Preview

Australian Society of Exploration Geophysicists

ABN 71 000 876 040 ISSN 1443-2471 April 2005 Issue No.115

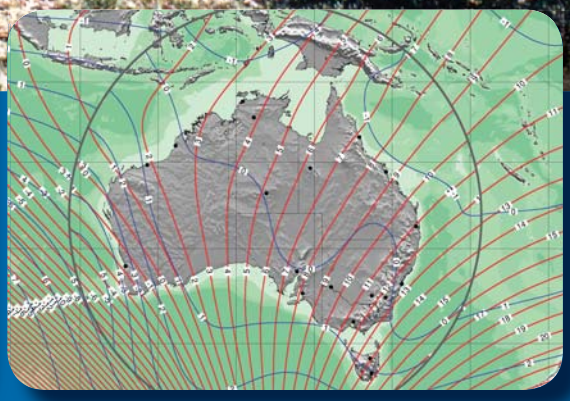
GEOPHYSICAL ANNIVERSARIES

A geophysicist and some camels

page 16

Geophysics at Newmont – a history of innovation and development

page 19



New geomagnetic field models released

page 29

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ASEG 2004: Annus Plenus

How many articles have been written in journals such as this about "What this organisation means to you"? In this, my ultimate President's Piece, I considered a similar banal theme about which to write, to convince ASEG members that their organisation is a worthwhile one and that their membership adds value to them in a demonstrable way. Bored with this approach and about to give up, I suddenly realised that the benefit of belonging to a multidisciplinary geophysical society like the ASEG was staring me in the face, and it looks like this:

In Australia, one of the hottest topics in petroleum geophysics is seafloor electromagnetics and one of the hottest topics in mining geophysics is high resolution seismic.

There. It's said, and I could stop there. The value of an organisation in which diverse specialists can trade expertise for the good of all needs little further elaboration. Consequently, I need not proselytise. But now that I have the floor I won't pass up the opportunity to recap the past year's accomplishments in advance of the upcoming Annual General Meeting, where a similar summary of the past year will be presented and new officers elected.

Inter-society Cooperation

ASEG was represented this year at meetings of the European Association of Geoscientists and Engineers (EAGE), the SEG of Japan (SEGJ), the South African Geophysical Association (SAGA), the SEG and the geological SEG. Agreements of cooperation were signed this year with EAGE and SAGA. Similar agreements with the Korean SEG (KSEG) and the Environmental and Engineering Geophysical Society (EEGS) will be completed and signed in the coming months.

Farther afield, ASEG this past year provided underwriting support of the Australian Institute of Physics (AIP) 16th National Congress 2005 in February, and provided endorsement for the 12th Annual Cultural Heritage and Native Title Conference 2005 being held in Perth this month.

Publications

EG and *Preview* were published this year in the usual way, informing the geophysical community and attracting the high quality articles the ASEG membership have come to expect. Publications chair Terry Crabb and editors David Denham and Lindsay Thomas have worked tirelessly to produce and distribute the journals, and my appreciation to them knows no bounds.

ASEG has worked with SEG Japan in their publication of the *Manual of Geophysical Surveys for Engineering and Environmental Application*. This is a publication that SEGJ published in Japan in 2001 and was subsequently translated into English. Fifteen Australian geoscientists, of whom thirteen are ASEG members, contributed to refining the translated English text and proposing technical suggestions.

In a major advancement in publication modernisation, ASEG this year moved closer to full electronic publication and distribution of its technical journal, *Exploration Geophysics*, with the release of a complete collection of past issues - from Volume 1 (1970) to Volume 34 (2003) — as a two-DVD set, a Herculean task led by the outstanding efforts of David Howard

Work continues toward the goal of full electronic publication and online distribution of *Exploration Geophysics* and *Preview*. Three key issues are being addressed: accessibility, cost and methodology.

Education

The 2004 Distinguished Instructors Short Course (DISC), featuring Paul Weimers addressing *Petroleum Systems of Deepwater Settings* was held in Perth, and as a symposium in conjunction with the 2004 ASEG-PESA Conference and Exhibition in August in Sydney. Attendance levels approached 100, a number we hope to improve upon in 2005 with the reprise of the DISC program.

A workshop entitled *Risk Assessment in prospect evaluation from a geophysical viewpoint* was held in Perth in July, built around the SEG 2004 Spring Distinguished Lecturer, Bill Abriel and his talk entitled *Earth Model Complexity and Risk Description in Resource Exploration and Development*. A series of excellent talks from a number of industry speakers, and insightful commentary from a number of participants resulted in a very successful workshop.

The EAGE Distinguished Lecturer this year was Paolo Dell'Aversana. His lecture was entitled *Time-depth processing of global offset data: a new perspective for seismic imaging in thrust belts*. He was the second keynote speaker in an ASEG Conference session called Innovative Seismic Methods, following Peter Duncan, SEG President, with his talk *Passive seismic*: *when, where and why*.

ASEG sponsored the development of the short course *Information from Geospatial Data for Natural Resource Management*. The three day course, aimed at giving scientists working in landcare a better understanding of how geophysics can help them, was assembled primarily through the efforts of Greg Street. The course has been run twice in Perth and once in Orange, NSW, and is available for future sessions.

The ASEG Research Foundation was active again this year, selecting two students, Ian Wilson and Jhana Hale, for funding of research projects in geophysics. With the booming petroleum and mining industries heating up the market, the Foundation is hoping for even more applications next year.

In another effort to assist in the education arena, two ASEG student members, Yusen Ley and Don Sherlock, received grants to assist in offsetting costs associated with travelling to Denver to present papers at the SEG conference. Students in Australia benefited from ASEG largesse as well, with one student from each state branch receiving a stipend to attend the ASEG Conference in Sydney.

This year, for the first time, ASEG contributed a Geophysics module to the Indigenous Australian Engineering Summer School. ASEG members Mike Moore, John Peacock, Derecke Palmer, Carina Simmat and the author spent an afternoon with 22 highly motivated year 11 and 12 Indigenous students selected from across Australia. The day was satisfying for all concerned, but the success will ultimately be measured by how many of these students were impressed enough on the day to study geophysics at a tertiary level.

Conference

The 17th Annual ASEG Conference and Exhibition in Sydney was an unqualified success. With a budget of more than $1 million, the August 2004 Conference attracted almost 600 delegates, while exhibitors filled 94 booths. Attendees from 23 countries were able to benefit from four simultaneous technical sessions over four days. The Conference Committee, chaired by Barry Smith and Tim Pippett, is to be heartily congratulated.

Work is already in progress for the next conference in Melbourne in 2006, a joint event to be sponsored by ASEG and GSA. The ASEG Conference to be held in Perth in 2007 is in the planning stages as well.

Membership

Maintaining membership records is a complex and thankless job, done tirelessly by Koya Suto. Koya reports that renewals are currently in progress from over 1,200 members on last years roles. The categories of Active, Associate, Emeritus, Student, and Honorary continue, with an added Associate category now available for members of societies with an interest in geophysics, such as physicists' and teachers' organisations.

ASEG is proud to boast 26 corporate members, all of whom are listed in the 2004 Membership Directory. Two of those members, Seismic Asia Pacific and Eni Australia, are new members whom we hope will feel welcome for years to come.

ASEG organisation

One of the most profound changes to the ASEG organisation in the past year was the move to a new secretariat. CASM, based in Perth, has taken on the behind-the-scenes duties that keep the machinery of ASEG ticking over. The few glitches caused by the changeover are almost all ironed out. We welcome CASM to our organisation.

The new ASEG constitution approved at the last AGM in March 2004 is now in force, and officially registered with ASIC. The new constitution deals with everyday rules of the society, and ensures that the organisation complies with applicable legislation. Part of that compliance is related to financial control and, to that end, a new centralised banking system has been set up in ASEG. This process was more complex that anyone had anticipated, and it must be said that it is a work in progress, that in the end will result in less work for State treasurers and better bookkeeping for the organisation as a whole.

Another organisational adjustment this year was the addition of a voting position on the Federal Executive for a representative of state branches, appointed by the State presidents. Don Sherlock of WA has filled this role; a role that I hope will become more important as time goes on.

So many successes are recorded by committees and their chairs in the state branches, and by ASEG members, that it would be impossible to list them all. The above just scratches the surface of the breadth and depth of an organisation made up exclusively of volunteers, an organisation with which I am proud to be associated.

Howard Golden

Geophysics represented in AIP's International Year of Physics

Gary Nairn MP, Federal Liberal Member for Eden-Monaro and Parliamentary Secretary to the Prime Minister opens the 16th Australian Institute of Physics Biennial Conference in Canberra. Mr Nairn is one of the few MPs with a direct science connection; he was involved in the surveying of the super proton synchrotron (SPS) ring at CERN before he turned to politics.

The Australian Institute of Physics' year of celebration started impressively with one of the most successful Physics Congresses ever held in Australia. The 16th Biennial Australian Institute of Physics Congress was held in Canberra between 30 January and 4 February and provided the launching point for the AIP's Einstein International Year of Physics, which celebrates the amazing achievements of a young, 26 year old, Einstein in 1905. The ASEG, as a participating society, was part of the action.

Around 1000 delegates from 18 countries attended the congress. It attracted national and international speakers, including two Nobel Prize winners, Steven Chu (1997 Prize Winner) and Tony Leggett (2003 Prize Winner), and an outstanding series of Plenary Speakers. These included excellent presentations by Edwin van Leeuwen of BHP Billiton, who spoke about their program to develop and use airborne gravity gradiometry for resource exploration, and Graeme Pearman from Monash University who must have provided a wake-up call to the few remaining skeptics of global warming.

The applied and recreational physics streams were strongly supported with sessions on climate change, astronomy, gravitation waves, acoustics and music, and biophysics, the latter being particularly successful. The strengths of these sessions underline the importance of multi-disciplinary linkages throughout the sciences and being able to build on basic research results to make significant advances.

Apart from the geophysics section, which comprised an excellent series of talks on the structure and dynamics of planet Earth, the most interesting sessions I attended were on climate change. I will mention three papers that I found to be of particular interest. These dealt with the 20% rainfall decrease in Southwest WA since the 1960s, the overall **decrease** in evaporation rates both in Australia and overseas, and the way the Arctic ice cap is melting as a result of attacks from both above and below.

I think most people are aware of the recent climate change in WA - the winter rains being pushed farther south as a result of global warming, but the decrease in evaporation rates was new to me and at first sight is counter-intuitive.

As Michael Roderick from the CRC for Greenhouse Accounting said: "It has long been assumed that surface warming, as a consequence of the greenhouse effect, would result in increased evaporation over the land surfaces. However, while the surface has steadily warmed over the last 50 years (particularly with the minimum temperatures gradually increasing), the evaporation rate has steadily declined' (by ~3 mm/yr/yr globally).

The observations appear to be sound and consistent, so why is this happening?

The answer appears to be that the land surface is becoming more like a gardener's greenhouse with less sunlight and an overall increase in vapour pressure."

The other paper that I found to be of interest was by Stewart Turner from RSES. He argued that the Arctic ice cap is probably being attacked from both above and below. Observations over several decades indicate that a layer of warm water has been advancing across the Arctic Ocean below the halocline (the region of rapid change in salinity with depth in the ocean) and that the sea ice is now melting at an increased rate. He showed that the extra heat supplied beneath the ice, coupled with the increase in the air temperature above the ice, could well explain the current rapid melting rate.

Hence the implications, not only for polar bears, but for all northern Europeans if the Gulf Stream is suddenly turned off.

Anyway, all the abstracts are available at: http://aipcongress2005.anu.edu.au/index.php?req=CongressProceedings, or on CD from the AIP.

ASEG participates in Indigenous Summer School

As reported in the President's Piece in the December 2004 *Preview*, ASEG participated in The Indigenous Australian Engineering Summer School (IAESS). The summer school, established 8 years ago by Engineering Aid (a non-profit organisation), is designed to attract Indigenous students with an aptitude in maths, science and technology to consider engineering or geophysics as a career. The Summer School is organised by the University of NSW (UNSW) Faculty of Engineering, Nura Gili Indigenous Programs at UNSW, and Engineering Aid. Applicants are selected for IAESS on the basis of their interest in useful engineering subjects (mathematics and science) and personal initiative and outlook.

Fig. 2. Students of the 2005 IAESS summer school program with organiser Jeff Dobell, far left, and ASEG volunteers (Carina Simmat, PhD student at UNSW; John Peacock, Fugro Ground Surveys; Howard Golden, ASEG President & WMC; Michael Moore, President of NSW ASEG Branch & NSW GS; and Derecke Palmer University of NSW) standing on the right.

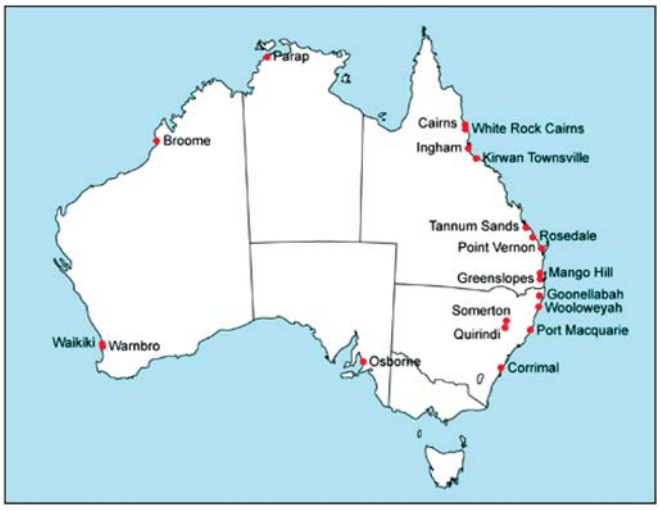

Fig. 1. Map showing the home bases (red dots) of indigenous students attending the 2005 IAESS summer school program in Sydney.

This year, twenty-two Indigenous students from across Australia (see Figure 1) gave up part of their summer holidays to learn about geophysics and engineering at UNSW.

ASEG members Michael Moore, Derecke Palmer, John Peacock, Carina Simmat and Howard Golden spent a portion of the summer school with the students at

Bankstown airport at Fugro Airborne Survey's facility (see Figure 2).

At this facility the ASEG volunteers and indigenous students engaged in a lively discussion about what exploration geophysics is all about, what is necessary to become qualified as a geophysicist, and what a geoscientist could do to benefit rural and Indigenous communities. The students were treated to a tour of airborne and ground geophysical equipment and saw examples of regional Australian geophysical data sets.

The day was a resounding success, prompting one student to write that the session "has opened my eyes to an exciting career in the wonderful world of geophysics."

Fig. 3. Carina explaining some of the technicalities.

Fig. 4. Howard with radar smart cart.

Fig. 5. John relaxing with two of the participants.

Fig. 6. Michael Moore hard at work explaining the complexities of geophysics.

2005

23-27 May
2005 AGU Joint Assembly
Venue: New Orleans, Louisiana, USA
Website: www.agu.org

6-7 June
11th Annual South East Asia Australian Offshore Conference
Venue: Darwin, NT
Email: rreilly@iir.com.au
Website: www.seaaoc.com

13-16 June
67th EAGE Conference & Exhibition
Venue: Madrid, Spain
Website: http://www.eage.nl/conferences/

16-17 August
Central Australian Basins Symposium (CABS) 2005
Theme: Minerals and petroleum potential
Venue: Alice Springs (details TBA)
Contact: Greg Ambrose, Northern Territory Geological Survey
Email: greg.ambrose@nt.gov.au

19-23 September
22nd International Geochemical Exploration Symposium
Sponsors: The Association of Exploration Geochemists
Theme: From Tropics to Tundra
Venue: Sheraton Hotel, Perth, WA
Website: www.promaco.com.au/conference/2005/iges

6-11 November
SEG International Exposition & 75th Annual Meeting
Venue: Houston, Texas, U.S
Website: www.seg.org

5-9 December
2005 AGU Fall Meeting
Venue: San Francisco, California, USA
Website: www.agu.org/meetings

2006

2-7 July
The Australian Earth Sciences Convention 2006
ASEG, in collaboration with GSA; ASEG's 18th International Conference and Exhibition, and GSA's 18th Australian Geological Convention
Venue: Melbourne, Vic.
Website: www.earth2006.org.au

2007

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

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

The material published in *Preview* is neither the opinions nor the views of the ASEG unless expressly stated. The articles are the opinion of the writers only. The ASEG does not necessarily endorse the information printed. No responsibility is accepted for the accuracy of any of the opinions or information or claims contained in *Preview* and readers should rely on their own enquiries in making decisions affecting their own interests. Material published in *Preview* becomes the copyright of the Australian Society of Exploration Geophysicists.

Contributions

All contributions should be submitted to the Editor via email at denham@webone.com.au.

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

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.

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 **June 2005 issue is 15 May 2005**.

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 June 2005 issue will be 22 May 2005. A summary of the deadlines is shown below:

Preview Issue	Text & articles	Adverts Copy In
116 Jun 2005	***15 May 2005***	***22 May 2005***
117 Aug 2005	15 July 2005	22 July 2005
118 Oct 2005	15 Sep 2005	22 Sep 2005
119 Dec 2005	15 Nov 2005	22 Nov 2005

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[1] Members and chairpeople of ASEG's Standing and ad hoc Committees can be found on the ASEG website.

New Members

The ASEG welcomes the following new members to the Society. Their membership was approved at the Federal Executive meetings on 19th January and 23rd February 2005.

Essam Aboud Aboudeshish
Kyushu University *Japan*

Graeme Ross Beardsmore
Monash University *Vic*

Mark Patrick Brincat
CSIRO Petroleum *WA*

Grant Malcolm Butler
Grant Geophysical *ACT*

Tad Choi
Woodside Energy Ltd *WA*

Michael Benedict Clennell
CSIRO Petroleum *WA*

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CSIRO *WA*

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Beach Petroleum *SA*

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Andrew Robert King
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Kerry Lewis
Woodside *WA*

Duncan Alistair Lockhart
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Alan Melville Tait
Sedimental *WA*

Hillary Todd
BHP Billiton *Vic*

John Campbell Tompson
RPS Hydrosearch *WA*

Andrew David Tyson
University of Tasmania *Tas*

Christopher James Wallace
DeBeers India pvt Ltd *India*

Claybon Mark Wallis
Australian School of Petroleum *SA*

Sandy Watters
Santos Ltd *SA*

Shane Westlake
PGS Australia Pty Ltd *WA*

Peter Williams
Independence Gold NL *WA*

Denis Edwin Winch
University of Sydney *NSW*

Takao Yagi
INPEX Alpha Ltd *WA*

Branch News

Australian Capital Territory – by Adrian Hitchman

The year began with the ACT Branch's AGM on 16 February. The President's and Secretary's reports were a reminder of the active year enjoyed by the Branch in 2004. The 2005 committee elected at the meeting comprise:

President:	Jacques Sayers
Vice President:	Alice Murray
Secretary:	Adrian Hitchman
Treasurer:	Mario Bacchin
Committee:	Leonie Jones
	Peter Milligan
	Brian Minty
	Matthew Purss
	Nick Rawlinson
	David Robinson

The Branch is grateful to outgoing President, Ben Bell, and Treasurer, Eva Papp, for their service during their teams in office. We are also grateful to those members who have volunteered to join or continue to serve on the committee. Their contributions to supporting branch activities are invaluable.

Immediately following the AGM members enjoyed excellent talks by Cvetan Sinadinovski and Phil Cummins (Geoscience Australia) on *The Great earthquake/tsunami event of 26 December 2004*. Cvetan was the duty seismologist at Geoscience Australia when the eartquacke occurred. Phil has been modelling tsunamigenic seismic activity and published in September 2004 a prescient article warning of the need for a tsunami-modelling network in the Indian Ocean. Both Cvetan and Phil were prominent in the media in the immediate aftermath of the tsunami, and the Branch was fortunate to benefit from their expertise during their highly informative and topical presentation.

This year is shaping as another active year for the Branch with talks by international speakers in the pipeline. A complete program of presentations/workshops will soon be formulated.

We welcome new members and visitors who may wish to participate in branch activities. Please contact Adrian Hitchman (02 62499800, adrian.hitchman@ga.gov.au) or Jacques Sayers (02 6249 9609, jacques.sayers@ga.gov.au) with enquiries.

New South Wales – by Naomi Osman

The NSW branch held its first meeting of the year and it's AGM in February. The 2004 office holders were re-elected unopposed. Michael Moore will continue as President, Roger Henderson as Treasurer and Naomi Osman will stay on as Secretary. Carina Simmat will remain the student liaison officer and Peter Gidley our webmaster. The President's and Treasurer's reports can both be found on the branch website.

Following the AGM, various members spoke about what they had been involved with over the recent months. Mike Moore reported on the involvement that he, Howard Golden and other branch members had in enticing students at the Indigenous Australian Engineering Summer School to consider a career in geophysics (see the President's Piece in this issue of *Preview*). They spent an afternoon at Heli-Aust's hanger at Bankstown airport and chatted to the students about geophysics, as well as showing them around various pieces of geophysical equipment - the highlight of which was a helicopter with magnetometer attached. Thanks go to Fugro and Heli-Aust for their time and use of facilities and equipment, and to John Peacock, Derecke Palmer and Carina Simmat for their assistance. Mike Smith then filled us in on how the Mineral Exploration Action Agenda (MEAA) implementation group has decided that geophysics must have a dominant role and discussed how the ASEG could be involved. Finally, Roger Henderson spoke on how he has made contact with members of the first ASEG Federal Committee 35 years later (see February's edition of *Preview*) and what is planned to acknowledge their work. The meeting concluded with discussion on the form and venue of future meetings, with an unanimous decision being made to maintain the current arrangements.

We would also like to extend an invitation to interstate or overseas visitors to attend NSW meetings if they happen to find themselves in Sydney. The meetings are usually held on the third Wednesday of the month at 5:30 pm at the Rugby Club, Rugby Place (near Pitt & Alfred St). The meeting notices and relevant contact details can be found on the NSW branch website.

Freeware/ Shareware for Geoscientists

The last few years has seen a proliferation of free downloadable software on the internet. Software developers around the world are taking advantage of the freeware/shareware or "try before you buy" method of marketing their products. The benefit to us, the geoscience community, is obvious – software for nothing. We have the opportunity to make a thorough evaluation prior to registering for or purchasing the software. So why do developers make their product available free over the Internet? The idea behind this type of marketing is simple: developers pay a fraction of the price for marketing than their 'commercial' software competitors. With a large community of users, the developers receive feedback, allowing authors to feed more money into improving and developing their software. So shareware/ freeware is a win-win situation for developers and users alike.

Software made freely available over the Internet is generally made available 'as is' with no warranties or technical support. Authors retain rights to software under copyright laws, so be sure to check the copyright statement, to check what restrictions authors have placed on their software before use.

Whether you are a hard or soft-rock geophysicist, you will find plenty of free software applicable to your field of interest available on the Internet. These websites should get you started.

CWP – ★★★★
The Centre for Wave Phenomena: Colorado School of Mines

http://www.cwp.mines.edu/cwpcodes
http://www.cwp.mines.edu/software

Center for Wave Phenomena Colorado School of Mines

This is the homepage for Seismic Unix or SU – a public domain seismic processing software package developed at the Colorado School of Mines and maintained by the Centre for Wave Phenomena. The CWP supports research into seismic exploration, with the main focus in seismic modelling, migration and inversion methods, as well as improving the accuracy and efficiency of computation algorithms for seismic data processing.

Where commercial software packages are used for production work, SU can be used alongside as a prototyping package. Also, if new code needs to be written, SU can provide a starting base for new software applications. SU runs on numerous UNIX operating systems and also on Linux platforms.

Other free code available from this site includes:

- **BHP_SU** suite of programs - a collection of Seismic UNIX applications used for random reading and writing of seismic data cubes. Special file formats make it possible to rapidly examine large volumes of data. This software runs on Solaris, IRIX and Linux platforms. New releases appear every three to six months.
- **BHPViewer** - an open source product of DownUnder GeoSolutions (see http://www.downundergeo.com). BHPViewer is a platform independent package used to manipulate and view multidimensional data. This graphical tool can be used with BHP_SU codes. Professional support contracts are available with this product. Look out for the new version, due to come out this month.

DownUnder GeoSolutions

Henry Thorson Consulting
Customized Computer Applications

- **TKSU** – an interactive graphical user interface developed by Henry Thorson Consulting, for the Seismic Unix processing package. It can be considered the interactive 'front end' to the Seismic Unix. It provides the ability to interactively build a processing flow out of SU modules. See http://www.henrythorson.com/software for more information.

BPAmoco's UNIX Seismic Processing (USP) Software ★★★★1/2

http://www.freeusp.org

FreeUSP.org

FreeUSP is a collection of signal analysis and seismic processing routines (over 450) originally written at Amoco Production Company's Tulsa Research Centre over the last 40 years. These routines are capable of handling a wide variety of data types including 2D and 3D seismic, VSP, potential field, full waveform borehole, multi-component, cross-well and synthetic. The USP toolkit offers an efficient method to construct and test new scientific algorithms.

Under *>FreeUSP >Toolkit >Functionality Listing*, you will find a list of subroutines categorically listed under subheadings. Some of these include attribute extraction, deconvolution, DMO, format conversion, inversion, migration & modelling.

Opendtect – 3D Seismic interpretation software ★★★★

http://www.opendtect.org

Released in 2003, OpendTect is both a functional seismic interpretation system and a platform for fast-track development of plugins. OpendTect Base, the open source part of the system, runs without license manager restrictions and can be extended with commercial plugins for more functionality. The system enables you to process, visualise and interpret multi-volume seismic data using attributes and modern visualisation techniques such as stereo viewing and volume rendering. OpendTect is currently supported on PC-Linux, Sun-Solaris, SGI-Irix, MS Windows (2000/NT/XP) and Mac-OSX.

NetLib – a collection of mathematical software, papers & databases ★★★

www.netlib.org

netlib

The Netlib website contains freely available software, documents, and databases which may be of interest to the numerical and scientific computing communities. The repository is maintained by AT&T Bell Laboratories, the University of Tennessee and Oak Ridge National Laboratory, and by colleagues world-wide. The collection is replicated at several sites around the world, automatically synchronised, to provide reliable and network efficient service to the global community.

University of Missouri-Rolla: Electromagnetic Compatibility Laboratory ★★★

http://www.emclab.umr.edu/codes.html

UNIVERSITY OF MISSOURI-ROLLA
ELECTROMAGNETIC COMPATIBILITY LABORATORY

This site provides a large list of computational electromagnetic modelling codes available on the Internet in alphabetical order.

Emlib ★★★★1/2

http://emlib.jpl.nasa.gov/

This site has been created for the free distribution of electromagnetics software and related information such as conference information, other EM sites, and a user-defined searchable directory of people working in the EM field. The EMLIB staff actively encourage colleagues with appropriate material to deposit it here so that it can be shared (and perhaps even improved) by the greater community of EM workers. Such material includes:

- EM analysis codes (for propagation, scattering, microwave devices, etc.);
- Math functions/subroutines of particular interest to the EM community;
- Functions or modules for use with commercial analysis or visualisation codes such as Mathematica, MATLAB, AVS, etc; and
- Graphics utilities with EM applications.

Anthony Lomax – Seismolog Scientific Software: Software for the observation, analysis & understanding of seismological information. ★★★★

http://alomax.free.fr/nlloc/index.html
http://alomax.free.fr/software.html

This site hosts a set of programs written by Anthony Lomax for velocity model construction, travel-time calculation and probabilistic, non-linear, global-search earthquake location in 3D structures, and for visualisation of 3D volume data and location results. The site includes updates on new releases and program bugs.

There are four packages which may be of interest to geoscientists:

- **Seismicity Viewer** - an interactive, animated, 3D visualisation of hypocentres and associated probabilistic errors and geographic data;
- **SeisGram2K** – for interactive visualisation and basic analysis of earthquake seismograms;
- **QuakeExplorer** – this package lets you rapidly explore, visualise and analyse the latest earthquake events and associated seismic traces over the Internet; and
- **NonLincLoc** – Used to calculate probabilistic earthquake location in 3D media, to construct velocity models, travel times and for visualisation.

SIOSEIS ★★★

http://sioseis.ucsd.edu/

SIOSEIS is a software package for enhancing and manipulating marine seismic reflection and refraction data, sponsored by the National Science Foundation (NSF) and the Scripps Industrial Associates. The system currently runs on SUN, HP, SGI, Mac OSX, and Linux PC.

ORFEUS Seismological Software Library ★★★★★

http://orfeus.knmi.nl/

ORFEUS - Observatories and Research Facilities for EUropean Seismology. The premier site for free seismological software! ORFEUS is a European non-profit organisation that aims to coordinate and promote digital broadband seismology in Europe. Its site has an extensive software library, with links to numerous seismological freeware/shareware. This site has programs for mathematical operations, gridding, optimisation, statistics, graphics, modelling, ray tracing, earthquake location, hazard analysis, signal processing, data analysis, data viewing, data processing or data management just to name a few. The ORFEUS website maintains an updated record of recent earthquakes, and has links to seismological institutes, geoscience institutes, professional organisations, maps, publications…phew…the list goes on. The ORFEUS webpage is currently under development. The new website (www.orfeus-eu.org) is due to be completed late April, so stay tuned.

S. Sheriff's Geoscience Programs ★★1/2

http://www2.umt.edu/Geology/faculty/sheriff/Sheriff_Vita_abstracts/Sheriff_software.htm

These programs are written by Steven Sheriff, Professor of Geology at the University of Montana, for teaching, research, recreational and commercial purposes. Programs available include 2D gravity & magnetic modelling, 1D electrical resistivity modelling & inversion and a program for the interactive visualisation of Fourier transforms and other filtering operations.

Geologynet ★★★★1/2

http://www.geologynet.com/programs/html/geophysics.htm

Geologynet is a website dedicated to all things geological. There are numerous links to freeware under the subjects of geophysics, astronomy, geochemistry, mapping, maths, mining, mineralogy, palaeontology & structural geology. Programs with geophysical applications include Euler deconvolution, gravity & magnetic modelling, seismic interpretation, signal processing, SP inversion and resistivity inversion. The site also includes links to geoscience associations, websites, books & journals, computer software, freeware & hardware, geological surveys etc. Check out the minerals database, under geology web links. If only I had known about that in my Geology 101 class!

As an editorial addition: I came across a reference to a freely available ray tracing software in the 1st March issue of the AGU's EoS (Vol 86 No. 9), which may also be of interest to members. The program is named RayGUI 2.0, and provides a graphical user interface for interactive forward and inversion ray-tracing.

RayGUI 2.0 uses an updated Java version (1.3), and can run on various operating systems (UNIX, Linux, and Mac OS X). Several new functions have been incorporated, including:

- Execute the forward and inversion codes;
- Create models or add new parts of models from an ASCII file;
- Graphically add layers or points;
- Graphically pinch layers;
- Change the velocity value of a control point;
- Report point location and velocity;
- Import travel time lists;
- Generate postscript files;
- Export the velocity model into an ASCII file;
- Generate 1D velocity profiles at specified locations;
- Calculate root-mean-square errors between observed and calculated arrivals for selected phases;
- Access the ray trace log; and
- Several other new display features.

RayGUI 2.0 enables the user to graphically edit a velocity model, to select ray type, to select shot and to change the ray-tracing parameters. The package can be obtained freely for non-commercial purposes by contacting Uri ten Brink at utenbrink@usgs.gov. More details and the complete manual can be downloaded following the link: http://pubs.usgs.gov/of/2004/1426/ or USGS Open-File Report 2004-1426 (PDF format).

David Denham

Some interesting inquiries

While bureaucrats in the Treasury were preparing the 2005 Budget, some interesting inquiries are being undertaken in other parts of government.

Inquiry into developing Australia's non-fossil fuel energy industry

An inquiry into Australia's non-fossil fuel energy industry was initiated by Federal Resources Minister Ian Macfarlane on 17th March 2005.

This is being conducted by the Industry and Resources Standing Committee chaired by Geoff Prosser MP, and will begin with a case study on Australia's uranium resources, under the following terms of reference:

a. Global demand for Australia's uranium resources and associated supply issues;

b. Strategic importance of Australia's uranium resources and any relevant industry developments;

c. Potential implications for global greenhouse gas emission reductions from further development and export of Australia's uranium resources; and

d. Current structure and regulatory environment of the uranium mining sector (noting the work that has been undertaken by other inquiries and reviews on these issues).

The inquiry will not examine the domestic use of nuclear energy.

The committee invites interested persons, organisations and companies to make submissions addressing the terms of reference by 6th May 2005. Submissions should be sent electronically to: ir.reps@aph.gov.au.

Issues papers to affect universities

On 29th and 31st March respectively, the Government released two important documents affecting research and future governance structures of universities.

The first is an issues paper on the proposed **Research Quality Framework (RQF)**: ***assessing the quality and impact of research in Australia***. This paper has the potential to make major impacts on resource allocation for research. According to Minister Nelson, it will provide "the basis for developing a Research Quality Framework to measure both research excellence and research impact. The framework will provide a more consistent and comprehensive approach to assessing publicly funded research and will provide a sound foundation for future research resource allocation."

The process for developing the framework will be led by a world expert on research quality assessment, Professor Sir Gareth Roberts, who has recently conducted a review of the UK's Research Assessment Exercise. Sir Gareth is President of Wolfson College, Oxford and a member of the Higher Education Funding Council of England Board.

The RQF Issues Paper and Submission Template can be obtained from DEST's web site http://www.dest.gov.au/resqual/issues_paper.htm. Interested stakeholders are invited to make submissions before the closing date of 2nd May 2005.

The second is a discussion paper on re-aligning Commonwealth and State responsibilities for higher education.

The Australian Government currently has significant financial and policy responsibility for higher education, while the States and Territories retain major legislative responsibilities. The discussion paper, **Building Better Foundations for Higher Education in Australia: *a discussion about re-aligning Commonwealth-State responsibilities***, examines the merits or otherwise of changing these arrangements.

The paper outlines some of the areas in which the current responsibilities have created overly complex arrangements and a lack of transparency. For example, legislative differences mean that universities cannot always operate on a level playing field when engaging in commercial ventures. Additionally, variations in the recognition and accreditation of universities and courses between jurisdictions have often been costly for providers seeking to operate in more than one State and Territory, and confusing for students.

Submissions are welcome until 20th May 2005. The minister plans to discuss the paper with his State and Territory colleagues at an upcoming Ministerial Council (MCEETYA) meeting in May. Maybe another opportunity for a lively State/Commonwealth interaction. Consultations will follow with key stakeholders during June/July. The discussion paper is available at: http://www.dest.gov.au/highered/pubs/papers/responsibility/.

National Research Priorities Standing Committee established

On 2nd March Minister Nelson announced the appointment of the National Research Priority Standing Committee.

This committee, to be chaired by the Chief Scientist, Robin Batterham, has been established to oversee the implementation of the National Research Priorities. It will also develop medium and longer term strategies.

Other members of the Committee and their areas of expertise are: Jim Peacock (science/CSIRO), Henrique d'Assumpcao (engineering/ICT), Hugh Morgan (business development), Sue Rowley (social sciences and humanities), Terry Enright (agriculture), Bob Beeton (environment), Suzanne Cory (biotechnology and medicine) and Brian Anderson (ICT).

For those with short memories, the four National Research Priorities are 'An Environmentally Sustainable Australia'; 'Promoting and Maintaining Good Health'; 'Frontier Technologies for Building and Transforming Australian Industries'; and 'Safeguarding Australia'.

The committee will also annually assess progress by agencies in implementing the priorities, and report to Government. Further details of the National Research Priorities are available on the website: www.dest.gov.au/priorities.

New Global data sets available via the Internet

Topography and bathymetry

Gridded data of topography and bathymetry of the earth's surface have become widely available via the Internet, thanks to the efforts of multiple research groups. These data are continually growing in importance both for monitoring operations and for scientific research. They are critical for the clear presentation of final results to end users.

An excellent site for this information is that developed and maintained by the University of Alaska: http://www.gina.alaska.edu/page.xml?group=data&page=griddata.

The Alaskans have combined three publicly available gridded data sets of topography and bathymetry to produce a single integrated data set (see Lindquist *et al.,* 2004, Global Topography and Bathymetry Grid Improves research Efforts: Eos, Trans. AGU, **85** (19), 186).

The three data sets are:

1. GTOPO30 data from the US Geological Survey;
2. The 1997 Global Bathymetry data set (from Smith and Sandwell 1997, Global seafloor topography from satellite altimetry and ship depth soundings: Science, **277**, 1956-1962); and
3. Version 1.0 of the International Bathymetric Chart of the Arctic Ocean (IBCAO) data set (Jakobsson *et al.,* 2000, New grid of Arctic bathymetry aids scientists and map makers: Eos Trans. AGU, **79**, 579).

The eight standard images that cover the earth are only about 3 Mb each so they are not super large to download. However, the gridded data sets for each 90º x 90º 'quadrant' are about 500 MB each so they are not so easily accessed.

Fig. 1. Image of the bathymetry and topography of the 'north east' quadrant of the Earth downloaded from the University of Alaska website given in the text.

An image of the 'North East' quadrant is shown below. Part of the 'South far-East' quadrant was shown on the cover of the December 2004 *Preview*.

Global Stress Maps

Another interesting source of global data is the World Stress Map (WSM) Project, which has facilitated the compilation of a repository for contemporary tectonic stress data from the Earth's crust (see http://www.world-stress-map.org). The 2004 release contains 13,853 data points from four types of stress indicators:

1. Earthquake focal mechanisms (76%);
2. Well bore breakouts and drilling induced fractures (17%);
3. *In-situ* stress measurements - overcoring, hydraulic fracturing, borehole slotter (3%); and
4. Young geological indicators - from fault-slip analysis and volcanic vent alignments (4%).

New data come from either direct contact with individual researchers, publications or catalogues.

The World Stress Map is used by various academic and industrial institutions working in a wide range of earth science disciplines such as geodynamics, hydrocarbon exploitations and engineering. The main operational areas where the stress data are used are as follows:

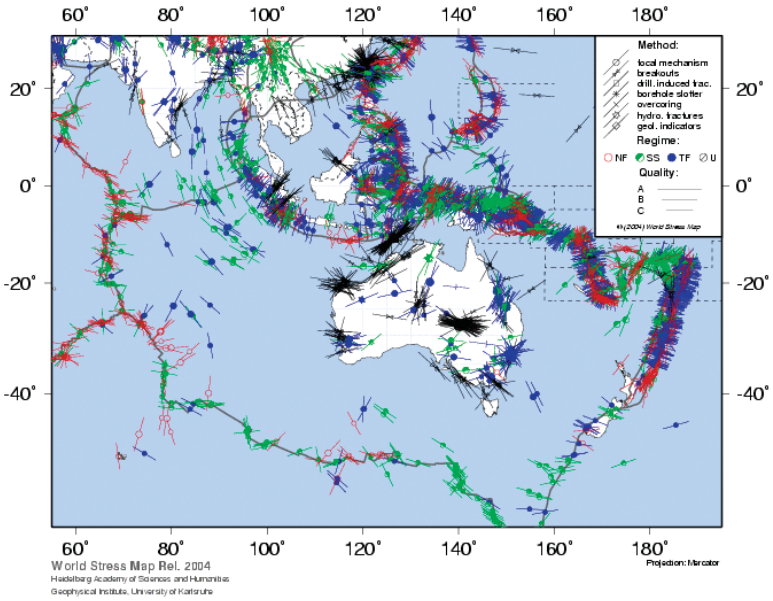
- Basin modelling
- Tectonic modelling
- Reservoir management
- Stability of mines, tunnels and boreholes
- Fault slip tendency
- Seismic risk assessment

The website includes stress maps, software, stress interpretation guidelines, and a fast online data base interface *Create a Stress Map Online* (CASMO). The maps are delivered on-line, free of charge to the users.

The stress maps display the orientations of the maximum horizontal stress SH. The length of the stress symbols represents the data quality, with A as the best quality category. A-quality data are believed to record the orientation of the horizontal tectonic stress field to within ±10°-15°, B-quality data to within ±15°-20° and C-quality data to within ±25°. D-quality data are considered to yield questionable tectonic stress orientations. The tectonic regimes are: NF for normal faulting, SS for strike-slip faulting, TF for thrust faulting and U for an unknown regime.

The Project originated in 1986 by a research group headed by Mary Lou Zoback as part of the International Lithosphere Program (ILP). Since 1995 the WSM Project has been a research project of the Heidelberg Academy of Sciences and Humanities. The WSM research group is located at the Karlsruhe University within the Institute of Geophysics and operates as a task group of the International Association of Seismology and Physics of the Earth's Interior (IASPEI).

Figure 2 shows the map for the Australian Plate.



So get on to the web and have a play.

Fig. 2. Stress map with A-C quality from the 2004 WSM release for the Australian Plate (see Reinecker, J., Heidbach, O., Tingay, M., Connolly, P., and Müller B., 2004: The 2004 release of the World Stress Map [available online at www.world-stress-map.org]).

Monash goes international with CEGAS

The Centre for Environmental and Geotechnical Applications of Surface Waves (CEGAS), based at the Monash School of Geosciences, now involves collaborative partners from Geoscience Australia, the University of Melbourne and the University of Hong Kong. Founder of the Centre Michael Asten and graduate student James Roberts recently spent two weeks in Hong Kong on a project with Adrian Chandler and Lung Chan of HKU to measure microtremor wave velocities at a series of local sites, using the multi-mode Spatial AutoCorrelation (MMSPAC) passive surface-wave seismic method. The surface-wave data are interpreted to yield shear-velocity profiles which are then used as input for earthquake site response calculations.

The high density of urban development in Hong Kong made it necessary to use several sports grounds and school playgrounds for the site observations, and the Monash representatives were asked twice to give impromptu talks on the method to Year 12 physics classes. Fortunately for our geophysicists from Oz, all school students in Hong Kong are fluent in English!

Above: Year 12 Physics Class of 2004, St Stephens College, Hong Kong, gather for a talk on surface wave vibrations from the fellow in the kangaroo-skin hat (photo – James Roberts).
Left: Michael Asten (left) explains the use of an array of geophones to A-level students Allen Man and Ling Chan, and (right) their physics teacher Kelvin Lau of the Fung Kai Secondary School, Sheung Shui, Hong Kong (photo – James Roberts).

The CEGAS recently signed funded research agreements with the US Geological Survey ($75,000) and Geoscience Australia ($21,000) for 2005, with in-kind contributions expected to be of similar size.

WMC's GEOFERRET TEM system to hunt for wealth

A new distributed array geophysical data acquisition system, dubbed GEOFERRET, was unveiled at the Prospectors and Developers of Canada (PDAC) meeting in Toronto in March.

Developed by WMC Resources Ltd (WMC) in conjunction with the Western Australian-based geophysical instrumentation and software specialist Electromagnetic Imaging Technology Pty Ltd (EMIT), GEOFERRET is a distributed array time domain EM system that employs newly developed sensors combined with smart real-time data processing and long occupation times to collect fixed loop time domain EM data with S/N up to an order of magnitude better than equivalent conventional systems.

Further, the GEOFERRET technology has been shown to achieve this with up to five times improved productivity and mobility, deployed regularly with up to 20 simultaneous measuring stations.

The system comprises, at each measuring station, a single axis coil with an autonomous electronics box, or node that stores data internally until such time as an operator harvests the data using a Personal Digital Assistant (PDA) equipped with wireless networking capability.

Timing and transmitter synchronisation are accomplished with an on-board GPS receiver with a backup 10 MHz crystal clock. Each receiver electronics node hosts four 24 bit input channels with a bandwidth of DC – 50 kHz. Location is automatically recorded using a GPS.

New single-axis low-noise aluminium wire receiver coils have been designed for use with GEOFERRET. Measurements using the coils routinely achieve noise levels of 1 pT/A.s. Fluxgate magnetometers have also been successfully trialled with the GEOFERRET system.

WMC has been working on the development of GEOFERRET since late 2000 and began field trials at the Cliffs nickel sulphide prospect (south of WMC's Mt Keith Nickel Operations in Western Australia) in mid-2003. Field data acquisition has been accomplished routinely since then using a base frequency typically around 0.25 Hz.

GEOFERRET has assisted in the discovery of the North Cliffs extension and the Olympia nickel sulphide prospect at Collurabbie, also in Western Australia.

GEOFERRET is 100 % owned by WMC Resources Ltd.

90 Years Ago - some pioneering field trips

(Part I)

A geophysicist and some camels

Kidson and his camels

The camels names were Ben, Syd, Skipper, Lion, Scorcher, Niziam, Chunks, Chunky, Longlegs, Kangaroo, Lindsay and Goolam; and the geophysicist's name was Edward Kidson, the chief observer in Australia for the Carnegie Institution of Washington, Department of Terrestrial Magnetism (CIW/DTM). The date was 16th August 1914 (Figure 1).

The place was Flora Valley Station, near Halls Creek in the East Kimberley region of Western Australia, and when the weary Kidson and compatriots (Messrs Clarke, Cronin, Ryan and their exceptional aboriginal tracker "Nipper") halted they had just completed a journey by camel of almost two thousand kilometres that had started in Kalgoorlie some three months earlier (12th May 1914). They had traversed the Great Sandy Desert from Wiluna, along the remote, rarely travelled and potentially dangerous, Canning Stock Route (Figure 2). Little did the camels know they were about to turn around and make the return trip!

Fig. 1. Edward Kidson (1882-1939) – unsourced from Kidson, 1941.

Perth – Wiluna observations

By early April 1914 Edward Kidson had organised twelve camels - three of which were riding camels - from the Water Supply Department of Western Australia and hired camel drivers Messrs Clarke and Cronin who were already fitting out the team in Kalgoorlie. Later in the month Kidson reoccupied the known Perth magnetic observatory site to calibrate his newly arrived 'Magnetometer-Earth Inductor No. 24' (Figures 3 and 4).

This new invention was primarily designed for the measurement of magnetic inclination (dip) and was a great boon to field operations as the measurements could be made quickly – the alternative method, using dip circles, took hours to set up, stabilize and read.

Kidson, with all of his equipment, departed Perth by train on the 8th May 1914 and the following day, during a short stopover,

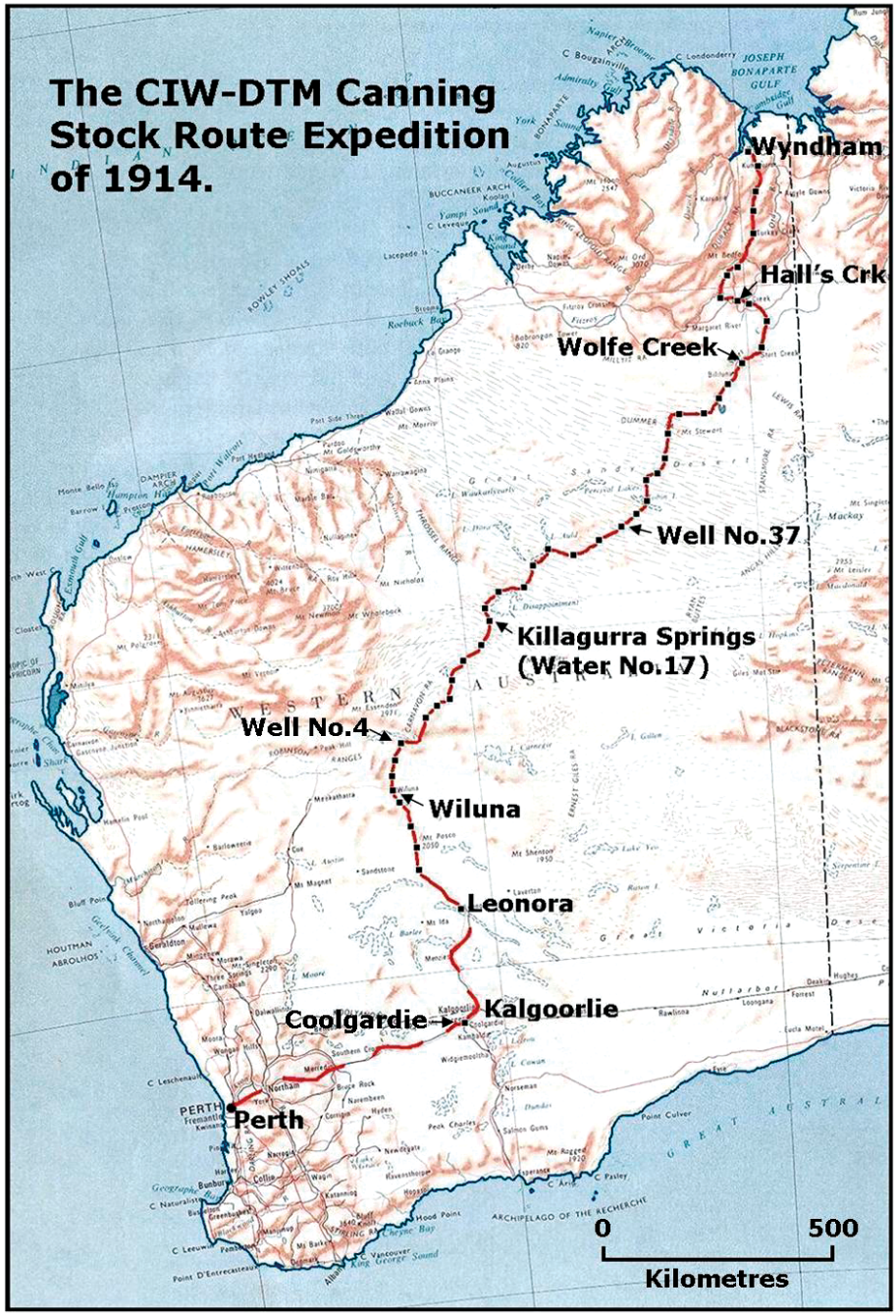


Fig. 2. Kidson's expedition route and magnetic station locations.

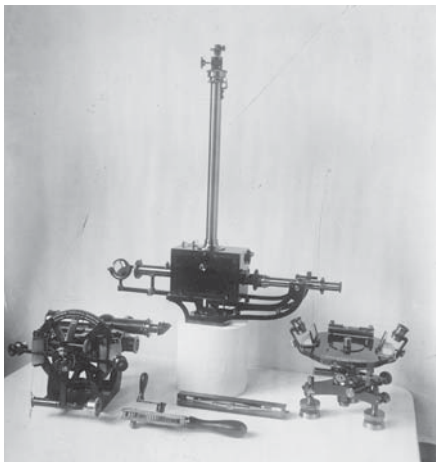


Fig. 3. CIW/DTM instrumentation circa 1913. Magnetometer (centre), 'Earth Inductor No. 23' (at left), compass declinometer (at right). In the front is the boxed needle for the declinometer and the winder/spinner for the earth inductor coil. There was also a 'magnetically cleaned' theodolite. All instruments fitted to the same tripod base and packed into a single carrying case. Courtesy CIW/ DTM-GL Library, instrument photo #182.

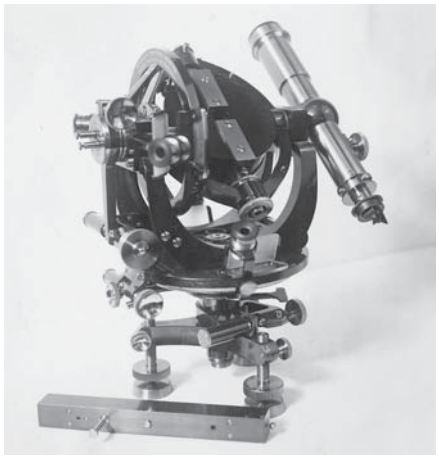
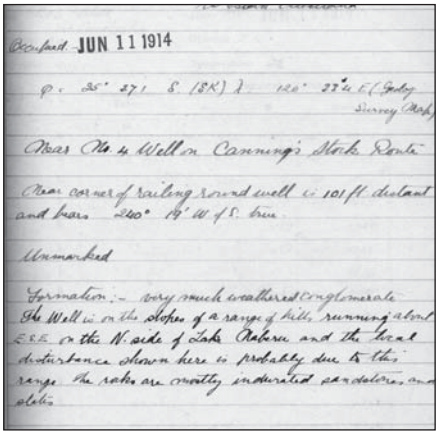


Fig. 4. Kidson's actual 'Earth Inductor No. 24' seated on the compass declinometer. Needle box at front. Courtesy CIW/DTM-GL Library, instrument photo #197.

reoccupied a previously established mag station at Coolgardie. On the 20th May, along with Clarke and Cronin, twelve camels, a cook named Mr. Ryan, the experienced aboriginal tracker Nipper and a dog or two, Kidson departed Leonora – firstly to Wiluna - observing inclination, declination and horizontal intensity along the way at Lawlers, Lake Miranda, Logan Well and Abercromby Well. Kidson, from the start, set procedures which were to be maintained throughout the expedition - his observations, for instance, were made at alternate camps and Sundays were always a day of rest for both men and camels (Figure 5).

The Canning Stock Route – some concerns

Kidson's narrative reports, observation tables, cahiers i.e., field notebooks (Figure 6) and thirty or so photographs taken during his



Observed JUN 11 1914

φ = 25° 27′ S. (SK) λ = 120° 37½′ E. (Geog. Survey Map)

Mean No. 4 Well on Canning's Stock Route

Near corner of railing round well is 101 ft. distant and bears 240° 19′ W of S. true

Unmarked

Formation:– very much weathered Conglomerate

The Well is on the slopes of a range of hills, running about E.S.E. on the N. side of Lake Auburn and the local disturbance shown here is probably due to the range. The rocks are mostly indurated sandstones and shales

Fig. 6. A page from Kidson's Observer Cahier No.232, 11th June 1914 at No. 4 Well. Includes a description of the site, a mention of a local magnetic disturbance and the general geology. Courtesy CIW/ DTM-GL Library.

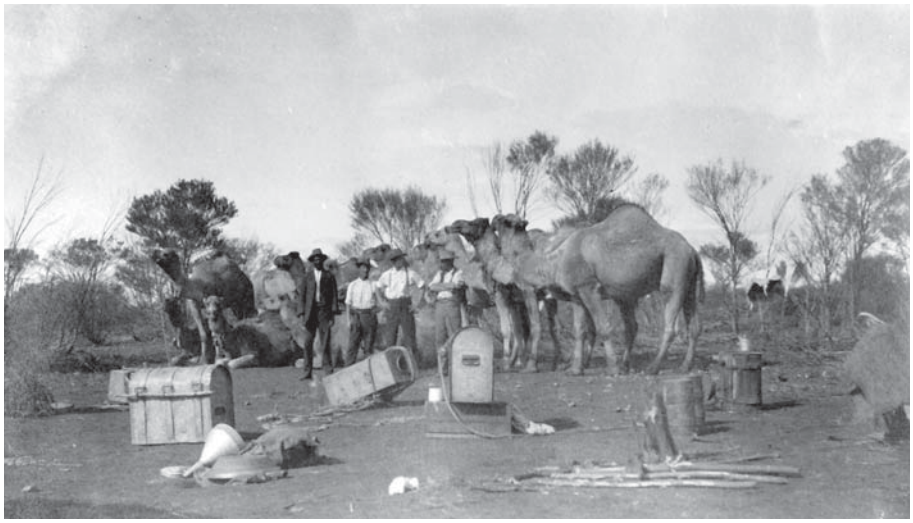


Fig. 5. Preparations at Wiluna circa 3rd June 1914. Courtesy CIW/DTM-GL Library photo #4154.

expedition have survived in the archives of the CIW/DTM-Geophysical Laboratory Library in Washington DC. A biography written and published in 1941 by Kidson's widow also includes snippets from a private diary he kept during his travels; so we are quite lucky that his field operations can be described in some detail and in some cases viewed as well.

Some of Kidson's private diary entries show he was anxious for the safety of the expedition, for instance, he mentioned he had received "urgent advice" at Wiluna to be careful of the desert aborigines "as they were both treacherous and unreliable". This somewhat uncomfortable observation (to us) probably originated from the police at Wiluna, although Kidson does not expand. The Wiluna police had travelled up the stock route a few years earlier investigating the murders of two drovers, Shoesmith and Thomson, near Well No. 37 – and the track had not been travelled since. Kidson certainly took the advice very seriously, for a number of times he noted in his diary that they were being followed by small groups of aborigines and that he had warned them off.

Scenery and Well No.37

Kidson was very impressed with the abilities of his aboriginal tracker Nipper. Nipper had made three journeys along the route with Alfred Canning during the well construction and despite the track not being used for over three years he was able to follow the camel pads made by Canning's construction expeditions with ease.

The scenery at a number of the watering places also impressed Kidson – he was particularly attracted to Killagurra Springs (No. 17 Water), as are most visitors, apparently. Kidson recorded the waterholes there were teeming with life including fish and large freshwater crayfish. It was at this camp that Kidson walked across the hills to the nearby Durba Spring and according to his diary he travelled alone "with gun and barometer"!

As the expedition approached Well No. 37 Kidson took extra precautions for, in his correspondence, he says that at Wanda (Well No. 36) he fortified his camp, he made an enclosure of the boxes, saddles and water tanks and they all slept inside the enclosure with a tarpaulin spread over. The camels were tied near to the camp rather than being hobbled. Kidson may have had some grounds to be

Fig. 7. The notorious Well No. 37, 18th July 1914. Note the dense bush and spinifex. Courtesy CIW/DTM-GL Library photo #4170.

Fig. 8. On the shores of the remote Tobin Lake (salt) between Well Nos. 39 and 40, circa 20th July 1914. Tobin, a member of Alfred Canning's 1906-09 expedition had been murdered nearby. Courtesy CIW/DTM-GL Library photo #4173.

careful as he says the dog Nellie growled throughout the night – we will never know the reason (Figures 7 and 8). Well No. 37 has gained a notorious history. In 1922 there was another murder there when the prospector Jock McLernon was clubbed to death.

Hall's Creek to Wyndham

On reaching Flora Valley Station, Kidson "received hearty greetings" from the owners, the Gordon brothers and the explorer/cattleman Gordon Buchanan. Kidson then travelled to the (old) Halls Creek telegraph station to send his telegrams, collect his mail and purchase a horse and dray.

Following a week or so of rest for his men and, especially, the camels, the crew said their goodbyes to Kidson and commenced their long haul back to Leonora – arriving there on the 23rd November (Figure 9).

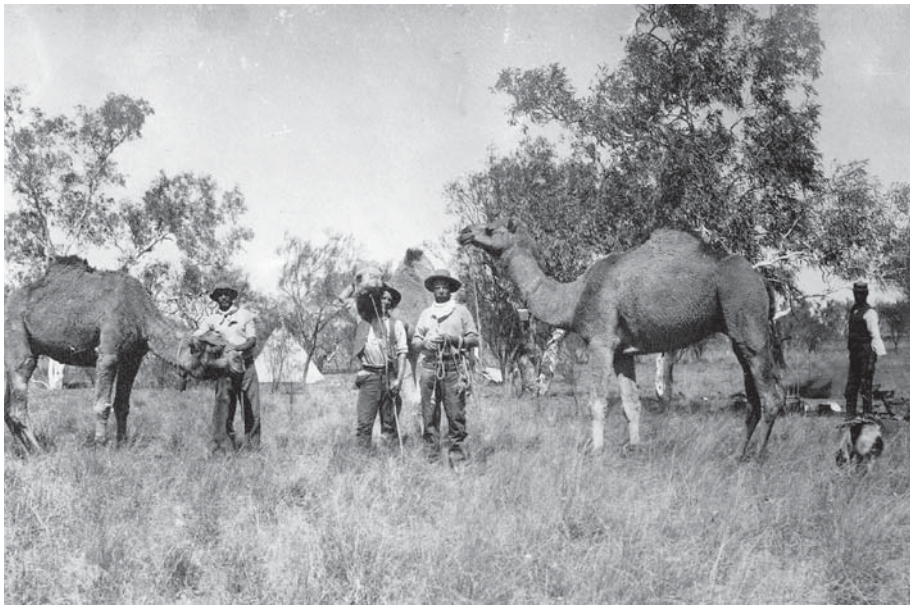


Fig. 9. At Wolfe Creek circa 11th August 1914. Note the magnetometer observation tent in the background. Courtesy CIW/DTM-GL Library photo #4179.

On the 29th August, Gordon Buchanan, with business to be done in Wyndham, joined Kidson in the horse and buggy from Halls Creek (with Buchanan doing the driving apparently). Kidson was to observe eight stations on this journey to Wyndham, arriving there on the 20th September and then embarking (conveniently) the following day on the "Kwinana" for Perth. From the time of his departure from Leonora in late May, Kidson had observed and accurately positioned magnetic inclination, declination and horizontal intensity measurements at 48 sites.

The memory of Kidson as both an explorer and pioneer geophysicist has faded, but his reports, field notes and photographs from this and other expeditions have survived in the CIW/DTM-GL Library in Washington. It is also good to know that he is remembered by some topographical features near the Canning Stock Route Well Nos. 33 and 35; firstly by Kidson Bluff and then by Kidson Track, the old WAPET access road to the capped and aptly named KIDSON oil well.

Sir Douglas Mawson named a site in Antarctica after Kidson, but that, and Kidson's significant influence in meteorology is another story.

Acknowledgements

It is with some degree of gratitude I thank the Carnegie Institution of Washington, DTM-Geophysical Laboratory Library for access to their Australian records and photographs. In particular I would like to thank their librarian, Shaun Hardy for his interest and complete co-operation with my requests to publish some of the old CIW/DTM images. Thanks also to my cousin Ewan Morrison who made the effort to visit the library, inspect the field notes, reports and photographs. It has been worth it.

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Geophysics at Newmont – a history of innovation and development

(Part II, 1975-2005)

by Chris J. Wiles, Newmont Mining Corp. chris.wiles@newmont.com

Introduction

Newmont's geophysical department has a long history of innovation and development since 1946. Essentially there were four major eras in its history so far:

1. **Jerome, Arizona (1949-1957)**: This was the amazing post-war period under Doc Brant that led to the development of IP and time-domain EM.

2. **Danbury, Connecticut (1957-1975)**: This was a difficult period with low metal prices, small budgets and the breakup of the Jerome group. Significant developments were primarily with computing and the first gridding and contouring routines in collaboration with IBM.

3. **Tucson, Arizona (1975-1989)**: A large portion of this period was spent developing and utilizing the ground-based high-power, deep-penetrating time-domain EM system (EMP). After the advent of the PC, portable imaging workstations were developed and sent out to the field, a major change in the way computing was done.

4. **Denver, Colorado (1989-Present)**: In downtown Denver and later at the Malozemoff Technical Facility, the significant developments were with rugged airborne and ground data acquisition systems aided significantly by the advent of GPS navigation. Significant in the late 1990s were the collaborative Newmont/ Normandy NewTEM/HoistEM helicopter-borne EM systems and the modelling and inversion of IP and EM data.

Fig. 1. Maurie Davidson (Director, 1975 – 1988), admiring a model EMP system.

The first part of the story, from 1946-1975, was told in the February 2005 Preview. In this issue we are covering the period from 1975 to the Present.

Tucson, Arizona 1975 - 1989

In 1975 the geophysical group returned to Arizona - this time to Tucson - to be near Magma's San Manuel and Superior copper mines and Newmont's emerging gold operations at Carlin, Nevada. Maurie Davidson headed the department until his retirement in 1988.

The Tucson years saw the development of a number of geophysical tools and techniques, the most notable of which was the ground-based time-domain electromagnetic pulse system known as EMP (Electromagnetic Pulse). This was the first practical technique capable of locating massive sulfides to depths of up to 500 m.

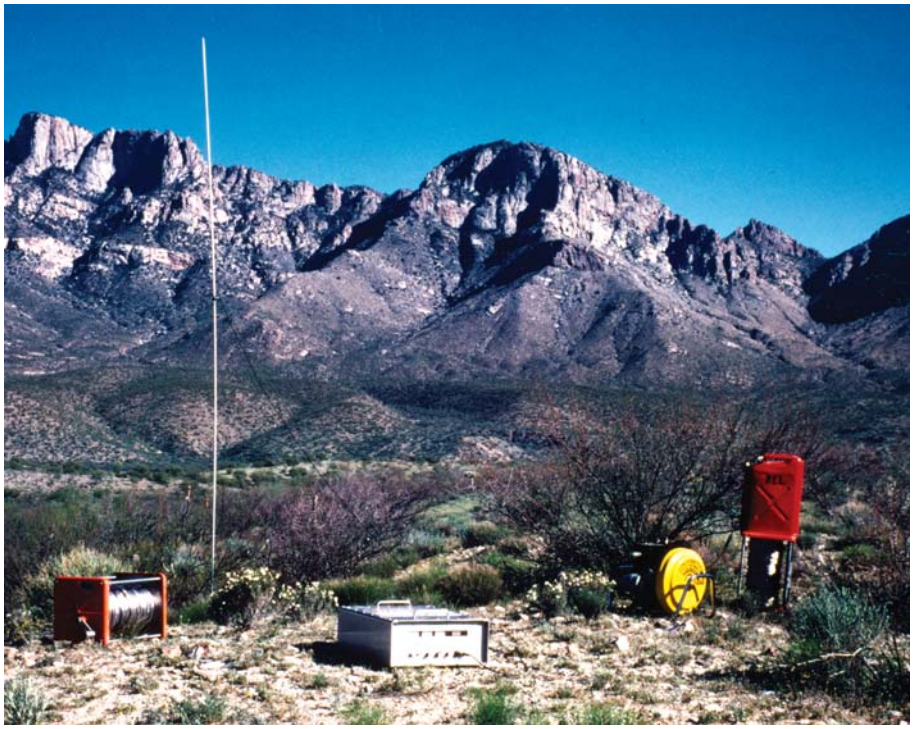

Fig. 2. The EMP transmitter was designed to pulse all day, allowing geophysicists to concentrate on data acquisition.

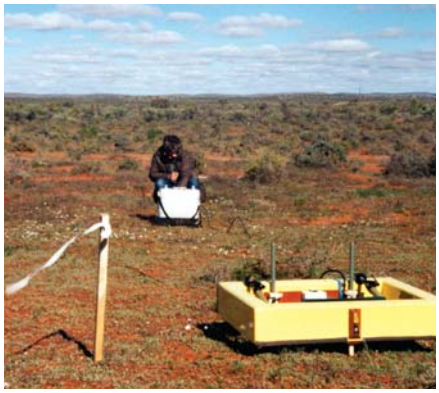

Fig.3. The highly portable EMP data acquisition system in the field near Telfer in the 1980s.

Fig. 4. Radiometrics at Telfer in the 1980s.

In the mid-1980s, Newmont geophysicists were quick to adapt the then-new IBM PC/AT personal computers to be able to take data processing, interpretation and visualisation to the field. Prior to that, most geophysical data processing had to be done in batch mode on mainframe computers at Danbury or Tucson.

Denver, Colorado 1989 - Present

When Newmont relocated its corporate headquarters to Denver, Colorado, in 1989, the geophysical group moved again and came under the direction of Colin Barnett who had joined Newmont in 1972. Colin was a product of Cambridge, Imperial College London and the Colorado School of Mines. Located on the 26th floor of a high rise building downtown, a special shielded room had to be constructed in the geophysical laboratory to eliminate all electromagnetic noise when testing ultra-sensitive field equipment.

With the advent of the Global Positioning System (GPS), Barnett oversaw the development of both ground and airborne data acquisition systems based on GPS navigation. For the airborne systems, an advanced integrated approach to navigation and data acquisition permitted the system to be operated entirely by the aircraft pilot. Bruno Nilsson played a major role in the development of these airborne GPS systems.

To provide the highest level of accuracy and reliability, the Newmont navigation system included both GPS and an inertial navigation system (INS). The INS provides accurate short-term positioning in situations where GPS signals are lost due to rugged terrain.

The group also successfully applied neural networks, an artificial intelligence tool, to aeromagnetic compensation, classification of reflectance properties in remote sensing, and regional exploration initiatives to help focus follow-up work.

Fig. 5. Colin Barnett (Director, 1989-2001) had to focus on indirect geophysical methods applied to gold exploration.

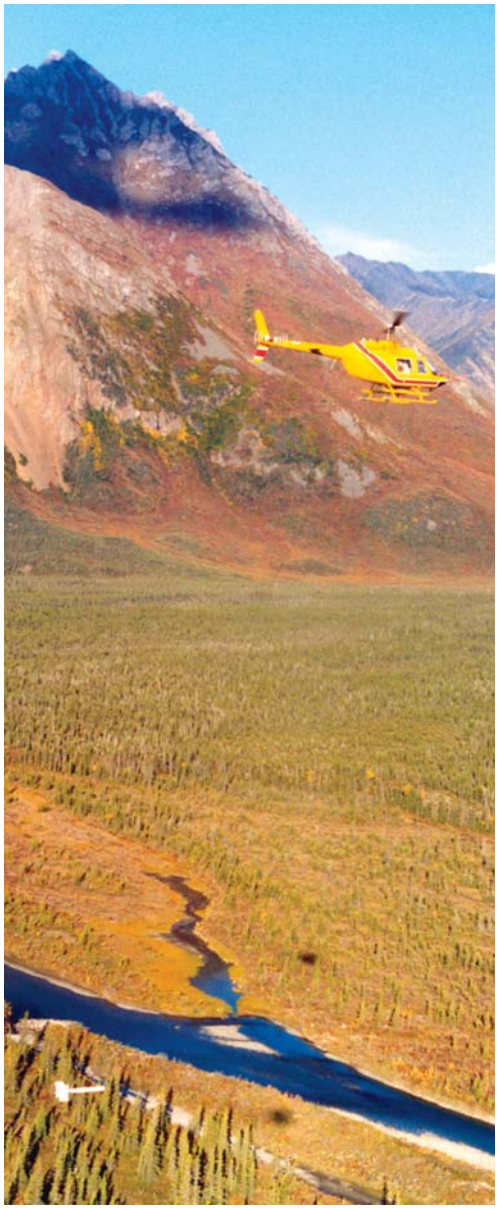

Fig. 6. Helicopter magnetics in the Yukon, 1990s.

Magnetics is one of the most effective geophysical mapping tools and is used by Newmont throughout its worldwide exploration programs. Newmont uses optically pumped potassium magnetometers in its airborne systems, being more accurate and less sensitive to temperature and orientation than most other magnetometers. The ability to fly accurately positioned, high-resolution magnetics (and radiometrics) surveys cheaply in-house gives Newmont a real advantage in its exploration programs.

Data acquisition was matched with advanced in-house processing, interpretation and visualization capabilities. Newmont began utilizing image processing techniques as a means of simplifying the interpretation of large aeromagnetics datasets. Newmont's software supports the integration and enhancement of geophysical, geological and remote sensing images as well as modelling software that simplifies the interpretation of multiple datasets and allows the construction of three-dimensional models.

In 1997, Newmont built the Malozemoff Technical Facility at Inverness in suburban Denver. Named after Plato Malozemoff, Newmont's distinguished President from 1954, and chairman from 1966 to 1985. The facility was the first of its kind built by the mining industry in 25 years.

Fig. 7. Launching the NewTEM system in the Tanami Desert, 2004.

Fig. 8. Assembling NewTEM Rx bird in 2004 in Indonesia.

The geophysical group relocated to the new facility and began the development of several new exploration tools, such as an initiative to acquire airborne resistivity data. Successful, but slow, the acquisition of resistivity data on the ground proved to be very useful for mapping high sulfidation epithermal systems associated with gold deposits in the Andes.

A cooperative effort between Newmont and Normandy resulted in the development of NewTEM and HoistEM, two helicopter-borne EM systems with simple coplanar-concentric geometry offering high resolution, small transmitter footprint, and low mean terrain clearance. NewTEM was designed for mapping a range of resistivities over more than four decades from 0.5 to 5,000 Ωm, and HoistEM developed into a system ideally suited for deep late-time mapping in conductive environments to more than 450 m in depth.

Low gold prices after 1997 saw exploration budgets cut followed by associated reductions in exploration and research staffs across the industry. With an upturn in the gold price in 2002, funds are again flowing to this important segment of the industry.

The Future

Today, Newmont has one of the largest, most capable geophysical and research engineering departments in the mining industry. Building on Newmont's history of technical innovation and development, the geophysical group is currently focused on developing advanced exploration systems that will make a significant step-jump in Newmont's ability to discover new gold deposits.

Fig. 9. The Malozemoff Technical Facility, built in 1997, in suburban Denver.

Acknowledgements

I would like to thank the large fraternity of Newmont's engineers and geophysicists for their innovation and hard work over the years in making this history possible. Their individual contributions are very much appreciated.

Velseis – an ASEG Corporate Plus Member

Velseis integrates operations in new Australian headquarters

In mid-2004, Velseis Pty Ltd moved into its upgraded Australian headquarters at Sumner Park, Brisbane, and has taken the opportunity to consolidate its primary acquisition and processing operations in the one location. This is already yielding benefits in terms of improved information flow between Velseis divisions, and centralised access to technical and research expertise. This move follows the 2001 establishment of Seisdrill, Velseis' drilling division. These recent initiatives have been driven by the desire to provide clients with a highly integrated suite of seismic services, including pre-survey (design, permitting and drilling), acquisition, processing and interpretation.

Founded more than 25 years ago with a focus on borehole seismology and high-resolution seismic reflection, Velseis has evolved into a highly experienced full-service contractor, serving the resource industries throughout the Asia Pacific.

Acquisition

Current acquisition activities include land 2D, 3D and multi-component for the coal, petroleum and mineral sectors, ranging from the Bowen and Surat Basins to Western Australia, New Zealand, PNG and Indonesia. Velseis prides itself on providing a flexible and high-quality acquisition service which is focussed on the client's geophysical targets, but also addresses logistical, climatic, environmental and safety issues.

Velseis has a well-earned reputation in dynamite reflection, driven by projects requiring the highest possible resolution of structural and stratigraphic targets. This approach is the norm for accurate 3D imaging of underground coal prospects, and is currently in demand for shallow to medium-depth petroleum targets. Shothole drilling is normally handled by Seisdrill, which is an evolution of Geodrill Pty Ltd, a company with 20 years shothole drilling experience. Currently Seisdrill operates a fleet of 6 Bourne 1000R/Ford Louisville rigs.

Velseis pioneered the use of Mini-SOSIE in the Asia Pacific region. The original hardware-orientated approach has been replaced by computer-control, for improved flexibility and performance. In 2005 Velseis deployed its latest production Mini-SOSIE system, capable of real-time stacking on high-channel-count 3D surveys. Data processing of the first production survey is currently in progress (April 2005). The quality of the 3D imagery obtained suggests that 3D Mini-SOSIE will experience increasing demand for exploration and pre-production surveying of coal and shallow hydrocarbon prospects.

Velseis' VELCOM recording system provides a core capability in excess of 1500 telemetry channels. Proven Sercel field hardware is integrated with sophisticated computer control, providing a flexible and efficient operator interface, as well as data QC and analysis. In-field data processing to preliminary stack is routinely provided, via Linux-based field workstations. Velseis is also experienced with Sercel 388 and 408 hardware, providing additional capability in periods of high demand.

Processing and Interpretation

Velseis implemented its original proprietary seismic processing system in 1985 to service the rapidly expanding high-resolution market. In 1992 Velseis Processing, a subsidiary of Velseis, was incorporated and has since evolved to be a leader in high-resolution 2D and 3D coal imagery. In addition, the company has an expanding petroleum-processing group focussing on low-to-medium volume surveys requiring specialised effort. Velseis Processing adopts an interactive approach to processing, based on industry-standard Promax software, and using Unix and Linux workstations and scalable clusters. Specialised interpretation services are built around GeoGraphix Seisvision software.

Research and Development

Since its inception Velseis has maintained its competitiveness with a proactive commitment to R&D. The R&D division provides regular technical support to all production divisions. Additionally, Velseis is engaged in several specific R&D initiatives, including computer-controlled acquisition, model-based deconvolution and multiple attenuation, and converted-wave acquisition and processing. The latter project has attracted ongoing support from the Australian Coal Association Research Program. In 2004/5, a number of commercial 2D converted-wave surveys were conducted using dynamite and Mini-SOSIE sources. This work suggests significant potential for integrated P-wave/S-wave reflection, particularly in the context of shallow coal targets.

ASEG Sponsorship

Velseis' emphasis on technical strength and innovation is exemplified by its long-term association with the ASEG. The company is currently a Corporate Plus member of ASEG. Velseis views the ASEG's encouragement of information sharing and geophysical research as valuable to the seismic industry. Company geophysicists have a long history of involvement in ASEG executives at the federal and state levels, and the company has been heavily involved in three ASEG Conferences.

Corporate Philosophy – The Future

Velseis' ongoing stability and growth, even during periods of industry consolidation, is a testament to simple corporate philosophies. The management structure is flat with company directors occupying hands-on operational positions. This ensures pragmatic and efficient decision-making, and flexible responses to changing exploration trends and technologies. The company's commitment to solution of client problems has resulted in a healthy portfolio of long-term client relationships. Probably the key factor, however, in the success of this relatively small competitor in the seismic marketplace is technical strength and self-sufficiency, arising from experienced, motivated and accessible personnel.

Key Contacts

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Progress Report on Geothermal Energy Exploration in SA

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Geological setting

Geothermal energy is the natural heat found within the Earth – around the globe, temperature increases with depth, typically by 10-50° C/km. The bulk of this heat is generated from the radioactive decay of naturally occurring potassium, thorium and uranium isotopes. Localised heat sources occur in active volcanic regions where geysers and hot springs are utilised for hydrothermal energy in over 45 countries, including Japan and New Zealand. In Australia, the main types of potential geothermal energy are hydrothermal (from relatively hot groundwater) and the hot basement rocks. In deeper parts of the Cooper Basin, geothermal gradients reach 55-60° C/km (Wyborn *et al*., 2004).

South Australia has large regions of interpreted high crustal temperature associated with buried granite intrusives at depths greater than 3 km, and these form key exploration targets for Geodynamics Ltd, Petratherm Ltd (MNGI Pty Ltd), Eden Energy (Tasman Resources NL), Havilah Resources NL, Perilya Ltd/Green Rock Energy Pty Ltd, Scopenergy Ltd. Other targets include hydrothermal energy from the Great Artesian Basin in SA's far northeast (Pacific Hydro Limited) and residual heat sources in the southeast of SA around Australia's most recently active onshore volcanoes (Scopenergy). Petratherm are also exploring for radiogenic iron oxide deposits similar to Olympic Dam and Prominent Hill, which may have even higher heat flow than the granites and enhanced natural thermal systems (Hillis *et al*., 2004).

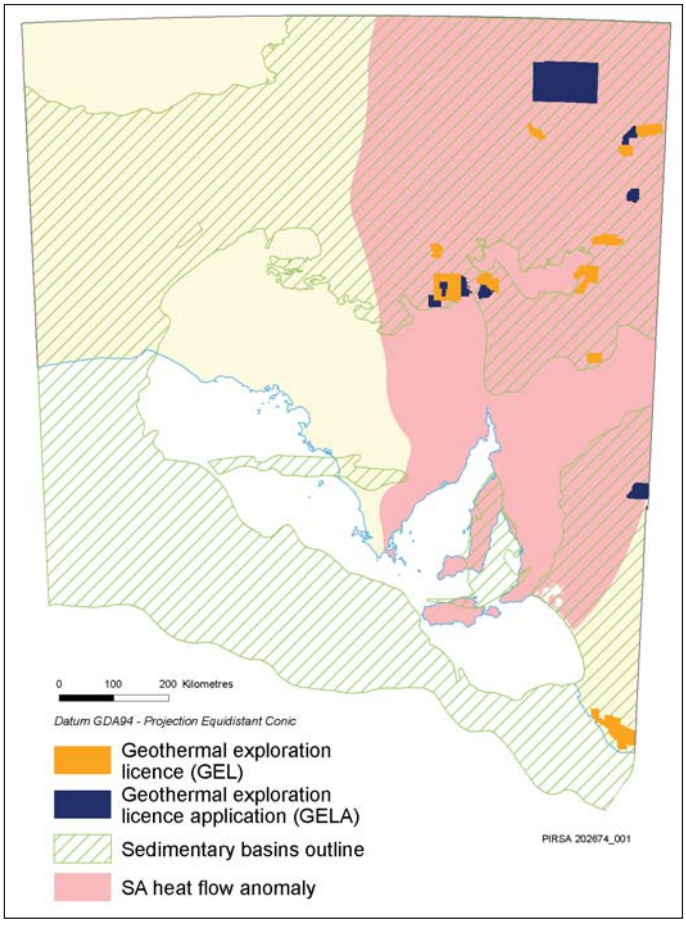

Fig. 1 – SA Heat Flow Anomaly (Neumann et al., 2000) and extent of thick sedimentary cover.

Geothermal explorers recently presented reviews of their activities and issues at PESA-ASEG in August 2004 and PESA's EABS2 conference in September 2004. EABS2 papers are presented in their entirety in the conference proceedings volume and as high-resolution pdfs on the DVD. Hillis *et al*. (2004) provide an overview of hot dry rock exploration in Australia and Petratherm's proposed approach, Wyborn *et al*. (2004) review significant progress made by Geodynamics in SA and Armstrong and Rahman (2004) examine the issue of sustainable water use in the Cooper Basin.

A viable hot dry rock geothermal prospect needs both basement rocks that will generate heat at depth and cover to insulate and trap the produced heat over geologic time. A subsurface water circulation system needs to be successfully established either through the hot rock or in the adjacent hot cover rocks. Other important considerations are the availability and sustainable management of groundwater resources to gather and transfer the heat (Armstrong and Rahman, 2004) and the proximity to electricity transmission infrastructure and/or local markets (e.g. mines like Olympic Dam and potentially Prominent Hill, the Moomba Plant and regional centres).

In SA, Mesoproterozoic granites, felsic volcanics and gneisses in the Gawler Craton and Curnamona Province contain anomalously high uranium and thorium concentrations relative to global Proterozoic averages. This has generated high heat flows, resulting in the SA Heat Flow Anomaly (Figure 1) identified by Neumann *et al*. (2000). Average heat flow is elevated in this region relative to Proterozoic or younger terranes on other continents. Mean heat flow within the SAHFA is 92±10 μWm^{-2} compared to an average of 51-54 μWm^{-2} in other countries (Neumann *et al*., 2000). The maximum heat flow measured within the SAHFA is 126 μWm^{-2} (Neumann *et al*., 2000) in the Mt Painter Inlier ~ 30km northeast of the Paralana Hot Springs, on the Paralana Fault Zone. Petratherm is targeting buried granites and the hydrothermal system on this trend (Hillis *et al*., 2004).

To identify geothermal exploration targets in SA, companies have used publicly available heat flow data (e.g. Neumann *et al*., 2000; Holdgate and Chopra, 2004) as well as reports on petroleum and mineral exploration wells, and seismic, gravity and aeromagnetic data held by PIRSA. Once identified, targets are drilled to test heat flow and suitably hot basement rocks are fracture stimulated using oilfield technology. Understanding of the orientation of both the *in situ* stress field and natural fracture systems in the hot basement rock is critical to optimise fracturing (Reynolds *et al*., 2004). Water is circulated via injector wells through the fractured hot rock and the heated water is recovered from production wells. Hot water is then circulated to a surface heat exchanger and used to generate electricity. The cooled water is then reinjected into the geothermal system and the cycle continues.

In SA's northeast, Mid-Carboniferous Big Lake Suite granite has been blanketed by over 3.5 km of a insulating sedimentary cover. While this granite has lower heat production, when compared to Mesoproterozoic granites, the thick thermal blanket of coal, sandstone and siltstone has very effectively trapped generated heat. Temperatures of 250º C occur at 4.5 km depth (Wyborn *et al*., 2004).

Much of central and northeastern SA, corresponding to the SAHFA, is anomalously hot at depth (Holdgate and Chopra, 2004). Higher temperature outliers occur in the Otway Basin where volcanoes were active as recently as ~4000 years ago (eruptions were witnessed by Aboriginal people), as well as under the Murray Basin.

The regional temperature anomaly in Queensland and SA coincides with granitic basements covered by stacked sedimentary basins (Cooper, Eromanga and Lake Eyre Basins). In this region, Great Artesian Basin groundwater has been heated to 100º C. Hydrothermal energy utilising this hot groundwater has already been harnessed on a small scale in both SA and Queensland. In SA, an experimental 20 kW Organic Rankine Cycle generator was installed at Mulka Bore in 1986 and generated electricity from 85º C groundwater. At Birdsville, a 150 kW demonstration plant has been operating since 1999 using 99º C groundwater from the town water bore. Pacific Hydro has recently applied for licences to target the Birdsville Track Ridge in SA to explore for geothermal energy.

In the southeast of SA, the most recent volcanic activity at Mount Gambier and Mount Shank has produced locally elevated heat flows (Neumann *et al*, 2000). Warm artesian water has been used for aquaculture to farm barramundi near Robe since 1985. In Portland Victoria, hot groundwater from the Portland Trough (which has elevated geothermal gradients) has been used since 1985 to heat buildings and a swimming pool.

Geothermal exploration activity in SA

Interest was first expressed about geothermal exploration in SA by Ashton Energy in 1996, around the Olympic Dam Mine. Other parties expressed interest in exploring the known 'hot spots' in the Cooper Basin around the same time. However, licences could not then be granted because there was no available legislative framework. During extensive stakeholder consultation, which started in 1996, for the new Petroleum Act, interested geothermal parties provided input. Because the most prospective geothermal area in the State was perceived to be under the Cooper Basin, and drilling would involve deep holes using petroleum industry technology, it was determined that geothermal exploration licences and activities would be regulated by the new Petroleum Act, rather than the Mining Act or separate legislation.

The Government of South Australia is now leading Australia with an effective

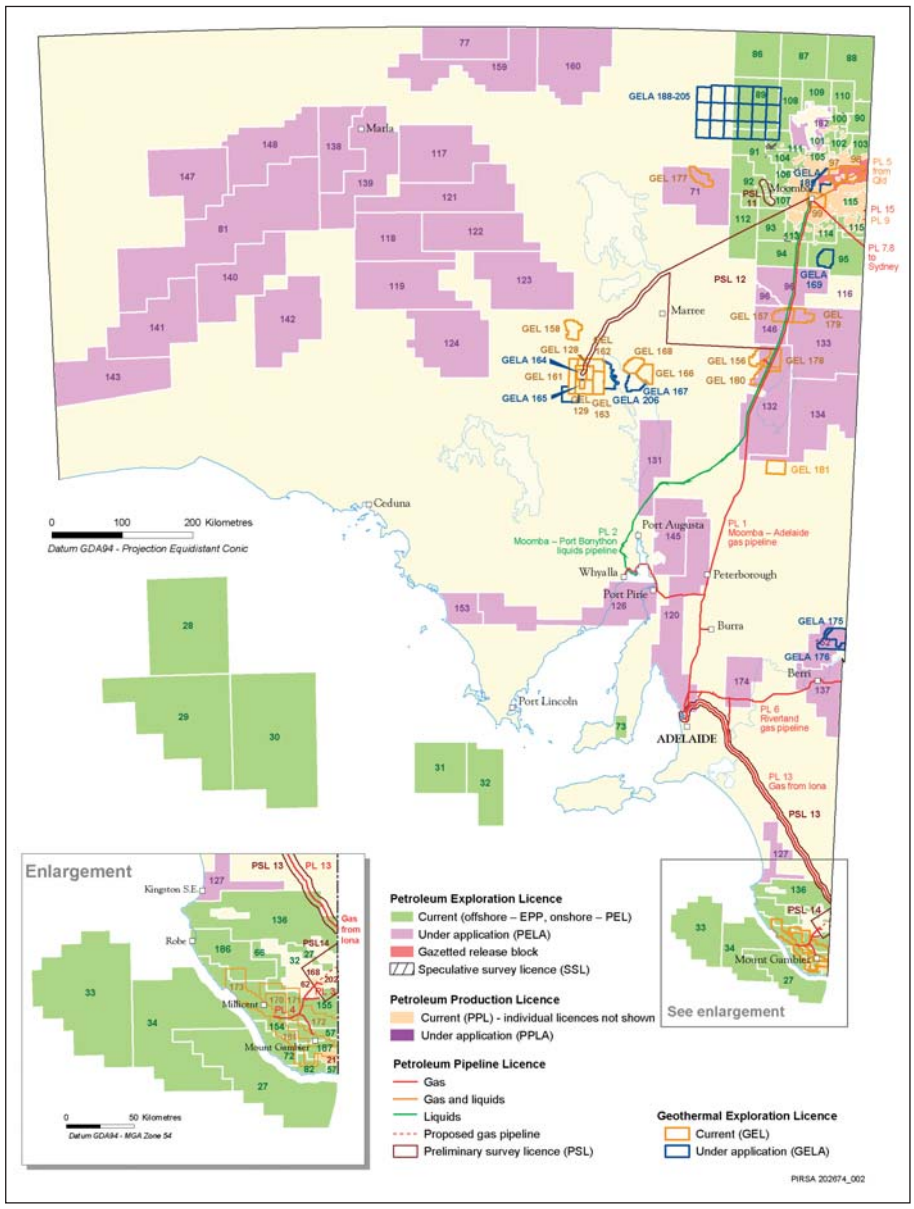

Fig. 2. Geothermal Exploration Licences and applications in South Australia (February 2005).

and expeditious geothermal regulatory and approvals framework, under the Petroleum Act 2000. The process commenced in SA in October 2000 with the release of three geothermal exploration blocks over hot granites underlying the Cooper Basin (Morton, 2000). Public domain seismic and drilling data from previous petroleum exploration activity by Delhi Petroleum and the Santos Joint Venture were readily available from PIRSA and helped to high-grade the region. Applications were received for all blocks, and the first South Australian Geothermal Exploration Licences (GELs) were granted in October 2001.

Since August 2004, over-the-counter applications for GELs can be accepted over the entire State, except over current GELs or lands excluded for exploration (e.g. certain parks). A 500 km^2 size limit currently applies to individual licenses. Because the Government of South Australia does not regard geothermal exploration as mining under the Commonwealth Native Act, the right-to-negotiate process is not required. The average turn-around from lodging a GELA with PIRSA to grant of licence is roughly 3 months, depending on whether parks and/or compatible licences are involved.

As at mid-February 2005, the 50 GELs and GELAs in SA covered 23,659 km^2 (Figure 2) with aggregate 5 year work programs to a value of $338 million. In 2004 there was a rush to acquire GELs in South Australia to explore a variety of plays and the number and area of licences and applications (Figure 3) increased dramatically. Geothermal exploration licence holders include Geodynamics, Scopenergy, Petratherm (MNGI), Eden Resources, Perilya/Green Rock, and Havilah Resources NL. Pacific Hydro Limited has applied for 18 GELs over 8,894 km^2 in the western Eromanga Basin. As recently as early February 2005, Perilya/Green Rock Energy applied for GELs adjacent to their existing tenements around Olympic Dam. Proactive Energy, a new geothermal explorer in SA, has applied for 386 km^2 to the southwest of existing Olympic Dam GELAs.

Current GELs and GELAs in SA cover a diversity of geological provinces, so a range of potential new energy sources and exploration models are being tested. If initial exploration is successful, the total potential investment in geothermal energy in SA over the next five years could reach >$337 million. Just one of the 22 current GELs has potential to contain hot rocks able to yield emission-free electricity equivalent to several Snowy Mountains Hydro Schemes. A royalty of 2.5% of the value of geothermal energy is payable in South Australia.

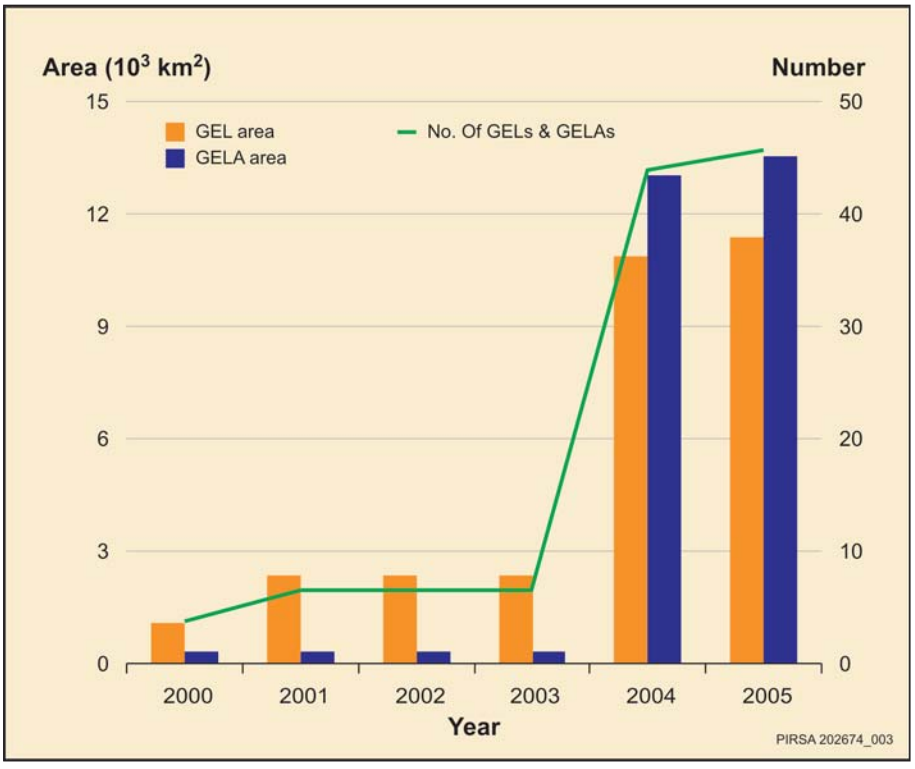

Fig. 3. – Chart showing cumulative growth in geothermal licences and applications since 2000.

Geodynamics

Geodynamics is the 'first mover', having already progressed exploration and proof-of-concept projects in GEL 98, successfully drilling Habanero 1 exploration well last year to 4421 m depth to access hot Big Lake Suite granites. The well was subsequently tested and overpressures were discovered in the granite, which was unexpected and significantly increased the likelihood of the resource being successfully exploited. A 0.7 km^3 zone of artificially enhanced permeability was created by hydraulic stimulation in October-December 2003 (Wyborn *et al*., 2004). Habanero 1 has been completed as an injection well.

Geodynamics further tested the heat exchange capacity of the granite by drilling Habanero 2 production well, which spudded in July and reached total depth of 4358 m in late December 2004. The well is located 500 m from Habanero 1. Geodynamics announced in September that hydraulic connection between Habanero 1 and Habanero 2 has been confirmed by the pressure responses recorded in Habanero 1 during drilling through major fractured granite zones in Habanero 2. In a first for the project, steam was vented during operations to free a stuck drill pipe in November 2004 (see *Preview*, 2005); the well was then successfully sidetracked. A coiled tubing unit will be on site from mid-January, well logging and a flow test are planned by early February.

Oil and gas explorers, Woodside and Origin Energy are major investors in Geodynamics and provided well design software and planning expertise. Geodynamics were also awarded a Commonwealth Government Research and Development Start Grant. Geodynamics has acquired South Australia Geothermal Energy Pty Ltd, the licensee of neighbouring GEL 97 and has secured two geothermal tenements in the Hunter Valley, New South Wales, targeting hot dry rocks.

Petratherm

Minotaur Resources NL was successful in raising capital for its geothermal venture through Petratherm Ltd in mid-2004. The University of Adelaide has been assigned ~1.8% of the initial capital in Petratherm in return for its intellectual inputs to projects. Petratherm (through MNGI Pty Ltd) is the operator of GELs 156, 157, 158 178 and 180,

and has applied for GELA 179 to test a range of geothermal exploration plays. The company is targeting hot geothermal rocks at >220° C, but no deeper than 3,500 m, close to electricity infrastructure and markets with a phased exploration program (Hillis *et al*., 2004).

Petratherm spudded Paralana 1 geothermal exploration well in an area of highly elevated shallow temperature gradients on 12 January 2005 to drill to a planned initial depth of 600 m. The well will test down-hole temperature gradients and enable rock physical property measurements. Petratherm reported in late January that drilling has been delayed due to unstable hole conditions near the top of the hole.

If projections of the temperature gradient in Paralana 1 to the target depth of around 3500 m are promising, it will be deepened in the future to ~1500 m to gather more data. Drilling into the deep thermal resource will follow if results from other stages are positive. Developing the well design and logistics is advanced for drilling the Callabonna geothermal target in GEL 156 in mid-2005. On successful completion of the geothermal evaluation phase, injection and production drill holes are planned, along with a heat exchange system, and a grid-drilling program to establish a commercial power plant.

Scopenergy

Scopenergy is still negotiating with a number of companies to obtain financial and technical support for a proposed HDR development program in GEL 99. It has also proposed that the work program be carried out under a joint venture agreement. Scopenergy has undertaken a detailed study of water availability and usage for geothermal projects in the Moomba area (Armstrong and Rahman, 2004).

Scopenergy has recently been granted five GELs (170, 171, 172, 173 and 184) in the State's southeast, around volcanic centres, and have undertaken technical and commercial studies for both projects.

Perilya/Green Rock

Ashton Energy raised geothermal exploration issues in SA in 1996, by lodging applications for licences for geothermal exploration around the Olympic Dam Mine and Roxby Downs township. No regulatory regime was in place at the time to manage this, so licences could not be issued. The Petroleum Act 2000 provided the legislative framework for geothermal exploration and Ashton Energy subsequently gave consent for Perilya/Green Rock Energy to take up GELs in this area.

Perilya/Green Rock, WMC and PIRSA's Petroleum Group entered into negotiations that determined a mutually acceptable outcome enabling the grant of GELs 128, 129, 161, 162 and 163 in proximity to WMC Resources' Olympic Dam mining lease and occupational licence at Roxby Downs. The joint venture has undertaken technical and commercial studies and the next phase of the evaluation process will involve drilling of geothermal exploratory wells to optimise location of the first geothermal well.

Negotiations are continuing on the grant of licences for GELAs 164 and 165 over the Olympic Dam mine area, and a new application for the area was lodged in February 2005.

Eden Energy

Tasman Resources (through Eden Energy, a wholly owned subsidiary with a focus on geothermal and hydrogen energy) currently hold GELs 166 and 168 on the Gawler Craton. Tasman has lodged further applications for GELA 167 over the Gawler Craton, GELA 169 over the Tenappera Trough in the Cooper Basin, GELAs 175 and 176 over a temperature anomaly in the Murray Basin region and GELA 185 adjacent to the GELs operated by Geodynamics in the Nappamerri Trough.

Havilah Resources

Havilah Resources NL have been granted GELA 181, to target Mesoproterozoic granites in the Curnamona Province, where Havilah is operating a number of mineral Exploration Licences targeting Au, Cu-Au and Pb-Zn.

Pacific Hydro

Pacific Hydro, an owner and operator of wind and water renewable energy generation facilities in Australia and overseas, recently lodged applications for eighteen contiguous GELs on the Birdsville Track Ridge. The applications cover a total area of ~9,000 km^2. Exploration will target heat sources in the Great Artesian Basin.

Conclusion

There are currently high levels of technical interest in geothermal energy in Australia, typified by the recent sessions on Geothermal Energy at the ASEG-PESA Conference in August and PESA's Eastern Australasian Basins Symposium in September. The embryonic Hot Dry Rock industry in South Australia has been well supported by share market investors, including major petroleum exploration and production companies.

If South Australia's geothermal energy potential is successfully realised, the state will become a world-leader in providing emission free and sustainable energy, as well as a hot bed for the development of associated technologies and processes.

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Sensing and modelling electric fields associated with high frequency excitation of plant roots

By:

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Why measure roots?

Plant-related studies often require information on the spatial distribution of roots as it influences water use, growth, yield, carbon sequestration and inter-species interactions. The measurement of plant roots by conventional methods is slow and laborious. Electrical methods offer an opportunity to develop a rapid, non-destructive method.

Can roots act as transmitting antennas?

Low frequency experiments (1 kHz) have shown that root capacitance is proportional to root biomass (Dalton, 1995), but give no information about root position. High frequency measurements were undertaken as a method that was likely to be responsive to the spatial arrangements of roots. To determine the likely optimal operating frequency for this method, a series of Impedance Spectroscopy (IS) experiments were performed (Figure 1).

It was determined through the IS experiments that at 16 MHz there was a large capacitive component for sand. The roots used for the IS experiments were young bean roots grown especially, and roots such as privet, calitris and nightshade dug from the garden. For all these roots, the impedance seemed to be approaching its high frequency limit at 16 MHz, so they could be presumed to be behaving as low impedance elements. It was then supposed that a root could act as a wire embedded in a dielectric, and the induced field of an excited root may be characteristic to its spatial distribution.

A field trial was performed on a young Acacia tree (Figures 2a and b). The probe was a tuned circuit that measured magnetic field strength perpendicular to the plane of the coil. A lateral root was exposed for approximately 1.5 m, and the probe was swept approximately 10 cm above the root in a zigzag fashion approximately 50 cm wide.

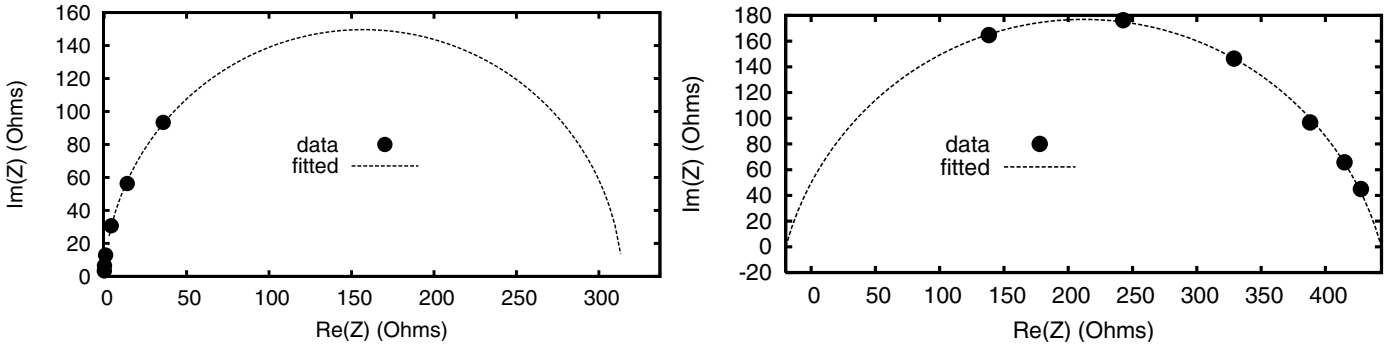
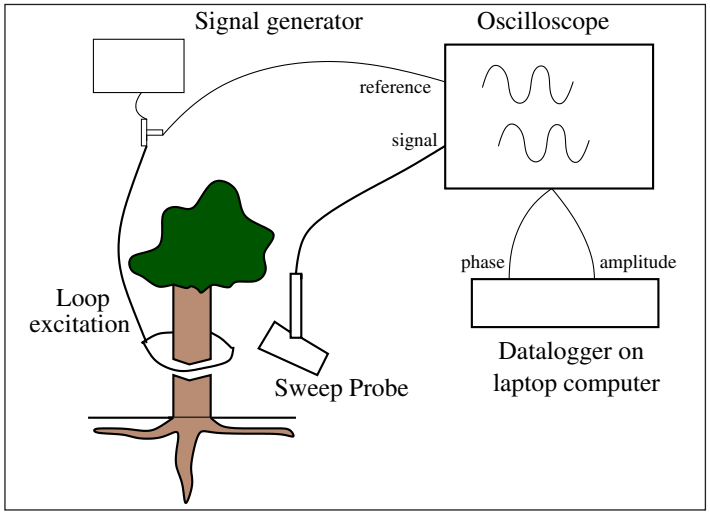


Fig. 1. Impedance Spectroscopy for piece of young bean (Vicia faba) root (left) and for sand at 12.8% moisture (right). Re and Im are the real and imaginary components of the impedance Z and the black discs are the observations. The dotted lines are circular arcs fitted to the data. Frequency increases anticlockwise from 0.5 to 20 MHz.



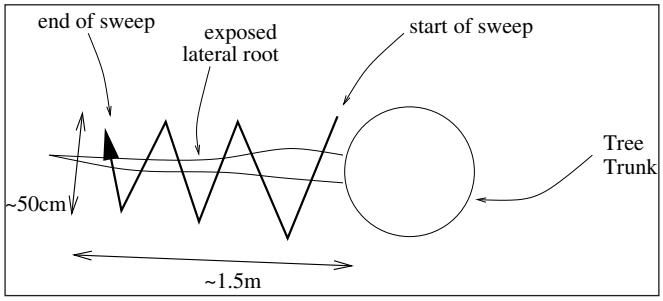


Fig. 2a (left). Schematic diagram of the field trial apparatus. The EMF loop is completed by capacitance between the above-ground tree and the soil. The sweep loop and the excitation loop around the tree are ~10 cm and ~50 cm above the ground respectively.

Fig. 2b (above). Birds' eye view of the path over which the data of Figure 3 were obtained; schematic view only, not to scale.

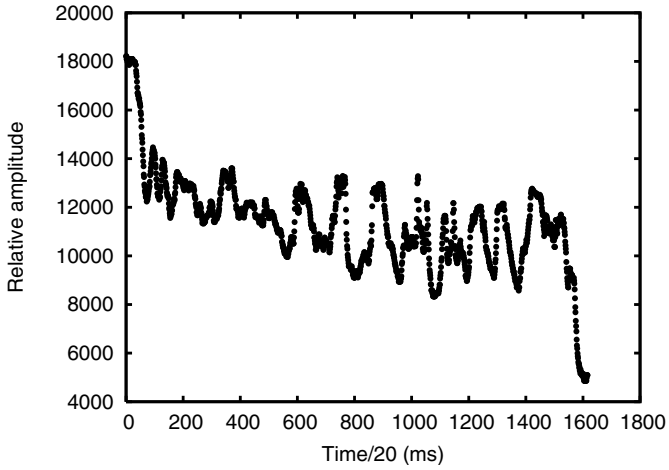


Fig. 3. Field trial shows the magnetic field strength varies with respect to root position. Each peak corresponds to when the sweep loop probe crossed the lateral root (see Figure 2b). The left of the plot corresponds to observations made close to the trunk; the right of the plot corresponds to observations made ~1.5 m away from the trunk. The data were logged at 20 ms intervals.

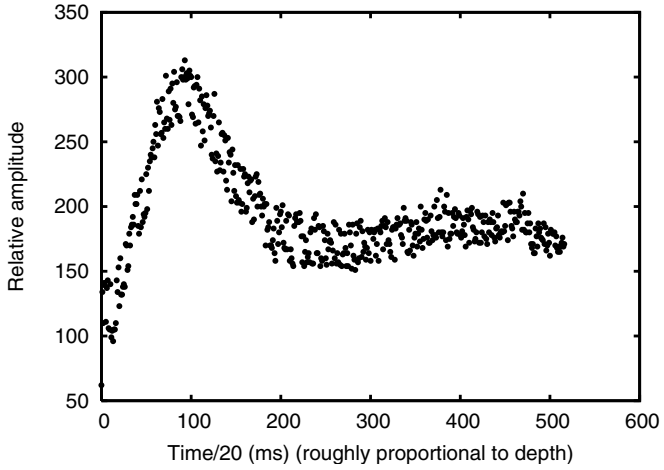


Fig. 4. A plot of field strength vs time. The data were taken parallel to a vertical root, 200 mm long in sand, which has been excited by an induction loop, at a radius of 50 mm away from the root, and to a depth of 340 mm. The data were logged at intervals of 20 ms.

The field strength is plotted versus time (Figure 3). The peaks correspond to when the probe was directly over the root. The field strength was not measured with respect to ground; therefore it is only a relative amplitude. The data were logged at intervals of 20 ms.

The peaks seem to indicate that the excited root does induce a field. However, the shape of the induced field must be understood before it can be used to map roots.

Modelling

The typical root dimension of a small young plant (10^{-1} m) is much smaller than the typical wavelength at 16 MHz (10^{2} m) and so it may be suitable to apply an electrostatic approximation in calculating the induced field (Wait, 1986). Current paths in root tissue are not well characterised, so we begin by assuming that the most conductive paths are via the ionic solution in the interconnecting xylem tissue, which is surrounded by other tissue presumed to be moderately insulating. In turn, we assume that current would 'leak' out along the root. We formulated a hypothetical charge distribution ρ on a single, cylindrical, excited root, growing vertically in soil corresponding to this scenario:

$$\rho(z) = e^{-\alpha z}$$

Presently, α is for mathematical convenience, but its connection to physical reality is unknown. We think that it may be related to the electrical behaviour at the root-soil interface.

To evaluate the model, a section of Agapanthus africanus root (approx. 200 mm long and 4 mm thick) was excited in damp sand and electric field traces were taken with respect to depth, at a radius of 5 cm (Figure 4). The field strength was not measured with respect to ground, therefore it is only a relative amplitude.

The data were logged at intervals of 20 ms to a depth of 340 mm. The static electric field in the soil is calculated for the charge distribution with $\alpha = 0.05$ and presented as a log plot (Figure 5), using the dimensions of the actual root. The dielectric constant of the soil was set to 10, which is representative of damp sand. The field is calculated on a grid 10 cm wide and 35 cm deep.

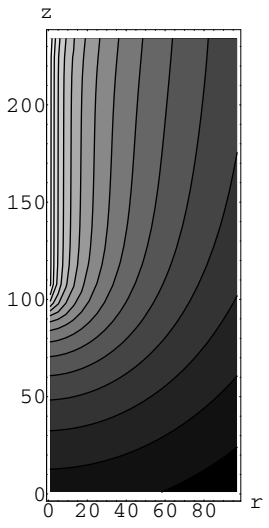


Fig. 5: Contour plot of field strength. Top of root is at the top left edge. Soil-air interface is at top edge. Both the ordinates and the abscissa represent ~1/7 cm (i.e. 1 cm ~ 7 data points). Field strength strongest in white areas, weakest in black areas.

Conclusion

The results shown in Figure 4 have a structure that is not apparent in the model. This suggests that the presumed charge distribution on the root is oversimplified, as the variation of α did not produce significantly different results. Further investigation of the electrical properties of plant matter is required.

Future work

We expect that the electrical properties of roots are not isotropic. In particular we expect there to be radial differences. To this end, we plan to measure the permittivities of the core and outer skin of a young bean root and of sand at varying moisture contents over a wider frequency spectrum. This information will be used to further investigate the optimum range of operating frequencies. It will also be used in the next modelling stage of calculating the field induced by a root excited by a 16 MHz signal (and possibly by signals of other frequencies).

Acknowledgements

This work was funded by the Rural Industry and Research Development Corporation. We thank Jim Brophy and Chris Williams for assistance in the field and lab.

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New geomagnetic field models released

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Space Geodesy and Geomagnetism

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The Australian Geomagnetic Reference Field Model

The 2005 revision of the Australian Geomagnetic Reference Field (AGRF) model has now been released by Geoscience Australia. The AGRF is a mathematical model of the geomagnetic field originating from the core and long wavelength crustal sources in the Australian region. The model covers Australia, nearby offshore areas, Papua New Guinea, parts of eastern Indonesia and East Timor, and is valid until 2010.

The 2005 revision is the fifth in the series of AGRF models. The first model was derived for epoch 1985.0 and since then the model has been improved and updated every five years to ensure that the slow but unpredictable changes which originate from sources within the Earth are tracked as accurately as possible.

The AGRF model is a spherical cap harmonic representation of the undisturbed geomagnetic main field at 2005.0 and its secular change from 2005 to 2010. The main field is modelled to a nominal minimum wavelength of 1500 km. Extensive vector geomagnetic survey data sets were used to derive the main field model, including satellite magnetic data, high elevation airborne data and Australia-wide ground based vector survey data. The main field data sets were updated to epoch 2005.0 using a secular variation model of the Australian region for the period 1960-2005 based on geomagnetic observatory and repeat station data from the region collected over the last 45 years.

The AGRF 2005 secular variation model for 2005-2010 is modelled to a nominal minimum wavelength of 2000 km and is derived from linear extrapolation of the most recently available geomagnetic observatory and repeat station data from Australia and neighbouring countries. The 2005 revision of the AGRF is built upon the recently released 10th generation of the International Geomagnetic Reference Field model, which is a global spherical harmonic model of the geomagnetic field. The extensive regional data set used in developing the AGRF model allows it to be considered the best available model for the Australian regional magnetic field for the interval 2005-2010 (see Figure 1 for a plot of the declination).

An online calculator for the AGRF model is available on the Geoscience Australia web site at http://www.ga.gov.au/oracle/geomag/agrfform.jsp.

Software to evaluate the AGRF at a single point or a grid of points is also available from Geoscience Australia.

The International Geomagnetic Reference Field

The 10th generation of the International Geomagnetic Reference Field (IGRF-10) was released by the International Association of Geomagnetism and Aeronomy

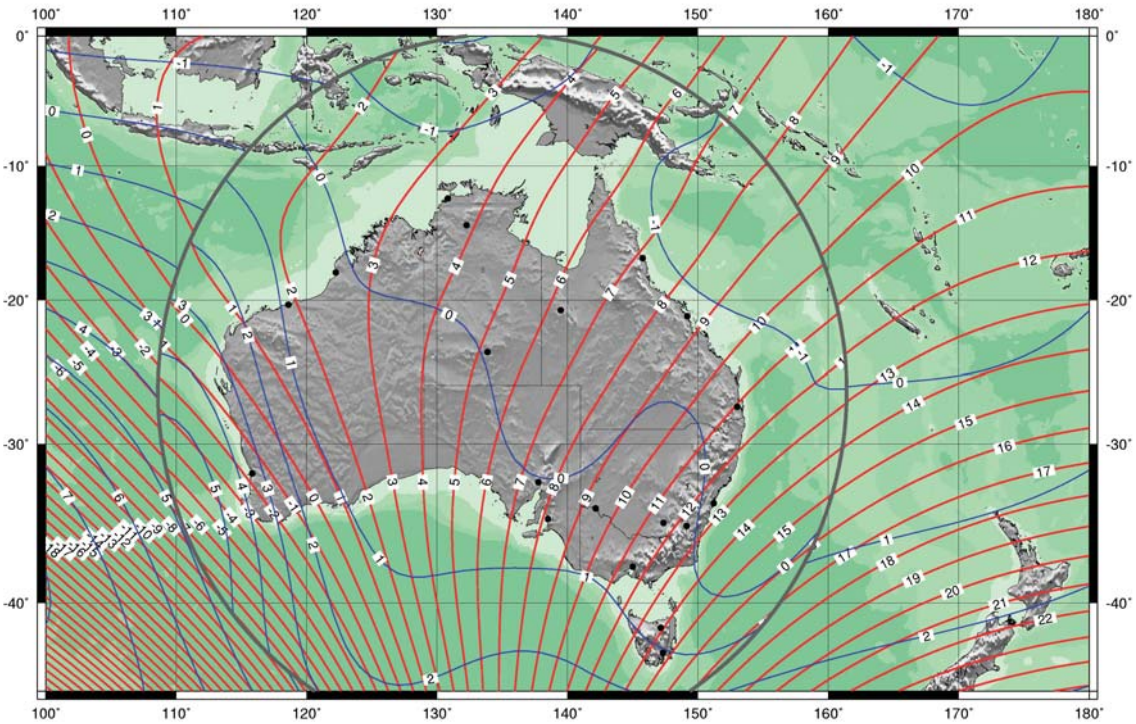

Fig. 1. Contours of the geomagnetic declination in degrees (red) and annual change (blue) in minutes-of-arc per year from the AGRF 2005 model for epoch 2005.0. The circular boundary shows the limit of the AGRF model, contours outside the boundary are from the International Geomagnetic Reference Field Model (IGRF-10 at 2005.0)

(IAGA) in December 2004. This new release adds a main field model for 2005.0 and a secular variation model for the period 2005-2010 to the existing IGRF coefficient sets, thus allowing the undisturbed geomagnetic field to be calculated at any location on, or near, the surface of the Earth over the period 1900 to 2010.

The development of the IGRF is the result of international collaboration between magnetic field modellers and institutions that undertake satellite magnetic surveys and operate geomagnetic observatories.

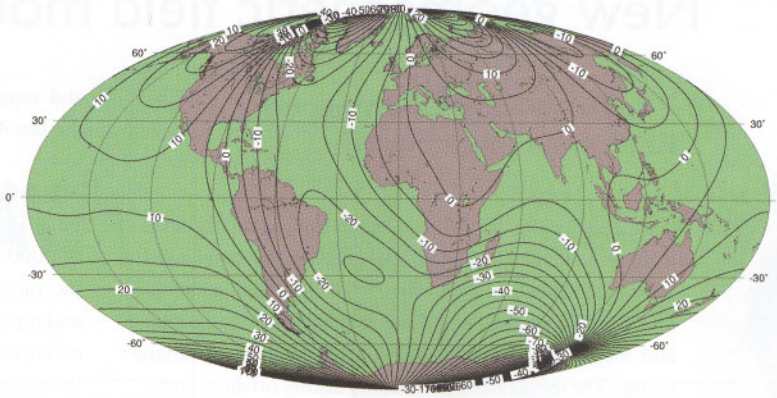

Fig. 2. Declination isogons derived from the IGRF-10 model for epoch 2005.0, the contour interval is 5 degrees.

The ninth and 10th revisions of the IGRF represent considerable improvements on previous revisions, mainly due to the large quantities of high quality satellite magnetic data currently available. Data from both the Danish Oersted satellite and the German CHAMP satellite were used in developing the IGRF-10 model for 2005.0, as well as data from the global network of geomagnetic observatories. The spherical harmonic degree and order 13 IGRF coefficients model the main field to a minimum nominal wavelength of 3000 km, and the degree and order eight secular variation coefficients to a minium nominal wavelength of 5000 km (see Figure 2 for a plot of the declination).

The model has wide application in the general, scientific, industrial and engineering communities, ranging from compass and GPS navigation, mineral exploration, surveying and mapping to understanding the global magnetic field and its secular change, studying the Earth's deep interior, the crust, ionosphere and magnetosphere.

Software for evaluating the model and the full set of spherical harmonic coefficients for IGRF-10 can be downloaded in several formats from the IAGA V-MOD website at http://www.ngdc.noaa.gov/IAGA/vmod/igrf.html.

A single point calculator is available online at http://www.geomag.bgs.ac.uk/gifs/igrf_form.shtml.

Software to evaluate IGRF-10 at a single point or a grid is also available from Geoscience Australia.

Geoscience Australia and Northern Territory Geological Survey

Birrindudu gravity survey

The Northern Territory Geological Survey, in conjunction with Geoscience Australia, is conducting a ground gravity survey over the Birrindudu 1: 250 000 Sheet area in the Tanami region of Northern Territory.

The survey, primarily funded by the Northern Territory Government's 'Building the Territory's Resource Base' initiative, involves helicopter-supported acquisition and processing of over 4000 new gravity stations on a 2 km by 2 km grid, excluding certain areas defined through the cooperation of the Central Land Council. It is hoped that explorers operating in the region will take advantage of the gravity crew's presence to acquire more detailed infill data on their tenements. The anticipated date for final data delivery is July 2005. They will be released shortly thereafter.

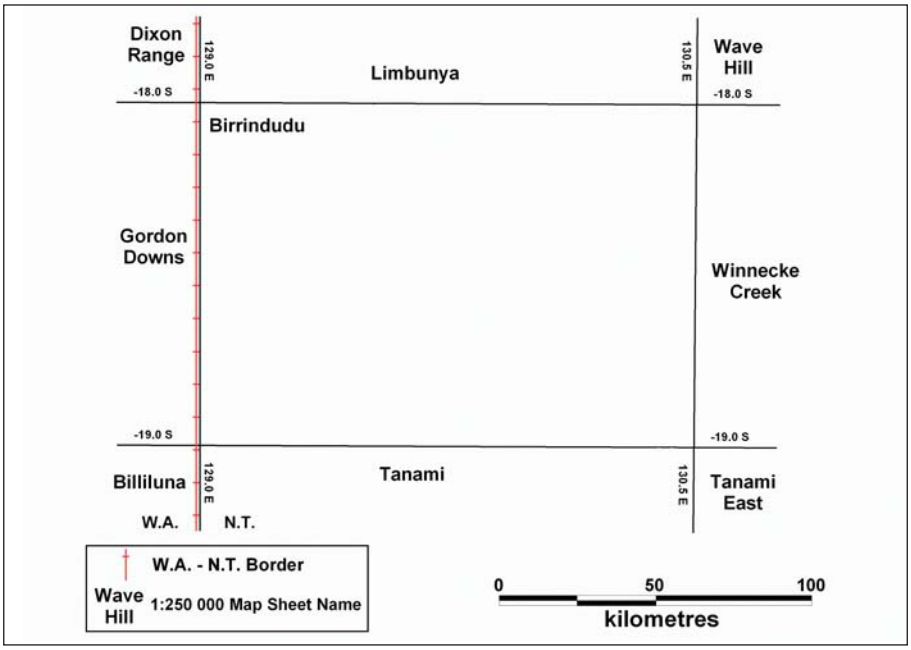

Fig. 1. Locality diagram for the 2005 Birrindudu Gravity Survey

The new data are expected to highlight northward extensions of the highly Au-prospective Tanami terrane, much of which is blanketed by shallow cover. This vastly improved gravity coverage will be a critical component in the production of an interpretive solid geology map for the Birrindudu 1:250 000 Sheet area, to appear in early 2006.

For further details, contact Mark Duffett at mark.duffett@nt.gov.au or Ben Bell at ben.bell@ga.gov.au.

Geoscience Victoria

International geology data model development

The Commission for the Management and Application of Geoscience Information (CGI) met at CSIRO in Perth, WA in December 2004 to establish a working group to produce an internationally accepted geological data exchange model. Geoscientists from CSIRO and the geological surveys of the USA, Arizona, Canada, Britain, Japan, Western Australia, New South Wales and Victoria were present.

The CGI is the Commission that underpins the International Union of Geological Sciences' digital information strategic objectives. The CGI aims to improve the quality and range of both information content and the applications that are used to acquire, analyse, process and disseminate geoscience data.

Data modelling is the process of defining the grammar, vocabulary, and content to be used to represent information in a database system. The workshop provided an opportunity to present the work being carried out in GeoScience Victoria on developing a Victorian geology data model in the light of similar work being undertaken in other national and international geoscience organisations. The Australian work was recognised as being an important step towards establishing an international geology data exchange model.

Over the past twelve months GeoScience Victoria has built on work carried out by the North American geological surveys and has now established a 'proof of concept' to define Victoria's geology data model and geological classification systems for rocks, contacts, folds and the like. This work, along with similar work carried out in the Western Australian and New South Wales surveys, was recognised by the CGI working group as a significant contribution to the international model. The recognition of the importance of the Australian work to the international community has resulted in Victoria, NSW and WA now being part of the international collaborative effort to develop a geological data exchange model. The aim is to deliver the draft model to the world geoscience community in Canada in August 2005.

For further information, contact Bruce Simons on 03 9658 4502.

Online delivery of Victoria's geophysical data

Geoscience Victoria has arranged online access to Victoria's geophysical data through the Geophysical Archive Data Delivery System (GADDS), see Figure 1. This web-based application delivers data from the airborne geophysics (magnetic and radiometric data) and gravity databases. The GADDS portal is maintained by Geoscience Australia.

Web access to geophysical data means that the mineral and petroleum exploration companies now have instant access to the data they require. Geophysical consultants, educational users, State Geological Surveys and other government departments will also benefit from the new data delivery system.

Download access is available through the department's web mapping application, GeoVic (www.dpi.vic.gov.au/minpet/geovic) or through the Geoscience portal (www.geoscience.gov.au). It allows the user to select a specific area of interest and have that data delivered free on-line within a very short time frame. When using GeoVic, the current window extents are used for the selection.

The main features of GADDS are:

- Data are requested using a standard web-browser
- Only the data required are delivered
- The data format (ASCII columns or Intrepid Database) for delivery, and the required datum and projection can be chosen online
- Vector (line and point) and raster (grid) datasets can be delivered

For further information, contact David Bibby on 03 9658 4504.

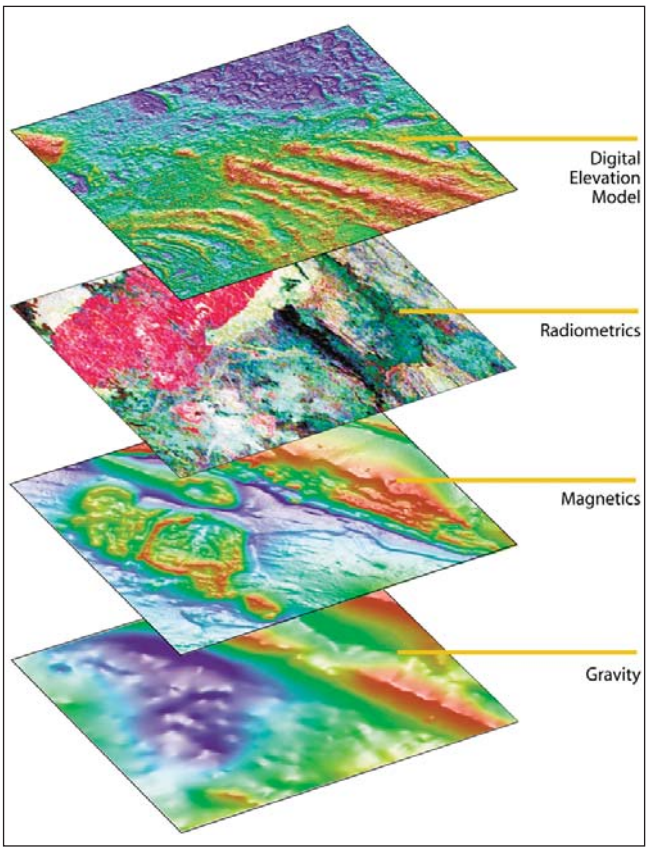

Fig. 1. Geophysical layers available through the GADDS delivery facility.

17th VIMP - Data Release

New information and opportunities for the mining and exploration industry will be on display at the Victorian Division of Minerals and Petroleum on 9th June 2005 in Melbourne.

Products to be released under the Victorian Initiative for Minerals and Petroleum include:

- New geology and geophysical interpretation maps and reports
- New Victorian GIS DVD in GDA94
- New digital open file exploration reports

Other displays will include:

- Progress maps on the Woods Point - Walhalla project and the Rupanyup regolith project
- GeoVic - online mapping application www.dpi.vic.gov.au/minpet/geovic
- GDA94
- A tour of DPI's new information centre and shop

The function takes place from 9:30 am - 2:00 pm at:
Department of Primary Industries, Minerals & Petroleum Division
1 Spring St, Melbourne
Victoria 3001
To attend, contact Paul McDonald at:
paul.a.mcdonald@dpi.vic.gov.au
Ph (03) 9658 4531.

Geoscience Australia and Western Australia Geological Survey

Paterson Province 2005 Regional Geophysical Surveys

Contracts have been awarded for the next set of large surveys in the West Australian Government's four-year, $12 million program to increase regional geophysical coverage of Western Australia. The Western Australia Geological Survey, in conjunction with Geoscience Australia, will conduct an extensive airborne magnetic and radiometric survey and a smaller ground gravity survey in the Paterson Province of Western Australia (Figure 1).

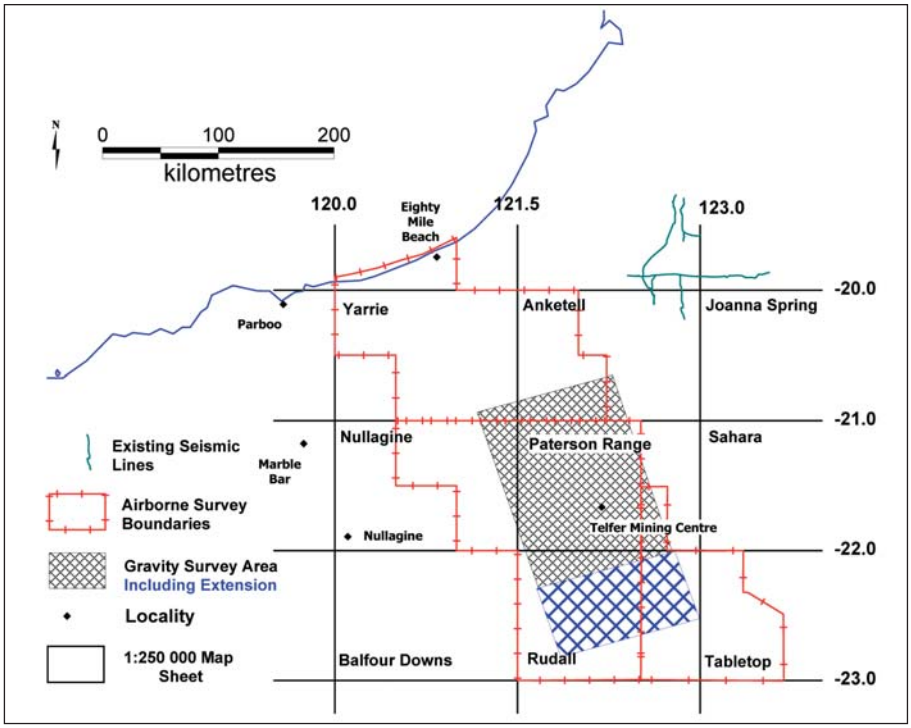

Fig.1. Locality diagram for the 2005 Paterson Province Regional Geophysical Surveys.

Airborne Magnetic and Radiometric Survey

UTS Geophysics and Fugro Airborne Surveys have been engaged to acquire 200,000 line-km of magnetic and radiometric data over an area of approximately 70,000 km^2 in the Paterson-Rudall region. The new data will be acquired on lines spaced 400 m apart with a ground clearance of 60 m above ground level. Geoscience Australia will be managing the flying program, which is expected to commence in April 2005.

Gravity Survey, WA

The gravity survey will involve the acquisition and processing of approximately 4000 new gravity stations on a 2.5 km by 2.5 km grid. Final gravity data delivery is anticipated to be in July 2005, with data release to the public occurring shortly thereafter. For further details, contact David Howard at david.howard@doir.wa.gov.au or Murray Richardson at murray.richardson@ga.gov.au.

Geophysical studies in the Bowen Basin by the Geological Survey of Queensland

by John Draper
Geological Survey of Queensland
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Introduction

A joint Australian/Japanese initiative to develop new exploration techniques based on the latest geoscientific data has been undertaken in the Bowen Basin. The cooperating Japanese agency was the New Energy and Industrial Technology Development Organisation (NEDO), which is attached to the Ministry of International Trade and Industry (MITI). The responsibilities of NEDO include co-ordination of research and development projects, creation of large-scale research facility development projects, developing a co-operative international research program and a global environment protection project.

Since 1992 NEDO has been involved in a long-term project entitled 'Basic Survey for Coal Resources Development / Research and Development of New Exploration Technology for Coal Resources'. From 1992 to 1996 NEDO and the then Queensland Department of Minerals and Energy carried out studies in Queensland under the umbrella of this project. From 1997 to March 2000, the project was based in NSW at Caroona.

A new joint project between NEDO and Queensland Department of Natural Resources and Mines (NR&M) was undertaken between 2000 and 2005. The joint project had three components. The first was to test the techniques NEDO had previously developed and to test further enhancements. The second was to develop a Coal Potentiality Evaluation System using GIS and artificial intelligence. The final component was to obtain an improved understanding of the geological framework of the basin, with airborne geophysics being used to underpin this understanding.

Seismic/Wireline Log Testing

The testing and evaluation of the techniques was undertaken in three separate areas of the Bowen Basin with the collaboration of the coal miners and explorers. The first field area was at Australian Premium Coals' Coppabella Mine, and the second and third were within an exploration permit held by Xstrata Coal Limited in the northern Bowen Basin (Figure 1). The

objective of the Coppabella project was to verify and improve a high-resolution and high-efficiency seismic reflection survey and evaluation technology for an Integrated Coal Resource Evaluation System (ICRES). The Northern Bowen Basin field test areas were used to evaluate improvements in the seismic equipment and the logging sonde, and were selected using the Coal Potentiality Evaluation System.

In 2001 a 3D seismic survey was carried out at Coppabella over an area of 1.35 km x 0.96 km, as was 3 km of 2D seismic split into four lines.

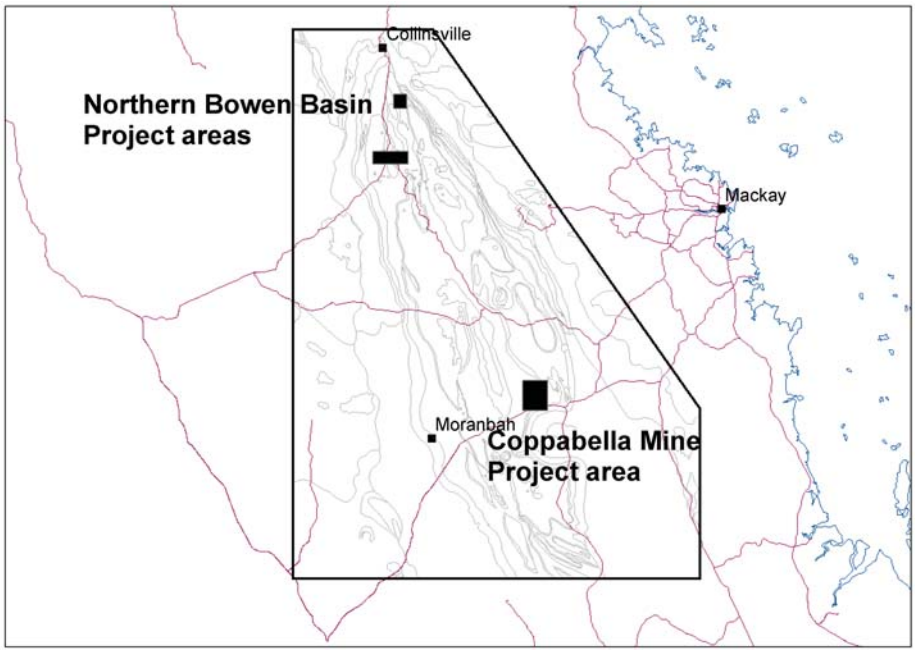


Fig. 1. Field test areas for the joint NEDO/NR&M Bowen Basin Project. The Coppabella project aimed to verify and improve a high-resolution and high-efficiency seismic reflection survey and evaluation technology for an Integrated Coal Resource Evaluation System. The Northern Bowen Basin field test areas were used to evaluate improvements in the seismic equipment and the logging sonde, and were selected using the Coal Potentiality Evaluation System (see text).

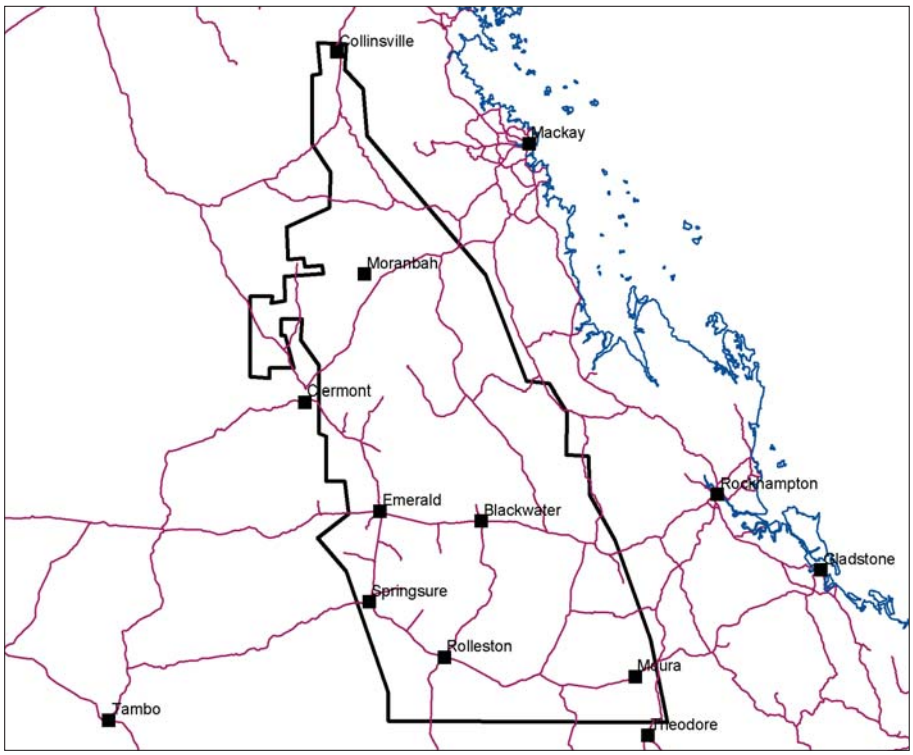


Fig. 2. Area (outlined in black) covered by airborne surveys flown between 2002 and 2004.

Four fully cored boreholes were drilled and subjected to geophysical logging and vertical seismic profiling. The geophysical logging also investigated the direct measurement of sulphur and ash content using a neutron-gamma tool. A 2 km^2 area gravity survey was also carried out. The data were integrated to produce a geological model based on the Kinetic Modelling System under development by NEDO since 1997. The model is being progressively compared to the results of mining.

An electromagnetic vibrator was used as a seismic source. The vibrator has a vibration force of 800 kgf and a sweep range of 6.5 to 500 Hz. The high sensitivity geophone has a natural frequency of 150 Hz and a sensitivity of 1.8 V/kine. The recording parameters for the 2D survey involved a 2.5 m interval with a single geophone, a split spread with near offset of 13.75 m and a shot interval of 10 m. Sweep parameters were determined from point tests on each line. Recording parameters for the 3D seismic survey were 10 m station interval with 60 m line spacing of station lines, 20 m shot interval with 30 m spacing of shot lines. This resulted in 20-fold maximum common mid point coverage and bin size with 5 m in-line and 10 m cross-line.

The Coal Potentiality Evaluation System consists of two main components, a coal GIS and an expert system (Coal Potentiality System). The Coal Potentiality Evaluation System was used to assess field study areas in the northern Bowen Basin. A potentiality map was prepared for the area covered by the northern Bowen Basin airborne geophysical survey. Areas of high potential were identified.

The field test areas were required to evaluate improvements in the seismic equipment and the logging sonde. For the seismic system, a pseudo-random code signal has been introduced to the electromagnetic vibrator and recording system. This signal is introduced for improved measurement of high-velocity near-surface layers such as basalt. During November/December 2003, a 10 km seismic line was recorded using the updated equipment. Three fully cored boreholes supplemented the seismic data, the deepest borehole being 301 m. The upgraded wireline log sonde was run in all three holes. This was followed up in late 2004 and early 2005 with two fully cored boreholes and 14.2 km of seismic surveys.

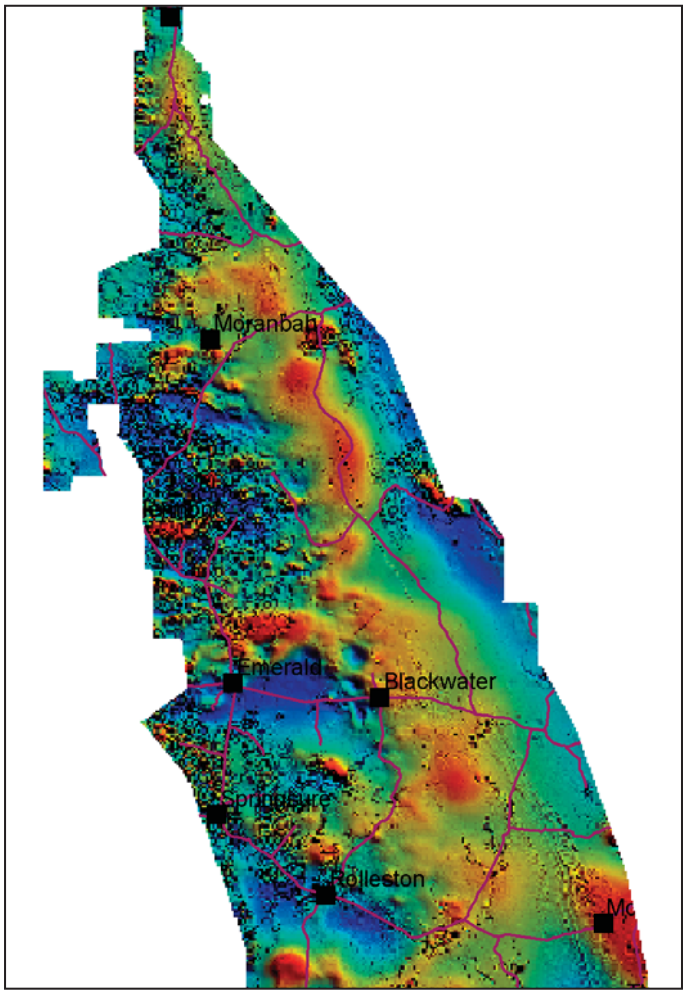


Fig. 3. Total Magnetic Intensity image.

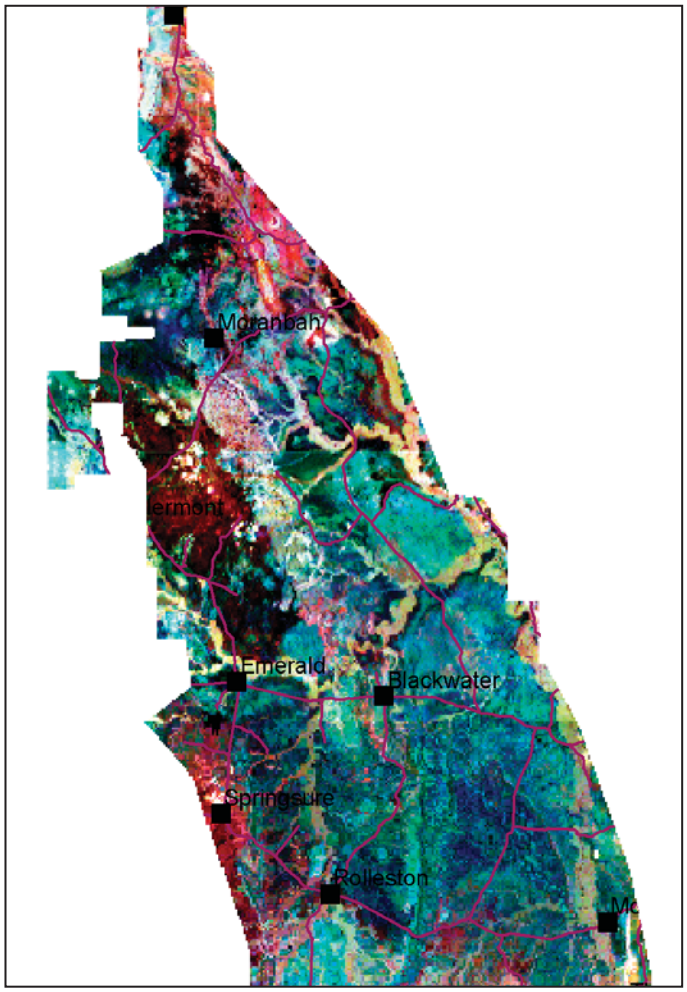


Fig. 4. KThU image.

Airborne Geophysics

As part of the project, the Department of Natural Resources and Mines flew airborne geophysics over much of the Bowen Basin (Figure 2). The magnetic (Figure 3) and radiometric (Figure 4) data were obtained to assist in the development of an improved knowledge of the geological framework of the basin. The surveys were flown over three years (2002-2004) and at a line spacing of 400 m and a flying height of 80 m.

A new Northern Bowen Basin Solid Geology Map was prepared jointly by CSIRO (Renate Sliwa) and NR&M (John Draper), but the remaining airborne data are still being interpreted. Highlights from the data interpretations to date are: the verification and better definition of structural compartmentalisation, the mapping of much greater extent of basalt than that previously mapped, enhanced mapping of faults, identification of previously unknown structures, high potassic nature of tuffaceous units and identification of previously unknown intrusions. The mapping in the northern Bowen Basin will be extended throughout the Basin to produce a revised solid geology map of the Basin.

In 2003, Pitt Research P/L, under licence from Vector Research P/L, undertook overburden filtering (OB filter) of a test area across the central Bowen Basin, near Blair Athol. The aim of the commission from GSQ was to test the technique's ability to resolve geology from an area of basalt cover, deep structures, strong curvilinear features (dykes, faults and bedding) and stock-like intrusions. The results showed that:

- These new datasets allow the sub-basalt response to be better resolved
- Details of the near-surface geology are clearer
- Linear and stock-like features are resolved

Outcomes/Outputs

The joint NEDO/NRM&E Project in the Bowen Basin is an example of a successful co-operative project. It has involved not just two government bodies but also a number of sub-contractors and coal companies. Co-operation has operated at strategic and policy levels, and at technical levels. The project produced the planned outputs and achieved the planned outcomes.

For further information on the Bowen Basin Project please contact John Draper (07 3362 9340 or john.draper@nrm.qld.gov.au). For information about airborne data in Queensland contact David Searle (07 3362 9357 or david.searle@nrm.qld.gov.au). Information on geophysical surveys can be obtained from the Interactive Resource and Tenure Maps on the Department's website (http://www.nrm.qld.gov.au/mines/index.html). The website contains a link to GADDS from where the government airborne data can be downloaded.

Australian gold output slumps in 2004, but ABARE forecasts 17% increase to 325 t in 2005/06

Australia's gold production slumped to 261 tonnes in 2004, according to a survey of industry production by Melbourne's Surbiton Associates. It ranked second behind South Africa (345 t) and ahead of the US (259 t) and China (212 t). 2004 production was 6.5 per cent, or 18 t, less than in 2003, according to Surbiton's latest Australian Gold Quarterly Review, released in March.

Output for the December 2004 quarter at 66.6 t was slightly ahead of 66.4 t in the preceding (September) quarter but was down by 9.5 per cent on the December 2003 quarter (Figure 1).

Surbiton's Managing Director Sandra Close said 2004 production was the lowest since 1995 – mainly as a result of mine closures and wet weather in WA.

The plant closures of Sons of Gwalia, Hannans South, Kundana, New Celebration and Bronzewing were all in WA.

It was not until late in the year that any new capacity was commissioned, at St Ives and Telfer in WA and Cracow in Queensland.

Dr Close called on the Federal Government to provide incentives for mineral exploration, saying it was the "best hope of redressing Australia's appalling balance of trade".

She said the downward trend in gold output was a result of lower exploration spending and fewer new discoveries.

"Australia is now producing about 50 t of gold a year less than it did in the peak year of 1997. This represents a reduction of around $900 million a year in gold exports at current prices," Dr Close said.

However, the government's Australian Bureau of Agricultural and Resource Economics (ABARE) forecast, also in March this year, that gold output will increase by 17% next fiscal year to 325 t, then rise another 9.2% to 355 t the following fiscal year ending June 30, 2007 (Figure 2).

Gold production is forecast to jump in Australia largely because of the commissioning of Newcrest Mining Ltd.'s Telfer mine and some smaller operations, including Newcrest's Cracow Mine, Bendigo Mining Ltd.'s New Bendigo Mine, Perseverance Corp.'s Fosterville Mine and Nustar Mining Corp.'s Paulsens Mine.

Although the forecasts are bound to be rubbery, they form the basis of better forecasts when more information comes to hand.

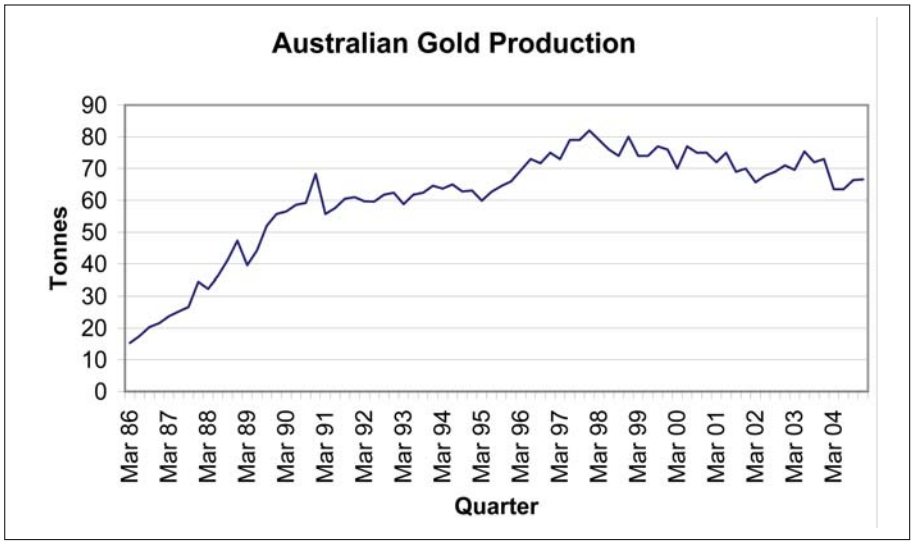


Fig. 1. Australian quarterly gold production from 1986 through 2004. Note the gradual decline since peak production in the Decmber Quarter 1997.

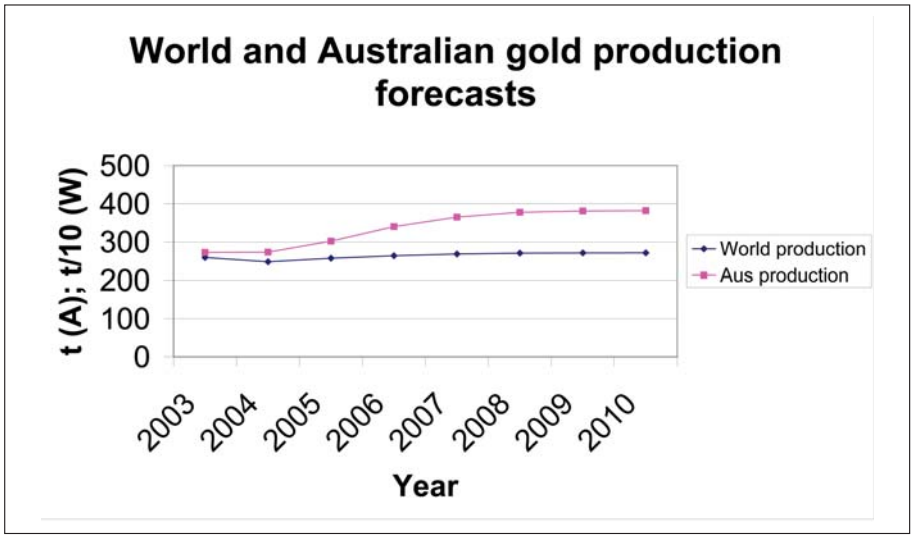


Fig. 2. Gold production forecasts by ABARE for Australia and the World, through 2010. Note the difference by a factor of 10 in the ordinates for the two data sets. Data have been adjusted so that the two reporting periods are in calendar years.

Global expenditure on non-ferrous exploration now at highest level since 1997: Australia slips from 2nd to 5th

The total non-ferrous mineral exploration expenditure for 2004 was almost US$ 3.8 billion[1]; according to Metals Economics Group's recent edition of ***Corporate Exploration Strategies***.

Worldwide non-ferrous exploration budgets steadily increased through the early 1990s to a maximum of $5.2 billion in 1997, before

[1] Information for this article was obtained from the website of the Canadian Metals Economic Group: http://www.minesearch.com/catalog/pages/press2004.htm. We thank the MEG for permission to use these data. All dollars are in $US.

falling for five straight years to a 12-year low of $1.9 billion in 2002. Since that time, exploration budgets have risen for two straight years, rebounding to $2.4 billion in 2003. The 2004 estimate of $3.8 billion is double the estimated worldwide total at the bottom of the cycle in 2002.

Last year's increase in worldwide exploration expenditure was mainly due to three main factors:

1. Increased spending by the majors, as they recognised the dearth of new projects moving up the pipeline;
2. A significant reduction in the negative influence of industry consolidation on exploration from the peak consolidation levels seen in 2000 and 2001; and
3. Two consecutive years of increased spending by junior companies on the back of increased gold prices and rising investor interest.

The impact of increased exploration budgets by junior companies was very significant. They were up by 103%, accounting for about 60% of the overall increase in exploration allocations and almost 45% of the overall exploration total by all companies surveyed by the MEG.

Latin America still the leading location for spending

The figures below illustrate the regional distribution of the $3.55 billion in exploration expenditure by the 1138 companies included in the 2004 study and the comparison with the $2.19 billion budgeted by 917 companies in 2003 (Figures 3 and 4 and Table 1).

Table 1: Estimated total worldwide exploration spending

Year	MEG estimated total budgets (US$ billions)	$ Change from previous year (US$ millions)
2004	$3.8	+$1400
2003	$2.4	+$500
2002	$1.9	-$300
2001	$2.2	-$400
2000	$2.6	-$200
1999	$2.8	-$900
1998	$3.7	-$1500
1997	$5.2	+$600
1996	$4.6	+$1100
1995	$3.5	+$600
1994	$2.9	+$400
1993	$2.5	+$300

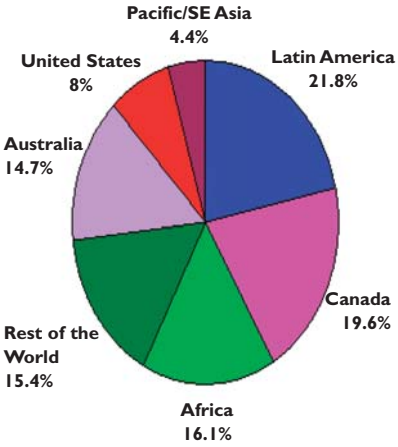


Fig. 3. Worldwide nonferrous exploration spending by region 2004 (1138 companies' budgets totaling US$3.55 billion).

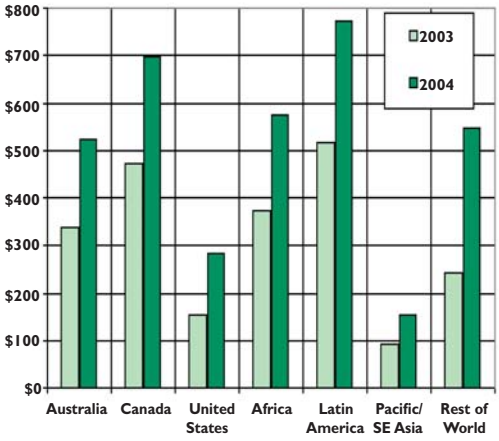


Fig. 4. Worldwide ferrous exploration spending by region, 2003-2004 (US$ millions)

Exploration allocations by surveyed companies have increased in each of the regional categories for the second consecutive year. In dollar terms, budgets increased the most this year in the ***rest-of-world*** category, led by sharp increases in Russia, Mongolia, and China; Latin America, led by increased spending in Peru and Mexico; and Canada.

Latin America continues to be the most popular destination for exploration spending, increasing its lead over second-place Canada to more than $76 million in 2004 from the $46 million margin in 2003. Africa remains in third place by region, having surpassed Australia for the first time in 2003. The substantial increase in allocations in the ***rest-of-world*** region have outstripped a more moderate recovery in Australian spending, moving the region to fourth place, with Australia slipping to fifth. Before beginning its gradual slide in recent years, Australia had held second place by region from 1994 to 2001, when Canada displaced it for the first time.

However, it may be appropriate to change the regional classifications so that each region is normalised according to its surface area. For example Australia occupies only about a quarter of the area of Africa, yet the two regions are compared as though they had the same area.

The full report is a 900-page two-volume study and is now available (on the Internet and in print) for US$12,000 [approximately Aus$15,200] from Metals Economics Group, PO Box 2206, Halifax, Nova Scotia, B3J 3C4; email: meg@metalseconomics.com; web site: www.metalseconomics.com

WMC endorses BHP Billiton offer

WMC Resources Ltd recommended on 30th March that their shareholders accept the A$7.85 offer from BHP Billiton in the absence of a superior proposal. The BHP Billiton cash offer for $7.85 per WMC share is conditional on acceptances representing 90% of WMC shares, Foreign Investment Review Board and other regulatory approvals, as well as other conditions.

WMC Resources CEO Andrew Michelmore said, "The BHP Billiton offer represents a substantial increase on the current $7.00 per share Xstrata cash offer.

"We have consistently pursued all options to maximise value for WMC shareholders. We believe this $7.85 offer represents excellent value for WMC shareholders.

"We will work with BHP Billiton to put the offer to WMC shareholders as soon as practicable", Mr. Michelmore said.

WMC Directors indicated that they will be accepting this offer for their own holdings of WMC shares in the absence of a superior proposal.

So unless Xstrata pull a wealthy rabbit out of the hat it looks like the end of the road very soon for WMC. For WMC shareholders the short-term gain will be impressive. Back in September 2004 WMC shares were selling at $3.81 each, so the capital gain in seven months is about 106% - not a bad deal in the short term.

The question now is: Will BHP Billiton be able to develop WMC's resources to make the capital investment of $9.2 billion worthwhile? Only time will tell.

Hopefully WMC's exploration program will remain intact as there is a need to locate more resources in greenfields areas in Australia.

Mineral exploration continues to re-bound and petroleum remains steady

Minerals

Figures released in March 2005 by the Australian Bureau of Statistics showed that the trend estimate for total mineral exploration expenditure increased by 4.5% to $249.2 million in the 2004 December quarter. The estimate has risen in the last five quarters and is now 33.3% higher than the 2003 December quarter and 53% higher than the same quarter in 2001.

Figure 5 shows plots of the data from December 1996 through to December 2004.

As usual Western Australia dominated with an increase this quarter of 8.2 million (5.8%) to $148.4 million, or about 60% of the total national increase.

The December quarter was dominated by exploration on areas of new deposits, which increased by $9.4 million (9.6%). Expenditure on areas of existing deposits increased by only $0.3 million (0.2%). Most of the increase was due to rising exploration for nickel and cobalt (up from $30.8 million to $40.4 million), and iron ore (up $29.8 million to $35.1 million). The largest decrease was for exploration of gold, which fell by $13.1 million to $96.8 million.

The trend estimate for metres drilled has been increasing for the past five quarters. The estimate for the fourth quarter of 2004 of 1756 km is 31.8% higher than the December quarter estimate for 2003. The only concern regarding these numbers is the reduction of metres drilled in greenfield areas, which dropped from 898 km to 603 km. In other words, the drilling effort is being focused in the vicinity of known deposits rather than searching in new areas.

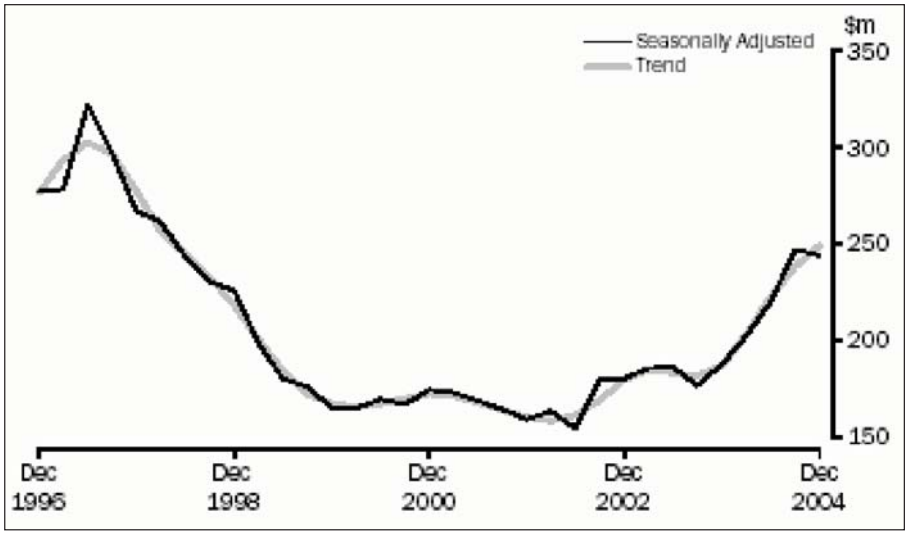


Fig. 5. Trend and seasonally adjusted quarterly mineral exploration expenditure from December 1996 to December 2004 (provided by the Australian Bureau of Statistics).

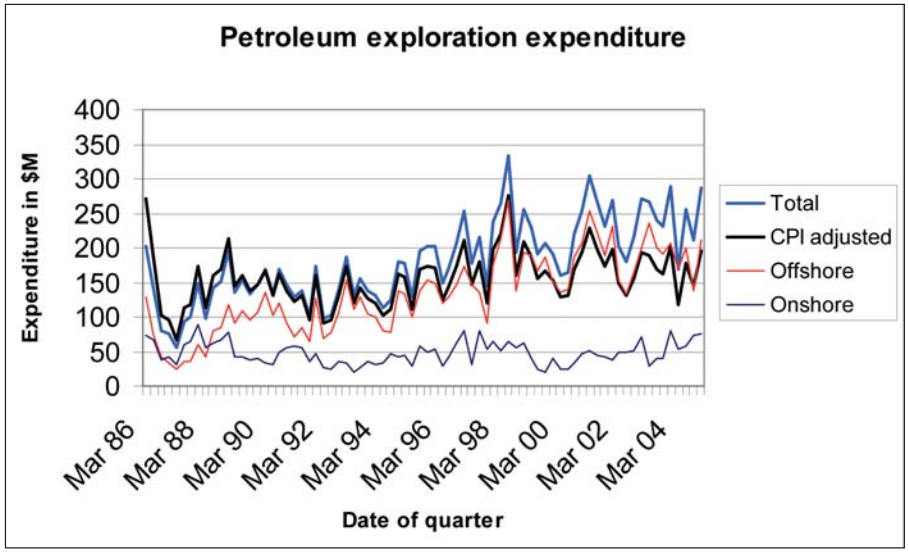


Fig. 6. Quarterly petroleum exploration expenditure from March 1986 through December 2004, for onshore and offshore areas. The individual offshore and onshore numbers are actual dollars spent, not CPI adjusted. Notice that the long-term trend, for the CPI adjusted (to 1998/99) total, decreases from 1998-2004.

Petroleum

In the 2004 December quarter, petroleum exploration expenditure rose by $76.1 million to $286.6 million from the previous quarter and was almost the same as the 2003 December quarter ($288.1 million). In fact, the CPI adjusted numbers indicate a slight decline in petroleum expenditure since 1998 (see Figure 6).

All states showed a rise in petroleum exploration expenditure except Western Australia, which recorded a decrease of $16.6 million to $113.1 million from the previous quarter, but still remains ahead of all the other states. Victoria had a huge increase of $49.0 million to $61.9 million.

Offshore exploration boosted with award of eleven new permits

Eleven new offshore petroleum exploration permits in the Western Australian and Tasmanian adjacent areas were granted earlier this year. The permits will be jointly administered by the Australian Government and the respective State Governments.

All the permits were awarded under the work program bidding system for an initial term of six years and result from bids in the round that closed on 30 September 2004.

The work program commitments for the awarded permits are valued at about A$220M over the next six years. A summary of the work programs and the permits are set out below.

Permit/Basin	Companies	Work program
T/37P & T/38P Bass	Galveston Mining Corp. and Exoil.	500 km^2 coverage of 3D seismic at a cost of $5.8 M. A program of geotechnical studies and two wells at a total cost of $24.8 M.
T/39P Bass	Benaris Petroleum BV	Seismic data purchase, of 1001 km of 2D seismic and geotechnical studies at a cost of $5.5 M, and a secondary program of 155 km^2 of 3D seismic, one well and geotechnical studies at a cost of $17.5 M.
WA-354-P Carnarvon	Apache Northwest and BHP Billiton Petroleum	50 km^2 of 3D seismic surveying, seismic data reprocessing and geotechnical studies at a cost of $0.75 M. One well and geotechnical studies at a cost of $12.25 M.
WA-355-P Carnarvon	Apache Northwest	3D seismic data purchase and geotechnical studies at a cost of $0.24 M, and a well and geotechnical studies at a cost of $12.05 M.
WA-356-P Carnarvon	Apache Northwest and Kufpec Australia	3D seismic data purchase, 812 km^2 of 3D seismic surveying, geotechnical studies and the drilling of four wells at a total cost of $37.88 M, a secondary program comprising a data review and the drilling two wells at an estimated cost of $15.3 M.
WA-357-P Carnarvon	Apache Northwest	Two wells, data purchase and review at a total cost of $13.05 M, and a secondary program of data review and a well at a cost of $6.1 M.
WA-358-P Carnarvon	OMV Barrow, Nippon Oil Exploration (Australia) and Tap Oil	Reprocessing 3D seismic data, one well and geotechnical studies at a total cost of $8.7 M, and a secondary program of geotechnical studies and a well at a cost of $8.4 M.
WA-359-P Carnarvon	Cue Exploration and Exoil Ltd	Geotechnical studies and 250 km of 2D seismic surveying at a total cost of $1.0 M, and a secondary program comprising geotechnical studies and a well at a cost of $15.45 M.
WA-360-P Carnarvon	Cue Exploration and Gascorp Australia	Geotechnical studies and 200 km^2 of 3D seismic at a total cost of $3.1 M, and a secondary program of geotechnical studies and one well at a cost of $15.45 M.
WA-361-P Carnarvon	Cue Exploration and Gascorp Australia	Geotechnical studies and 250 km of 2D seismic at a total estimated total cost of $1.1 M, and a secondary program of geotechnical studies and one well at an estimated cost of $15.45 M.

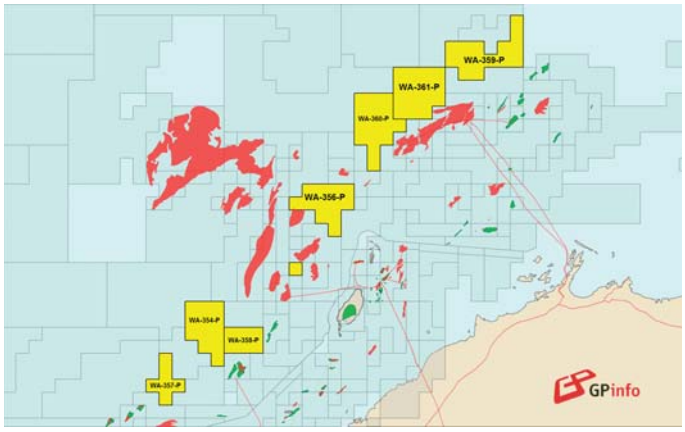


Fig. 8. Location of the Bass Basin permits recently awarded by the Commonwealth. The red and green colours represent known gas and oil fields. This figure has been provided courtesy of Encom Petroleum Information Pty Ltd.

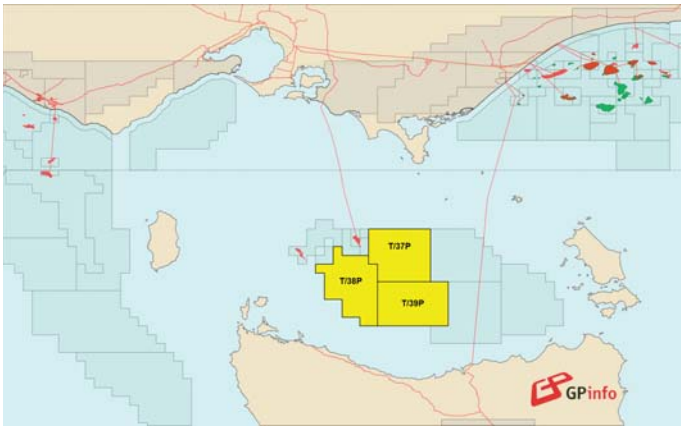
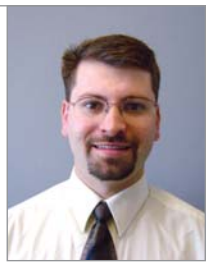


Fig. 7. Location of the Carnarvon Basin permits recently awarded by the Commonwealth. The red and green colours represent known gas and oil fields. This figure has been provided courtesy of Encom Petroleum Information Pty Ltd.



Physical Properties of Rocks: Fundamentals and Principles of Petrophysics

by J. H. Schön

Handbook of Geophysical Exploration: Seismic Exploration – Volume 18

Edited by Klaus Helbig and Sven Treitel

Elsevier Academic Press 583 pp; $171

ISBN: 0-08-044346-X

This ten-chapter book is the latest volume of the Handbook of Geophysical Exploration. It is targeted towards scientists and engineers involved with interpreting data collected in exploration, mining and environmental geophysics and presents an up to date and comprehensive overview of the physical properties of rocks. The book focuses more on the description of physical principles and processes rather than a detailed presentation of experimental results. On the whole this book conveys the information in a concise manner and is a good reference text for those engaged in the applied geosciences.

Chapter 1 details the role of rock physics as an integral part of geosciences. It covers the physical composition and classification of the major rocks of the earth. It also introduces the idea of conceptual rock modelling to represent the physical earth.

Chapter 2 describes the physics of porous media. It specifically details the physical properties of porosity, specific internal surface, and permeability and gives examples of the relationships between these properties for a number of characteristic sedimentary rock types.

Chapter 3 is devoted to the density of rocks. It gives a brief theoretical definition of density and how it may be employed to distinguish between different rock types and their constituents.

Chapter 4 deals with the magnetic properties of rocks. As with Chapter 3 it begins with an overview of the physical and theoretical background of magnetics. The general magnetic properties of rocks, minerals and fluids are discussed; including the correlation between magnetic susceptibility and magnetic mineral content, the influence of grain size and shape on susceptibility, and the effects of rock structure and temperature. It also gives a brief introduction to the phenomenon of natural remanent magnetization.

Chapter 5 presents an overview of the application of natural radioactivity to classify rocks. It gives a brief coverage of the physical principles behind the study of radiometrics and provides information on the relative proportions of Potassium, Uranium and Thorium in rocks and minerals. The concept of radioactive heat generation and terrestrial heat flow is also introduced.

Chapter 6 provides a theoretical background into the elastic properties of rocks, and their pore fluids and gases. It describes how the elastic properties of rocks may be used to distinguish between them through the exploitation of compression and shear-wave velocity characteristics and how these are affected by porosity and fracturing of the rock

Following on from Chapter 6, Chapter 7 describes the phenomenon of seismic wave attenuation and how it may be used to compare different rock types. It deals with various igneous and sedimentary rocks and the effects of thermal conditions on the characteristics of seismic attenuation. A detailed theoretical discussion on attenuation mechanisms is also included.

Chapter 8 deals with thermal properties of rocks and their constituents. It gives a detailed overview of the thermal properties of various minerals and rocks and describes the theory of heat flow modelling.

Chapter 9 describes the electrical properties of rocks and how these may be used to identify rocks of differing electrical conductivities. It gives a comprehensive overview of the underlying physical principles; including a discussion on complex resistivity, induced polarization, permittivity and anisotropy of electrical properties of rocks.

Chapter 10 focuses on tying the various physical properties of rocks together and describes some of the relationships between properties determined by the geophysical methods detailed in previous chapters. It also outlines some of the methods used to correlate between the results of these geophysical methods.

This book would be of interest to a broad spectrum of the geoscientific community engaged in the applied use of the physical properties of rocks and there constituents. It should be an essential reference for anyone directly engaged in the study and application of rock physics.

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