossible when they struck impassable boggy tracks. Many of the tracks were signposted only in Chinese. Neumayer made the comment that the gold workings were extensive and a quite deplorable sight.

When Neumayer reached the isolated and primitive Dargo Station on the 14th January 1864 and after being *so fortunate to kill a wombat*, he received a visit from the pioneer Angus Macmillan. Macmillan had been *driven by adverse circumstances from his homestead at Bushy Park, his kind nature and great hospitality having in a great measure brought him to this position*. Neumayer and Macmillan talked together for almost two days about the region, discussing everything from geology to the aboriginal population. Macmillan told Neumayer that there were scarcely 120 aboriginals left in Gippsland when once there had been thousands when he had first arrived. Neumayer *rejoiced very much at being able to treat Mr. Macmillan to a joint of wombat which he stated never to have been better prepared.*

Poor old Hector

Leaving Dargo and Mr. Macmillan, Neumayer headed south to make observations westward along the coast. At Port Albert, he compared his barometers and clocks with those of Mr. Ferres, the local weatherman.

Chevalier at about this time wished to visit Wilsons Promontory – but Neumayer, being too busy to follow and not really wanting Chevalier to leave the party, made an arrangement whereby Chevalier, on his own, could make the diversion and then catch up by following markings and blazings set by Neumayer and Brinkmann.

On the 28th January (1864) heading west along the coast, and just after crossing the Franklin River, Neumayer turned to see Hector collapse into convulsions and within six minutes die, poisoned by a bait. Neumayer was, not surprisingly, *exceedingly exasperated*; he buried his mate and at Sandy Point sought out those responsible – apparently the dingo problem was way out of control in the area. Poor old Hector, except for some rail trips he had at that time travelled almost every inch (and more) of every one of Neumayer's trips around Victoria.

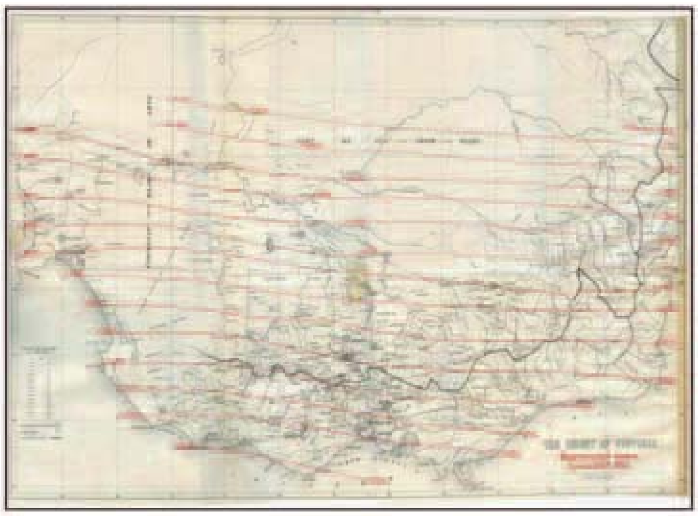


Fig. 3. Neumayer's historic 1858-64 Horizontal Intensity map of Victoria. Contour interval 0.0600 British Units (about 276.65 nT). The black jagged lines represent the main topographical ridges. Author's copy.

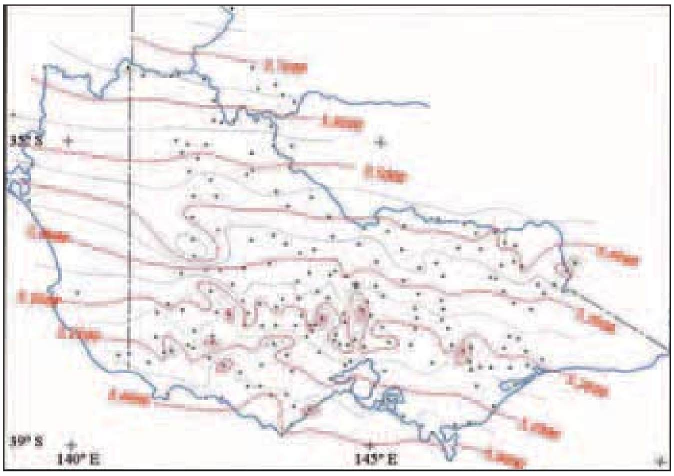


Fig. 4. Neumayer's station locations and modern contouring (by hand) of the acquired horizontal intensity data – contoured in British Units –these data were smoothed by Neumayer to produce the map shown in Figure 3. Drawn and compiled by Doug Morrison

Chevalier loses his pictures

Chevalier followed the trail of Neumayer as best he could, but unaware Hector had been poisoned got confused as he missed Hector's footprints, despite Neumayer having marked many trees and suspended directional notes from them. Neumayer wrote that Chevalier was to spend two days searching for the trail, without food and with little water.

Neumayer crossed the Powlett River but Chevalier also missed this critically marked safe crossing and in his attempt to cross the fast flowing river almost drowned when he was carried downstream with his horse. Neumayer wrote that Chevalier lost everything he carried – including, sadly, all his sketches from the journey.

With the completion of this 800 kilometre trudge (and data from 23 observed stations) Neumayer's Victorian field work ended.

To Rossbank, Hobart

One of Neumayer's last tasks before returning to Germany was to travel with his magnetometers to the site of the defunct Rossbank magnetic observatory in Hobart. Between the 13th and 19th April 1864 he made observations as close as he could get to the original observatory pillars (Pillar "D" specifically). This exercise, not surprisingly, wasn't entirely to Neumayer's liking as the pillar location had become magnetically contaminated by development within the grounds of Government House. He had to find a new spot to observe:

The distance of the place of observation from the old observatory was 9.4 chains and its astronomical bearing S 4°27'.76E from it. To avoid the vicinity of basaltic stones near the observatory is a matter not very easily to be accomplished, as it is surrounded by rocks influencing the values of the magnetic elements, though the observations themselves were made on a small dyke of free-stone. This becomes at once manifest by the great and rapid changes on moving the instrument round the locality[2].

In February 2006 the author mentioned Neumayer's Hobart observations to our valued Tasmanian ASEG member Bob Richardson, and on his own initiative he gained permission and access to the historic Rossbank pillar "D" site within the Government House grounds and accompanied by the Secretary to the Governor, John Chilcott, photographed the site (Figure 2).

Neumayer goes home

Neumayer, shortly before he left Victoria, was made a honorary life member of the Royal Society of Victoria, he also received other accolades including one from the Melbourne Chamber of Commerce, to which he had made a donation of his original (now extremely historic) oceanographic maps and reports of over 300 voyages to Melbourne. The German Gymnastics Association on the night of 17th June 1864 even serenaded him at his residence and on Monday 20th June the German Association gave a farewell dinner at which Neumayer, according to the Age newspaper, responded with a somewhat "animated" address that included, amongst other angst, comments on the meagre support which science and fine arts received in the colony.

He publishes his maps

When he returned to Europe, Neumayer re-calibrated his magnetometers at the Munich Observatory and then commenced the preparation of his Victorian meteorological and magnetic results for publication. He reduced all of his field magnetic observations to the 1st January 1860.

He firstly published his observatory results and then in 1869, following some irritating financial misunderstandings and delays, his combined field magnetic survey results, narrative and regional maps. Neumayer's maps were of the standard magnetic parameters of declination, inclination and horizontal intensity, and covered much of south eastern Australia rather than just Victoria. A study of these maps has shown Neumayer had no hesitation in editing, deleting and smoothing his data to produce final maps – he certainly didn't need local anomalies masking the regional magnetic field and he certainly didn't try to hide the fact he deliberately knocked them out.

He wrote:

In cases of great irregularity, for which I could not account in any other way, I examined the observed values in that particular case in order to form an opinion, as to the applicability of the mean value. It was rejected and the observed values placed instead, if such a procedure would cause the value of the declination in question better to correspond with the general sweep of the curves. (Figures 3 and 4).

(to be concluded)

[2] This location, by modern calculation, would place it just within the site of the old Hobart Zoo and, for interest, within metres from where the last captive Tasmanian tiger was to die.

An Introduction to the Environmental Physics of Soil, Water and Watersheds

By Calvin W. Rose

*Publisher: Cambridge University Press, 2004, 436 pages**

Hardback (ISBN-13: 9780521829946 / ISBN-10: 0521829941) A$250.00

Paperback (ISBN-13: 9780521536790 / ISBN-10: 0521536790) A$90.00

I reviewed this text book during fieldwork in the very region that the front cover photograph of the book was taken i.e. Burdekin Delta, Queensland, and found it highly relevant to the groundwater recharge study we were undertaking. The author, Calvin Rose, is an Emeritus Professor of Environmental Sciences at Griffith University and is well respected in the field of soil science. Something I found interesting is that his physics career began with designing fighter jets for Australia before he made the change into soil physics. Now on to the book review.

"This introductory textbook describes the nature of the Earth's environment and its physical processes so as to highlight environmental concerns arising from human use and misuse of soil and water resources"

The book discusses the interaction of soil and water with a focus on how to study hydrological processes and environmental problems using a quantitative approach. Practical examples are provided throughout the text applying the principles of sustainable land use pitched at readers with no prior knowledge of the physical sciences. Each chapter has exercises, whose answers are available on the web.

Chapter 1 introduces basics of the physical environment such as the rock cycle, the formation of soils, and energy and water-exchange budgets, including what happens when there is imbalance, e.g. the greenhouse effect. The chapter concludes with a brief discussion of physical measurements defining units and quantitative measurements.

The physical properties of soils are discussed in Chapter 2, covering topics such as soil strength, and soil mechanics. The behaviour of liquids is discussed in Chapter 3 describing processes such as energy and fluid flow.

Chapter 4 describes how water enters the soil, how it is stored in the soil and how water exits the soil by means of evapotranspiration, overland runoff, or subsurface flows. One of the most fundamental quantitative principles used in hydrological studies, water balance or mass conservation of water, is introduced in this chapter along with environmental implications such as water quality and land degradation. Rose states the majority of environmental problems involving soil and water need to be addressed and managed at the watershed scale or greater.

The topics introduced in Chapter 4 are expanded in the subsequent chapters. Evapotranspiration, infiltration into soils and overland flow are individually described in Chapters 5 to 7. Instruments used to measure such properties are well described including hygrometers, radiometers and infiltrometers.

Chapter 8 provides an introduction to geomorphology with detailed explanation of the physical processes of erosion and deposition of sediment by water. Chapter 9 expands and applies this knowledge to discuss the ways that land, rivers and oceans should be used and managed sustainably. Such topics covered in the chapter include management options for excess rainfall, sediment transport, nutrient and chemical transport, and river health.

The Chapters 4 to 9 largely cover the effect of surface water processes, whereas Chapter 10 examines the environmental consequences of water infiltrating the soil profile and contributing to the groundwater. The chapter introduces hydrogeologists' most fundamental equation, Darcy's law, which showed that water movement in a saturated porous medium is proportional to the change in hydraulic head. Rose describes confined and unconfined aquifers and the complexity the subsurface geology has in hydraulic properties.

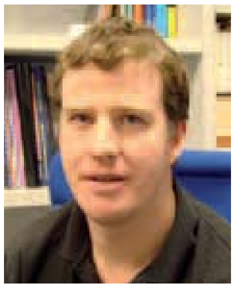
Chapter 11 describes in detail the movement of water in the vadose zone, or unsaturated zone above the water table. This zone is of great importance sustaining growth of plant and tree roots. In addition this zone is where chemicals enter the groundwater system. Rose points out that the complexity of the unsaturated zone is largely compounded by the variability in moisture content.

The increase in concentration of salts within the unsaturated zones and its impacts to land use is described in Chapter 12. Rose states that "one of the major environmental issues in sustainable management is the large-scale increase in salt-affected land caused by human activity". Topics covered include dryland salinity processes, irrigation induced processes and contaminant transport.

Each chapter provides many illustrations to explain the principles and problems being addressed. The text is up to date with current references to world wide concern in the increase in concentration of greenhouse gases, describing the role of soil with its biotic and vegetation components being a potential carbon dioxide sequestration option.

The book is an excellent introduction to soil physics. It is suitable for undergraduates and non-specialists. Environmental science so often applies a multidisciplinary approach; therefore I recommend this book as a valuable resource for those researchers that cross over into soil and water environmental management problems outside of their area of expertise.

Reviewed by:



Andrew Fitzpatrick andrew.fitzpatrick@csiro.au

* Copies can be ordered directly from Cambridge University Press: Tel (03) 9676 9955 or www.cambridge.edu.au

Sustainable Energy: Choosing Amongst Options

By Jefferson W. Tester, Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay and William A. Peters

MIT Press, July 2005, 872 pages

US$78 (Cloth bound)[1]

ISBN-10: 0-262-20153-4

Reviewed by:

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[1] Copies can be purchased direct from MIT press at http://mitpress.mit.edu

I have to admit that I have not yet read the entire 872 pages of this book, but I have read enough (>300 pages) to realize that it attempts to cover a topic of incredible breadth. It would be easy to look at the title and think you already know a bit about what is in it. I picked it up with an expectation of reading about all the ins and outs of wind power, solar energy, geothermal, biomass and so on, with maybe a bit about the comparative costs and benefits of each. What I found, however, was a book much broader in scope and ambitious in intent. It seeks to address the issue of how the world as a whole might satisfy its energy needs without adversely affecting the environment, health or economy of any region or future generation. It is an altruistic aim, but the book is presented with a pragmatic altruism, rather than the radical altruism often associated with this topic.

The five authors on this book are all from the Massachusetts Institute of Technology (MIT), America's number one ranked engineering university (present home to no fewer than 12 Nobel Prize winners!) and one that takes energy research very seriously—the MIT Energy Research Council (http://web.mit.edu/erc) has the humble stated aim to "produce a plan for a cohesive initiative to tackle the world's energy crisis through science, engineering and education." Jeff Tester, the lead author, attended the Australian Earth Sciences Convention in Melbourne in July this year to present the results of a large study into the future potential of geothermal energy in the USA.

When reading this book it very soon becomes apparent that "sustainability" means much more than "reducing greenhouse gas emissions". The issue is approached in the very broadest sense. How can we as a global community simultaneously sustain the developed world's way of life, environment, medical health and economic growth, while allowing developing nations and future generations to enjoy the same benefits we currently enjoy? The first six chapters give a "basic" grounding in a number of very different disciplines needed to understand and address the issue.

These include a definition of "energy"; thermodynamics (the maths and science of converting energy from one form to another); energy resource estimation; micro- and macro-economic analysis (including the difficulty of putting a dollar value on environmental and health damage); global climate modelling (including frank comments on the inherent uncertainties); carbon sequestration; global, national and local regulatory instruments (including an instructive case study on the successful regulations for reducing SO_2 emissions in the USA, and ozone-depleting chemicals globally); statistics on current and projected energy demands globally; complex systems modelling; the time and distance scales involved with different forms of pollution; and "sustainability metrics" (how do we measure the "sustainability" of a system or process?)

The above "background" information takes up almost 300 pages. The next 350 pages are dedicated to specific descriptions and investigations of the broad range of energy options currently available or being investigated. In the order they are covered in the book, these include separate chapters on fossil fuels (coal, petroleum, natural gas, tar sands, oil shale, peat, methane hydrates), nuclear power (fission and fusion), biomass, geothermal, hydropower, solar, ocean energy (waves, tides, thermal) and wind. Each chapter has roughly equal weighting in terms of pages, and covers the history, resource assessment, technology, economics, current usage and future prospects of the energy source.

Chapters 16–20 cover issues surrounding the storage, transportation and distribution of energy; the electric power sector; energy requirements for transportation; the energy needs of industry; and energy systems for commercial and residential buildings. Each sector is covered in enough detail to illustrate its particular challenges with respect to sustainability. The penultimate chapter, Chapter 21, is called "Synergistic Complex Systems", which is a bit confusing because it is really a discussion about how decisions ***can*** be made about issues that involve a large number of disparate areas of expertise (e.g. panels of experts), and how decisions often ***are*** made (e.g. consumer demand).

The Preface explains that this book grew out of a collection of teaching notes for a number of different MIT courses. This probably explains why the text is not as polished as might otherwise be expected. Although put together in a thoroughly logical and readable way, there are occasional typos, errors in cross-references (e.g. a referral to Chapter 23 of this 22 chapter book), and much of the information seems relatively dated (e.g. the Kyoto Protocol had not come into force when the book was written). These are minor irritations, however, and generally do not detract from the otherwise solid content.

The last chapter of this book, Chapter 22, is just three pages long and is titled "Choosing among options". After reading 820 pages admirably illustrating the complex challenges of moving towards global energy sustainability, the reader will crave a simple formula or "road map" for

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Who wants to be a Scientist? Choosing Science as a career

By Nancy Rothwell

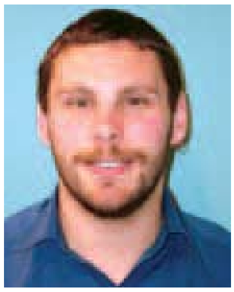
Cambridge University Press

ISBN: 0-521-52092-4

pp. 166;

price $55

Reviewed by:



David Robinson
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"Who wants to be a Scientist?" describes the career of a scientist. Rothwell, a Professor of Physiology at the School of Biological Sciences, University of Manchester, provides her own personal account of what it takes to be successful in science. She covers things to consider before entering science, the ongoing need to communicate, the impact on your social life and finally what it takes to be a departmental head.

Rothwell begins with a discussion of the early decisions that a scientist must make. These include what courses to enroll in (MSc., Ph.D. etc.), choosing a specialist field, where to study and how to select a supervisor. Chapter 3 deals with "getting down to research". It addresses the difference between thinking and doing. Experimental design and learning new techniques are discussed with an emphasis on attention, care and precision. Fleming's 'chance' discovery of Penicillin is presented as an example of how the prepared mind allowed Fleming to interpret the unusual. Time management, organisation, working with others, managing your supervisor, recording data, analysis and data presentation are also covered. Finally, Chapter 3 concludes with a discussion of scientific criticism and how to call it a day on a project that hasn't worked, however disappointing it may be.

The fourth chapter centers on "Scientific ethics and conduct". Severe cases of misconduct, whilst acknowledged as rare, are overviewed in the broadest sense. Examples include plagiarism, presenting the work of others as your own and intentional manipulation of data. Unintentional misconduct arising from poor experimental design, fixation on pre-conceived ideas, 'sloppiness', or simple error are also covered. The chapter describes fairness to colleagues through acknowledgement of contribution, discrimination and declaring conflicts of interest when in positions of power.

"Publish or Perish" outlines the what, why and when of publication. The importance of planning, preparation and presentation are highlighted. There are many tips in this chapter. Here are a couple that are worth remembering; (1) Think hard about everyone who has contributed and make sure they are acknowledged; and (2) choose carefully about where to publish your work – remember that you want maximum impact. Be selective about invitations for small articles and conference; they are important but over-commitment to deadline driven articles will mean less time to write peer reviewed papers.

"Communication and getting known" forms the basis of the sixth chapter. Oral and poster presentations are both discussed. Sections on audio-visual aids, responding to questions, meetings, networking and chairing sessions are all included. Rothwell cites from a 1979 book by Peter Medawar that "droning on to an uninterested audience … is one of the most serious errors a scientist can make". Upon reading this I was reminded of an amusing article written by Gottfried Schatz for FEDS Letters. According to Schatz you should "think of a scientist's three most important goals: (a) the Nobel Prize, (b) unlimited research funds, and (c) unlimited speaking time. To get (a) and (b), you must have brains; to get (c), you must have guts. So don't skip anything – say it faster". You can find the full article at http://www.if.ufrgs.br/~jgallas/bad_seminars.htm.

The next two chapters cover "Moving up" (Chapter 7) and "Responsibilities" (Chapter 8). The former addresses career advancement discussing post-doctoral positions, moving (places and projects), fellowships, academic positions, industry research and other careers. Sections on interviews and CVs are included and once again the importance of networking and communication emphasised. Chapter 8 describes managerial issues and includes discussions on directing research, managing people, appointing staff, supervising graduates, dealing with problems and assessing work. A small section, but one that I have chosen to emphasise, focuses on new staff. It stresses the importance of introducing new staff to the workplace; clarifying what is expected of them and making them feel comfortable.

Chapter 9 is based on "Funding Research". Differences between safe projects and fishing expeditions; novelty and feasibility studies; are highlighted. The chapter covers what to ask for, application design and dealing with rejection.

Knowledge of funding bodies including an understanding of who will review your application is essential. The application must be tailored to the expertise of the reviewing panel.

The next three chapters discuss ownership; dealing with the public; and politics. Patents, sharing, intellectual property and confidentiality are all overviewed in Chapter 10. In Chapter 11 Rothwell covers communication with the public discussing the public view of science, press and presenting to non-scientist. Chapter 12 addresses a broad range of topics, not all of which will be immediately identified with the title "Power, pressure and politics". These include leadership, delegation, becoming a departmental head, editing journals, serving on funding

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bodies and government committees. Chapter 13 deals with the social aspects of being a scientist. According to Rothwell "scientists are rather odd" to many people. The chapter discusses the balance between social life and work. In particular it stresses the need to find an understanding partner who is flexible when you spend a Saturday evening at the office (perhaps writing a book review).

Rothwell has created an easy to read commentary on the scientific career. Naturally, the text is strongly influenced by the author's own background. Ongoing reference to the lab and the lack of examples from outside the biological field reduce the appeal of this text to a wider scientific readership. In most cases a simple change in terminology or even sourcing examples from other fields would engage scientist form other fields. Nevertheless, if you can get past these minor issues you will find that the majority of the text is equally applicable to all scientific disciplines. Much of what is covered in this book is common sense. For the most part, your average scientist will be familiar with the main tips and is likely already practicing many of them. Therefore, the text is most suitable to those who are pondering a scientific career or perhaps embarking on the early throes of one. However, "Who wants to be a Scientist?" offers sound advice and may also represent a useful refresher to the practicing scientist.

Copies can be ordered directly from Cambridge University Press: Tel. (03) 9676 9955 or www.cambridge.edu.au

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how to achieve the goal. Alas, the reader is doomed to disappointment. The simple conclusion is that there is no simple answer. We can't blame the authors for this, but we can fulfill their closing wish: that armed with the knowledge and understanding from their text, each reader will go on to "practice the principles of sustainable energy and communicate to others the importance of more sustainable energy options in our workplaces and communities."

I wholeheartedly recommend this book to anybody with an interest in the direction the energy industry is heading—or should be heading. I challenge anybody to read it and not emerge at the other end with a profoundly broader understanding of the importance, issues and challenges of moving towards globally sustainable energy practices, and perhaps some guidance as to how to choose among the many options.

Aims and Scope

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

Contents

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Contributions

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

The text of all articles should be transmitted as a Word document. Tables, figures and illustrations should be transmitted as separate files, not embedded in the Word document. Raster images should be supplied as high-resolution (300 dpi) tiff files wherever possible. Vector plots can be supplied using software packages such as Corel Draw or Illustrator. Illustrations produced in any other software packages should be printed to postscript files. Authors are encouraged to contact the publisher, RESolutions, for information to assist in meeting these requirements.

References

References should follow the author (date) system as used by the SEG (see their website for full details). When reference is made in the text to a work by three or more authors, the first name followed by et al. should be used on all occasions. References should be listed in alphabetical order at the end of the paper in the standard form:

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

Abbreviations and units

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

Deadlines

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

Advertisers

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

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

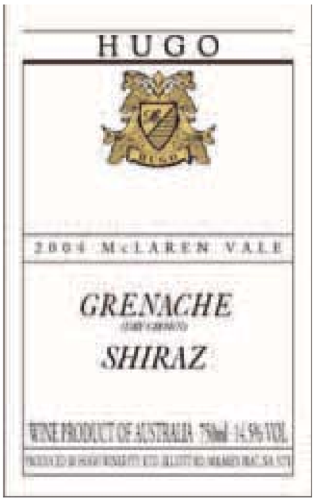
Preview Issue	Text & articles	Advertisement
125 Dec 2006	15 Nov 2006	22 Nov 2006
126 Feb 2007	15 Jan 2007	22 Jan 2007
127 Apr 2007	15 Mar 2007	22 Mar 2007
128 Jun 2007	15 May 2007	22 May 2007

ASEG 2006 WINE OFFER

The ASEG SA Branch is pleased to be able to present the following wines to you after tasting a field of wines in the price range. These wines were found by the tasting panel to be enjoyable drinking and excellent value. The price of each wine includes bulk delivery to a distribution point in each capital city in mid-December. Stocks are limited and orders will be filled on a first-come, first-served basis.

Please note that this is a non-profit activity carried out by the ASEG SA Branch committee. The prices have been specially negotiated with the wineries and are not available through commercial outlets. Compare prices if you wish but it is important that you do not disclose them to commercial outlets.

Hugo 2004 McLaren Vale Grenache Shiraz



The 2004 Hugo Grenache Shiraz is a silky number with a fragrant nose and a generosity of flavour, typical of the McLaren Vale wine region.

Being a deep plum in colour with hints of violet, this wine exhibits fruit scents of cherries and ripe plums with lingering notes of cloves and a pinch of white pepper. This wine is a pleasure on the palate with lifted berry and small stone fruit flavours, with delicate spice and pepper, complimented by fine, well structured tannins and a wonderfully soft finish. Chefs love this blend as it is truly a “Food Friendly” combination, not unlike the traditional “Rhone” blends, with the attractive nutty characters and silky, approachable tannins.

An excellent accompaniment to paella, tomato based pastas, moussaka or lamb.

Awarded 5 Stars - Winestate Magazine, May/ June 2006.

Retails at $220/case, ASEG price $125/case

St Hallett Poachers Blend 2006

The St Hallett Poacher’s Blend embraces the spectrum of aromatics and fresh, tropical fruit flavours typical of Semillon and early picked Sauvignon Blanc in the Barossa as well as a hint of citrus.

This wine leaps from the glass with intense aromas of citrus and tropical fruit, passionfruit, melon and pineapple with underlying lime and grassy aromas. The palate is full-flavoured exhibiting an array of fruity flavours that persist over the length of the palate The slightly phenolic backbone provides structure and mouth feel, which is balanced with zingy crisp acidity. Enjoy with spicy Thai dishes, crustaceans and fish.

Retails at $150/case, ASEG price $115/case

- -

2006 ASEG WINE OFFER: Orders close NOVEMBER 13th 2006

Please supply:

Number of dozens	Wine	Price per Dozen	Total
	Hugo Grenache Shiraz 2004	**$125**	
	St Hallett Poachers Blend 2006	**$115**	
	(includes GST)	**TOTAL**	

Name: ______________ Daytime telephone: (___) _____________ Email address ________________________

Address: ____ Capital city for collection: ______________

I would like to pay by: [ ] Cheque – payable to ASEG SA Wine Offer (enclosed) ; or

through on-line ordering and credit card payment at: www.aseg.org.au (click on Wine Offer on Home Page); or

[ ] Bankcard [ ] Visa [ ] Mastercard Card Expiry date: __ __ / __ __

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Atlantis B-Field DHEM System

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

In TEM surveys Atlantis can detect good conductors further from a borehole than conventional dB/dt measurements and can easily discriminate good conductors from weaker ones. Importantly, the cross-hole sensors have the same instrument noise level as the axial sensor.

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

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

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

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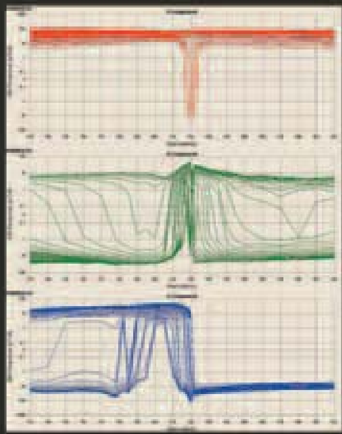
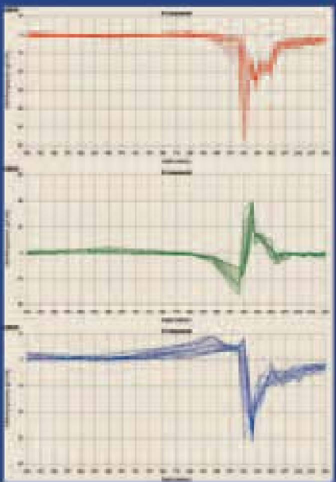
of Wes



It says that new copy should be
coming for this advert
on thursday the 5th



Inco … Sudb…

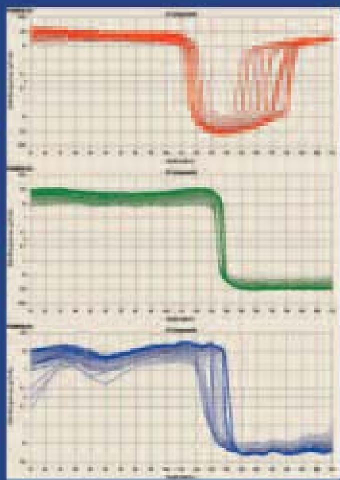
Inco … using an Atlantis system in the Sudbury Basin since late 2004 to define nickel exploration targets. Shown here (left) is an example of late-time EM data from the Sudbury area. It was acquired at a base frequency of 3 Hz in a borehole which intersected the edge of Cu/NiS bodies between 900 and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

Data provided courtesy of Inco Exploration, Sudbury.

… .A.

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

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



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

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

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

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

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