Preview

Australian Society of Exploration Geophysicists

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ANSIR Vibrators in the Tanami – page 33

- Digital gravity gradiometer – page 21
- Rock properties of the Sydney Basin – page 23
- Earthquake monitoring – page 26
- Climate change – page 2

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Climate Change takes centre stage

My annual excursion to the UK this year happened to coincide with the meeting of the G8 summit at Gleneagles and Tony Blair's attempts to persuade George W Bush that global warming is really happening. There were several excellent articles in the UK newspapers. I particularly like Mark Lynas's article The ***Proof of Climate Change*** which appeared in The Independent. Last year Mark published his book ***High Tide***, which is an excellent read for anyone interested in climate change. Anyway in his article he showed two photographs of the Jacabamba glacier in Peru. The first was taken by his father, Bryan Lynas in 1980, when he visited the valley on a geological surveying expedition.

The second taken by Tim Helweg-Larsen showed the same spot when he and Mark visited it in 2000. Just two decades of global warming had been enough to destroy the entire glacier.

These photos are reproduced (Figures 1 and 2), courtesy Mark Lynas for all readers to see.

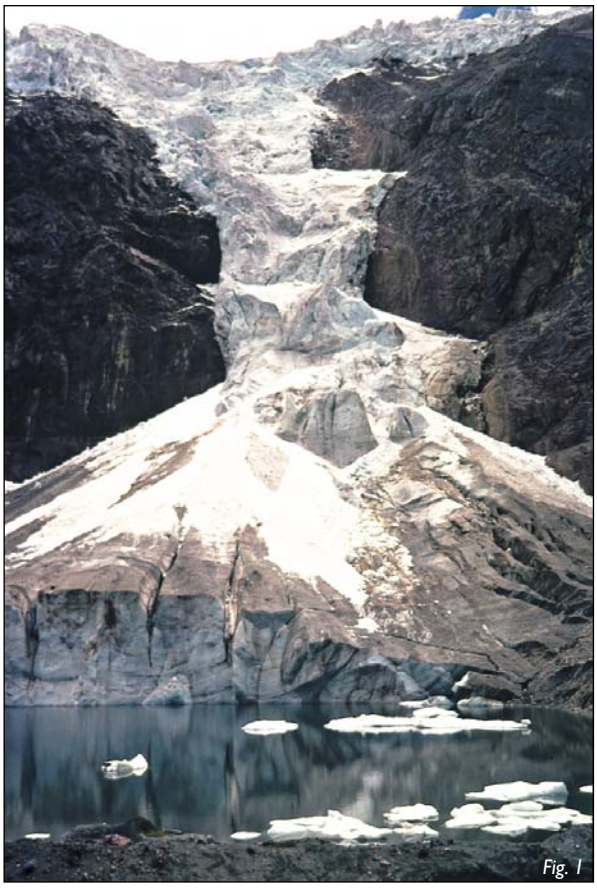
Then, in the New Scientist of 16 July 2005, an article by Bruce Lovett describes some of the effects on the Alaskan Glaciers in the last 100 years. In his article he refers to similar matched photographs taken by Bruce Molnia, of the USGS and he shows two photographs of the Glacier National Park taken in 1906 and 2004. I have reproduced these (Figures 3 and 4) for readers to see for themselves. The twist in this story is that the black and white photograph was taken in **1941** not **1906**!

So the changes you see in the photographs took place in 65 years not 100 – scary stuff.

It's not at all clear how, with evidence like this anyone could be in any doubt about global warming.

Fig. 3. Photo taken of Alaska's Glacier Bay National Park in 1941 shows the glacier ~650 m thick. (Photo courtesy of U.S. Geological Survey also re-published in the New Scientist, 16 July 2005, see: <http://sfgate.com/cgi-bin/object/article?m=/c/pictures/2004/12/17/mn_usgsmuir1941.jpg&f=/c/a/2004/12/17/MNGARADH401.DTL>).

Fig. 4. Photo taken of Alaska's Glacier Bay National Park from the same spot in 2004 by Bruce Molnia. It shows changes to Riggs Glacier in Muir Inlet and the growth of vegetation from 1941, when the glacier was ~650 m thick. (Photo courtesy of U.S. Geological Survey also re-published in the New Scientist, 16 July 2005, see: http://sfgate.com/cgi-bin/object/article?m=/c/pictures/2004/12/17/mn_usgsmuir2004.jpg&f=/c/a/2004/12/17/MNGARADH401.DTL>).



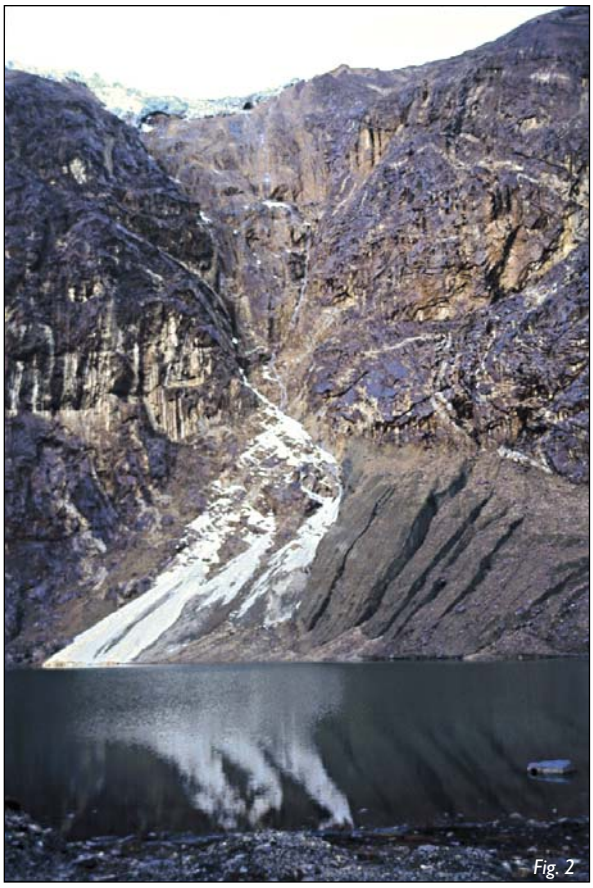


Fig. 1. Photo of the Jacabamba glacier in Peru, 1980, taken by Bryan Lynas in 1980, when he visited the valley on a geological surveying expedition.

Fig. 2. Photo of the Jacabamba glacier in Peru, taken by Tim Helweg-Larsen from the same spot when Mark Lynas and he visited in 2000.

It was some time ago when Peter Elliot, Secretary of the ASEG in Adelaide under the Presidency of Reg Nelson kick-started *Preview* as an A5 yellow paper photocopied newsletter to the members.

How things have changed – where are you Peter and Reg?

- Peter Elliot is now living in Perth and working almost everywhere else as a consultant geophysicist with emphasis on Indonesia.
- Reg Nelson is still in Adelaide (Strathalbyn) and is MD of Beach Petroleum.

What follows is a quick summary of a number of issues that require action during my tenure as President as well as some matters of interest and a couple of well-deserved acknowledgements.

Research Foundation – one tool for a truly 'smart country'

Rather than dumbing-down our education system and creating a second rate tertiary degree factory, (ABC, Four Corners, June 27) here is an opportunity for members of our Society to add quality to the product of our Universities and to make a difference.

The Foundation has a need for funds to cover an increasing number of applications from worthy geophysical graduates undertaking industry specific and focused research projects of high relevance to our science.

The ASEG Research Foundation is structured such that donations are fully tax deductible.

Please contact Phil Harman via: <phil.harman@gcap.com.au> to arrange the transfer of your tax-deductible funds.

Membership Directory

Every year for the past seven years, the fruits of one person's endeavours ripen and we are blessed with yet another plum. **Koya Suto**, I salute you. Many thanks again for your tireless efforts in producing a Directory, which, in spite of the ubiquitous web, is often my first port of call when I wish to contact a geophysicist, contractor or service supplier who I might have not seen or heard of for a year or two.

Wake up those geophysicists and contractors who have dropped out of sight. It is about time you advertised in the ASEG publications and supported your Society so it can support you. I hear too many of my peers saying they don't bother advertising in the ASEG publications because their real target market never reads *Preview* or *Exploration Geophysics*. Yet they are two of the most widely read publications in the industry, and Koya's plum is the most widely used directory in our industry.

SEG 75th Anniversary Ball

In this issue of *Preview* we are carrying a full page advertisement for this memorable occasion. I wish to express my appreciation on behalf of the membership to **Megan Evans** for her considerable efforts in organising, promoting and obtaining substantial sponsorship for this event. Some very impressive prizes will be drawn on the night and you will be entertained by a couple of famous sportsmen MCs. Tickets are selling fast, so don't hesitate.

Stirrings afoot in the Apple Isle

The University of Tasmania has recently benefited from the largesse of the Federal Government to the tune of $15,000,000. Not only that but they boast the President of the GSA Tony Crawford, and the ASEG President-Elect James Reid. What a hot-bed of societal activity can be expected during 2006, when the ASEG/GSA AESC Convention takes place during July 2-7 just across Bass Strait.

Alan Appleton – ASEG Service Certificate recipient

Big Al's last day at PIRSA was July 01, 2006. This day saw the end of a 30 year career with SADME, MESA and PIRSA. Alan was a constant in a sea of change within the Geophysics Section of the Geological Survey of South Australia. He has put in a huge amount of time over many years supporting the activities of the SA Branch of the ASEG.

Have an enjoyable retirement Alan.

Terry Crabb

Hydrogen is best chance

Your editorial on the Greenhouse Effect in the June *Preview* was timely.

As you point out, there are major problems of production, distribution, storage and use of hydrogen. I think there is some cause for optimism, due to the nuclear renaissance currently underway.

Large-scale production is feasible, at least through electrolysis.

Cheaper thermochemically-produced hydrogen is being developed as part of the Nuclear Hydrogen Initiative of the US DOE. It is scheduled to produce commercial-scale hot hydrogen in 2017 using helium-cooled HTR reactors. See http://nuclear.gov

Hot hydrogen is already in refinery demand to crack and upgrade carboniferous feedstock. When hydrogen is produced in and consumed by a refinery, it gets distributed and stored as a component of the familiar liquid hydrocarbons used in conventional engines.

Clearly, as cheap copious hydrogen comes into production, it can find an immediate market in the existing fuel economy.

Making the feedstock carbon greenhouse-efficient would require that its fossil sources be reduced and ultimately replaced with recycled carbon, such as biomass. Conceivably, industrial areas might pipe CO2 to the local refinery for reuse as backbones for hydrocarbon fuels.

Roger Clifton
NT Branch ASEG

2005

4-7 September
Near Surface 2005
11th European Meeting of Environmental and Engineering Geophysics of the Near Surface Geoscience Division of the EAGE
Venue: Palermo, Sicily
Website: http://www.eage.nl

13-16 September
South African Geophysical Association
9th Biennial Conference and Exhibition
Theme: More out of our Depth
Venue: Cape Town International Convention Center SA
Website: http://www.sbs.co.za/saga2005/

17th September
SEG 75th Anniversary Dinner and Ball
Venue: Burswood Resort and Casino, Perth
Contact: www.aseg.org.au/wa/seg_party

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

30 September
KSEG Special Symposium on Borehole Geophysics
Venue: Chonnam National University, Kwangju, Korea.
There will be a signing ceremony of KSEG-ASEG Association Agreement at this meeting.

13-14 October
Australian Frontier Basins Workshop
Sponsors: Geoscience Australia
Theme: Petroleum exploration opportunities of Australia's frontier basins. New seismic data acquired through the 'Big New Oil' program will be made available from the South West margin and results from the hydrocarbon seeps studies.
Venue: Geoscience Australia, Canberra
Contact: Jenny Maher
Email: jenny.maher@ga.gov.au

16-18 October
SEGJ 113th Conference, Naha, Okinawa, Japan
There will be a special international session in English. Papers are invited from associated societies including ASEG.
Website: http://www.segj.org/committee/gyouji/conf113_e.html

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

13-17 November
GREENHOUSE 2005: Action on Climate Change
Main sponsors: CSIRO, AGO and BOM.
Venue: Carlton Crest Hotel, Melbourne
Website: http://www.greenhouse2005.com

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

2006

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

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

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

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

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

2007

18-22 November

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

Australian Earth Sciences Convention 2006 – *Resourcing Our Future*

Invitation to Sponsor and Exhibit

The conference is now gathering momentum, with the opening of registrations and abstracts now being accepted live on the conference website.

Most importantly, now's the time for those keen to support our initiative by taking out a Trade Booth or becoming a Conference Sponsor. A trade exhibition, geoscience program and industry seminar series will give our supporters exposure to a large and diverse audience of explorers, miners, government and academia.

For those planning on supporting the Convention, the **Trade Exhibition** offers 100 trade booths across two levels of the stunning Melbourne Convention Centre. We've arranged for catering to be served in the exhibition area so that delegates and exhibitors alike can make the most of mealtime networking. An **Exhibition Prospectus** and floorplan layout is available from the convention website and we expect booths to be taken up fast.

A **Sponsorship Prospectus** is also available from the convention website, offering benefits at each of the four main sponsorship levels, plus some additional individual sponsorship opportunities. The organising committee is very pleased to welcome INCO as Platinum Sponsor of the Australian Earth Sciences Convention 2006, and the Victorian Department of Primary Industries as one of the Gold Sponsors.

The **program** has been organised into six **major geoscience themes**:

- Mineral Resources Geoscience
- Energy Resources Geoscience
- Environmental and Engineering Geosciences
- Geodynamics of Earth's Evolution
- Resourcing Geoscience
- Innovation in the Geosciences

A range of pre- and post-convention **workshops and fieldtrips** will be offered. A list of proposed field trips and workshops is available on the Convention website. Additional activities and details of each will be on the website soon. And don't forget that earth science conferences are great opportunities for catching up with old friends and colleagues, and meeting new ones.

Key Dates

- Second Call for Abstracts: September 2005
- Trade booth allocation: 2 December 2005
- Abstract Submission Deadline: 15 December 2005
- Early Bird Registration Deadline: 28 February 2006
- Australian Earth Sciences Convention 2006: 2 to 6 July 2006.

For more information please visit www.earth2006.org.au or contact the Convention Office: The Meeting Planners 91-97 Islington St, Collingwood, Vic., 3066 Tel: 03 9417 0888 Fax: 03 9417 0899 Email: earth2006@meetingplanners.com.au

New Members

The ASEG welcomes the following new members to the Society. Their membership was approved at the Federal Executive meetings on 25 May and 29:

Name	Agency	State
Angela Louise Bush	University of Melbourne	Vic
Gregory Cant	Integrated Geophysical Solutions	WA
Ashley Ezzy	Veritas DGC Australia	WA
David Patrick King	Marine & Earth Sciences Pty Ltd	Vic
Darren John Salter	Santos Ltd	SA

Ted Tyne moves to PIRSA

As members may be aware, Ted Tyne resigned as Director of the NSW Geological Survey in April this year and is now Director Mineral Resources Group, Department of Primary Industries and Resources of South Australia.

Ted was appointed as the Director, NSW Geological Survey in July, 2002 after previously holding the position of Assistant Director,

Regional Geology and Geophysics. He had the overall responsibility of managing the State's geoscience mapping and resource assessment programs as well as directing the Government's very successful Exploration NSW Initiative.

He is a BSc and PhD graduate from the University of NSW and more than 30 years government and industry experience.

Ted has been a member of the ASEG since 1971 and was awarded the ASEG Service Certificate, for outstanding service to the ASEG in 2000. We wish him well in South Australia.

Errata in the Membership Directory 2005

There were inadvertent errors in the Honours and Awards section (page 16-17) of the ASEG Membership Directory 2005:

— Mike Asten was the recipient of the Laric Hawkins Award in 2004.

— The Lindsay Ingall Memorial Award was awarded to Peter Hatherly in 2004 not 2006.

— 2004 ASEG Service Award recipient "Rod Lavibond" should read Rod Lovibond.

The Editor apologises these omission and errors.

ASEG officers

Published for ASEG by:

PUBLISHER: Brian Wickins
RESolutions Resource & Energy Services Pty Ltd
Tel: (08) 9446 3039
Fax: (08) 9244 3714
Email: brian@resolutions-group.com.au

EDITOR: David Denham
7 Landsborough Street, Griffith ACT 2603
Tel: (02) 6295 3014
Email: denham@webone.com.au

ASSOCIATE EDITORS:

Petroleum: Mick Micenko
Email: micenko@bigpond.com

Petrophysics: Don Emerson
Email: systems@lisp.com.au

Minerals: Peter Fullagar
Email: p.fullagar@mailbox.uq.edu.au

Book Reviews: David Robinson
Email: david.robinson@ga.gov.au

Web Waves: Jill Slater
Email: jill.slater@santos.com

Geophysical History: Doug Morrison
Email: sth.lands@optusnet.com.au

ASEG HEAD OFFICE & SECRETARIAT:

Ron Adams
Centre for Association Management
PO Box 8463, Perth Business Centre
WA 6849
Tel: (08) 9427 0838
Fax: (08) 9427 0839
Email: secretary@aseg.org.au
Web site: http://www.aseg.org.au

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

FEDERAL EXECUTIVE 2005[1]

PRESIDENT: Terry Crabb
Tel: 08 9385 9626
Email: tncrabb@westnet.com.au

PRESIDENT ELECT: James Reid
Tel: 03 6226 2474
james.reid@utas.edu.au

1st VICE PRESIDENT: Jenny Bauer
Tel: (07) 3858 0601
Email: jenny.bauer@upstream.originenergy.com.au

TREASURER: John Watt
Tel: (08) 9222 3154
Email: john.watt@doir.wa.gov.au

SECRETARY: Lisa Vella
Tel: (08) 9479 8476
Email: lisa.vella@wmc.com

PAST PRESIDENT AND INTERNATIONAL AFFAIRS:
Howard Golden
Tel: 08 9479 0576
Email: howard.golden@wmc.com

STATES' REPRESENTATIVE:
Don Sherlock
Tel: (08) 6436 8729
Email: don.sherlock@csiro.au

MEMBERSHIP COMMITTEE: Koya Suto
Tel: (07) 3876 3848
Email: koyasuto@optusnet.com.au

ASEG Branches

ACT

PRESIDENT: Jacques Sayers
Tel: (02) 6249 9609
Email: jacques.sayers@ga.gov.au

SECRETARY: Adrian Hitchman
Tel: (02) 6249 9800
Email: adrian.hitchman@ga.gov.au

New South Wales

PRESIDENT: Michael Moore
Tel: (02) 9901 8398
Email: michael.moore@dipnr.nsw.gov.au

SECRETARY: Naomi Osman
Tel: (02) 9460 0165
Email: nosman@awexp.com.au

Northern Territory

PRESIDENT: Jon Sumner
Tel: 0407 089 261
Email: jon@thepod.com.au

SECRETARY: Roger Clifton
Tel: (08) 8999 3853
Email: roger.clifton@nt.gov.au

Queensland

PRESIDENT: Nigel Fisher
Tel: (07) 3378 0642
Email: kenmore_geophysical@bigpond.com

SECRETARY: Binzhong Zhou
Tel: (07) 3327 4189
Email: binzhong.zhou@csiro.au

South Australia

PRESIDENT: Selina Donnelley
Tel: (08) 8224 7560
Email: Selina.Donnelley@santos.com

SECRETARY: Tania Dhu
Tel: (08) 8303 5326
Email: tania.dhu@adelaide.edu.au

Tasmania

PRESIDENT: Michael Roach
Tel: (03) 6226 2474
Email: michael.roach@utas.edu.au

SECRETARY: James Reid
Tel: (03) 6226 2477
Email: james.reid@utas.edu.au.

Victoria

ACTING-PRESIDENT: Suzanne Haydon
Tel: (03) 9658 4515
Email: suzanne.haydon@dpi.vic.gov.au)

SECRETARY: Ashley Grant
Tel: (03) 9278 2179
Email: ashley_grant@ghd.com.au

Western Australia

PRESIDENT: Donald Sherlock
Tel: (08) 6436 8729
Email: don.sherlock@csiro.au

SECRETARY: Julianna Toms
Tel: (08) 9266 3521
Email: julianna.toms@geophy.curtin.edu.au

Australian Capital Territory – by Adrian Hitchman

The ACT Branch has recently enjoyed presentations from two researchers visiting the Research School of Earth Sciences, Australian National University.

On 6 April, members attended a talk given by Doug Wiens at Geoscience Australia on *Mantle structure and flow patterns beneath island arcs and backarc basins*. Doug is a geophysicist with the Department of Earth and Planetary Sciences, Washington University, St Louis, Missouri. He has been active in geophysical research in the Asia-Pacific, South America and Antarctica for many years. Doug outlined the seismic characteristics of some Pacific island arcs and backarc basins, and discussed their implications for geodynamic models of mantle flow. Such models include viscous coupling between the backarc flow and the downgoing plate, which produces flow parallel to the convergence direction, and the subduction zone rollback, which produces along-arc flow. Doug's research suggests that viscous coupling does not exert a strong influence on mantle flow in backarc regions.

Our second talk was held at RSES on 25 May and given by Doug Schmitt, on *Rock physics and time lapse monitoring – experience in Canadian heavy oil reservoirs*. Doug had been on sabbatical at RSES from the University of Alberta where he holds a Canada Research Chair position in Rock Physics. Doug heads an experimental lab which focuses primarily on integrating rock properties with geophysical observations, particularly in relation to geophysical time-lapse investigations of heavy oil reservoirs. This research is especially pertinent in presence of significant heavy/bituminous oil reserves in Alberta, giving Canada the second highest known oil reserves in the world (behind Saudi Arabia). Doug outlined the challenges of producing these reserves and described the role of time-lapse techniques in production monitoring and reservoir characterisation. In view of the world's declining oil reserves, interest in exploiting heavy and bituminous oil resources is beginning to gather significant momentum.

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

New South Wales – by Naomi Osman

At our May meeting, Ray Shaw from Great Artesian Oil and Gas Ltd gave an interesting and informative talk on *Geophysical considerations for the new generation of oil and gas explorers in the South Australian Cooper Basin*. The Branch would like to thank Great Artesian Oil and Gas Ltd for the talk and for their sponsorship of the meeting. In June, instead of the usual technical meeting, NSW Branch held a social dinner at Zia Pina's Pizzeria in The Rocks. From the reports of sore heads the next morning it sounds like everyone had a great time. David Robson, Team Leader Geophysics of the Geological Survey of NSW, NSW Dept of Primary Industries, was convinced to travel down from Maitland to speak out our July meeting. We were shown photos of the new look location of the Geological Survey and heard about the current and future activities with details on geophysical surveys, DIGS, MinView and 3D/4D visualization and data delivery.

Branch meetings are usually on the third Wednesday of the month and held at the Rugby Club, Rugby Place (near Pitt & Alfred St), starting at 5:30 pm.

South Australia – by Selina Donnelley

In May, the SA Branch of the ASEG had 27 people attend a technical meeting during which Volmer Berens, a Hydrogeologist from the Department of Water Land & Biodiversity Conservation, presented "Instream Geophysics (NanoTEM): A tool to help identify Salt Accession Risk". The 40 km Loxton/Bookpurnong reach of the South Australian River Murray is estimated to contribute 200 tonnes of salt each day. Much of this accession results from excess irrigation water that pressurises the underlying saline unsaturated aquifer, consequently inducing the flow of saline groundwater to the river alluvium. A large survey using a floating version of the Zonge Engineering NanoTEM system was run in February 2004 from Blanchetown, SA to the Mallee Cliffs, NSW. The geophysical data set (which was acquired at a much lower cost and at a faster rate than conventional data) correlated well with RoR, EC trends, and a groundwater MODFLOW model. A further validation was undertaken using instream coring and sampling, as well as petrophysical and pore water analysis. All the results appear to correlate well with the geophysical study, further increasing confidence in its application.

On June 22nd two presenters from PricewaterhouseCoopers attended the SA Branch Technical meeting. Andrew Forman and Doug Craig presented "mine* Enter the Dragon: Review of Global Trends in the Mining Industry". PWC provides an overview of the financial performance and position of the global mining industry based on an analysis of some of the largest mining companies across the world. The report is based entirely on publicly available information, and concentrates on the 40 largest mining companies in 2004. These 40 largest companies represent 80% of the global industry by market capitalisation. The sharp increases in demand for commodities, particularly from China, and resurgence in investor interest in the mining sector has led to the global mining industry generating spectacular results across all measures. Doug presented a very interesting talk covering the key statistics for 2004, and discussed issues such as safety performance, company profits and how they will be spent, value, risk, sustainability, political risk. The concluding question fitted in with the title of the talk, how will the Chinese government target of doubling GDP by 2020 affect the global mining industry? The next few years are sure to be exciting! We are pleased that PricewaterhouseCoopers presented such an interesting talk to the SA Branch Members, and suggest anyone interested in the results can download the document from the PWC Australia Web Site, and click on "Enter the Dragon" http://www.pwc.com/au/eng/main/home/index.html

The SA Wine Committee is busy collating wine for the 2005 Wine Tasting night, which will be held on July 22nd at the Chapel Café in Adelaide. This year we have had an outstanding response from the wineries, and will taste over 60 wines in order to choose the winning white and red wines.

We again thank our sponsors for technical meetings in 2005: PIRSA, Schlumberger, Santos, Cooper Energy, Australian School of Petroleum, Minotaur Resources, Petrosys, Zonge Engineering, Beach Petroleum, Stuart Petroleum & PGS Reservoir.

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

Western Australia – by Anita Heath and Megan Evans

The SEG/EAGE Distinguished Instructor Short Course (DISC) will only be held in Perth this year. Dr. Rodney Calvert of Shell will be presenting *Insights and Methods for 4D Reservoir Monitoring and Characterisation* on Tuesday August 23rd 2005. The course will run all day at the Australian Resources Research Centre (ARRC), 26 Dick Perry Avenue, Kensington, Western Australia, 6151. For more information on the event see http://seg.org/services/ce/disc/2005/calvert_abstract.shtml and register at http://www.aseg.org.au/wa/Perth_DISC_Registration_Form.pdf .

Rodney reports that his DISC course has been very well received so far but with varying numbers. In Europe where everyone is applying 4D there were great numbers attending to hear about some of the finer points for success. In other regions where 4D monitoring is not practiced, the numbers were less but the impact has been that several companies have already embarked upon their first projects as a result of the course. Some key messages from Rodney that need to be heard by management:

1. We cannot make reliable flow models of a reservoir without flowing it and observing where the changes are taking place.
2. If we cannot see what is happening in a reservoir then we cannot manage it properly. Reality is nearly always much more complex than our models, so simulations should not be used as a substitute for reality when managing a field.
3. Improved methods (better, faster, cheaper) than repeat 3D are now reliably available for 4D monitoring. 4D is a potent catalyst for improved multi-disciplinary approaches to field management and improved performance. Every day we develop a field without proper monitoring and control we risk irrecoverable loss of potential production and knowledge of the field status.
4. A field starts in its most simple state and fluid and pressure distributions only get more complex with production. The goal is to observe and manage this complexity for the best recovery.

We hope to see you all in August.

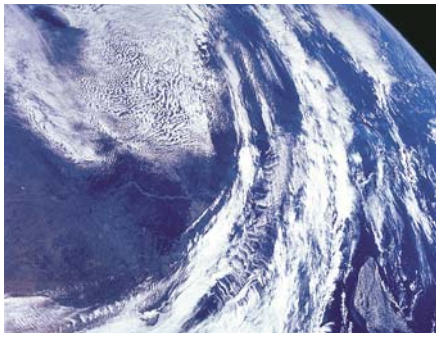
The ASEG is commemorating the SEG 75th Anniversary by holding a black tie ball in Perth on the 17th of September. Some historical geophysical equipment will be on display along with a brief history of the last 75 years of Geophysics.

There will also be many prize giveaways, including 2 return economy class tickets to anywhere in the world, thanks to Singapore Airlines. A raffle of a champagne diamond will also be performed on the night with all proceeds going to the Indigenous Australia Engineering Summer School, thanks to Linneys of Subiaco.

For more information please follow the links from the ASEG WA website: www.aseg.org.au/wa.

Weather and Climate Change

The weather is perhaps the most significant environmental influence on our day to day lives and as such it exerts some control over our day to day behaviour, for example, we all watch the weatherman (or woman) closely to help determine our activities for the immediate future.



Accurate forecasting only became possible when the telegraph was invented in 1844 by Samuel Morse, and data could be transmitted rapidly. Now only 160 years later a huge amount of information is available on the web, from climate modelling to station data, to observations from space that yield more accurate knowledge of events from tomorrow's local weather, to large scale processes such as El Nino and global energy budgets.

The increase in predictive accuracy combined with historical data has spawned the increasingly important field of climatic change and a large proportion of atmospheric science is now dedicated to forecasting how our climate is changing and attempting to determine its driving forces.

The NOAA (National Oceanic & Atmospheric Administration) National Weather Service ★★★★1/2
http://www.noaa.gov/wx.html

This national weather site primarily services the US, but there is loads of interesting information relating to space weather: http://www.spaceweather.noaa.gov, El Nino/La Nina effect: http://elnino.noaa.gov/ and http://www.pmel.noaa.gov/tao/elnino/nino-home.html, and links to several research organisations. Although mostly US based, it has some great satellite imagery of cyclones and severe weather all around the world including Australia.

Global Warming – US Environmental Protection Agency ★★★★★
http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html

This is an informative, easy to read, easy to navigate site which delves into the causes and impacts of global warming. The site has an interesting archive of publications, as well as up-to-date news and event information.

The Bureau of Meteorology ★★★
http://www.bom.gov.au

I believe this site is the best Australian weather website. It is easy to navigate and has some very good explanations on the information provided. It provides up to date charts and forecasts and radar images. In rainy weather conditions, I often check out the rainfall location and intensity radar map to gauge how wet I am going to get, or how fast I am going to have to ride my bicycle to avoid the next downpour.

After using this site for years, I hadn't realised just how much information is available on the BOM site. The links page has some very interesting science links which may be of interest. Science, maths and geography teachers may find this site useful, with subject-specific experiments and activities designed for students and teachers. Complete lesson plans and student work sheets are available. This site has something to offer everyone.

NOAA Operational Model Archive Distribution System ★★★
http://nomad2.ncep.noaa.gov/

If it is technical information you are looking for, this site from NOAA may be of interest. It requires some meteorological knowledge, but has the best archival data from all around the world, which would be useful for meteorological research. It gives clear instructions on how to produce weather plots.

Cooperative Institute for Meteorological Satellite Studies ★★★
http://cimss.ssec.wisc.edu/tropic/real-time/shemi/winds/winds.html

This site was formed as a collaborative effort between NOAA, NASA and the University of Wisconsin. It has excellent high resolution satellite imagery of Australia and derived wind information, upper level divergence (that's cyclone genesis stuff), vorticity and more.

Weatherzone ★★★★
www.weatherzone.com.au/

This is another good Australian general weather information site. Free registration gives you access to good daily weather briefings, personally customised to your location.

The American Institute of Physicists ★★★
www.aip.org/history/climate/

This is a site produced by the American Institute of Physicists. It has lots of information on global warming and climate change, including climate data, influences on climate, theory and models of climate and social implications of climate change. Very informative, but can be a bit tricky to navigate.

Earthshine Project – Big Bear Solar Observatory ★★★1/2
http://www.bbso.njit.edu/ > Projects > Earthshine

The Earth's climate depends on the net solar radiation trapped and emitted as long wave radiation by the Earths atmosphere and surface. A measure of the Earths albedo (reflectivity) is a good indicator for calculating changes in the global energy budget.

A very small long term change can have a significant impact on the weather described in the other websites. Very interesting.

US Global Change Research Program (USGCRP) ★★★★
http://www.usgcrp.gov/

The U.S. Global Change Research Program (USGCRP) aims to document, understand and project changes in climate and associated earth systems. Some of the USGCRP focus areas include climate variability and climate change, global water cycle, palaeoenvironment and palaeoclimate, human contributions and responses, and ecosystems. This website provides up to date information on these topics, and it also has an extensive archive of previous research findings.

Government gets serious about radioactive waste

The Australian Government has finalised a list of three possible locations for **a** Commonwealth Radioactive Waste Management Facility, after several years of bickering with the States. The original preferred site, at Woomera in South Australia was abandoned last July, when the siting of the facility in that state became a major issue during the last Federal Election campaign.

The proposed sites are on Defence Department properties at Mount Everard, Harts Range and Fishers Ridge in the Northern Territory (see Figure 1).

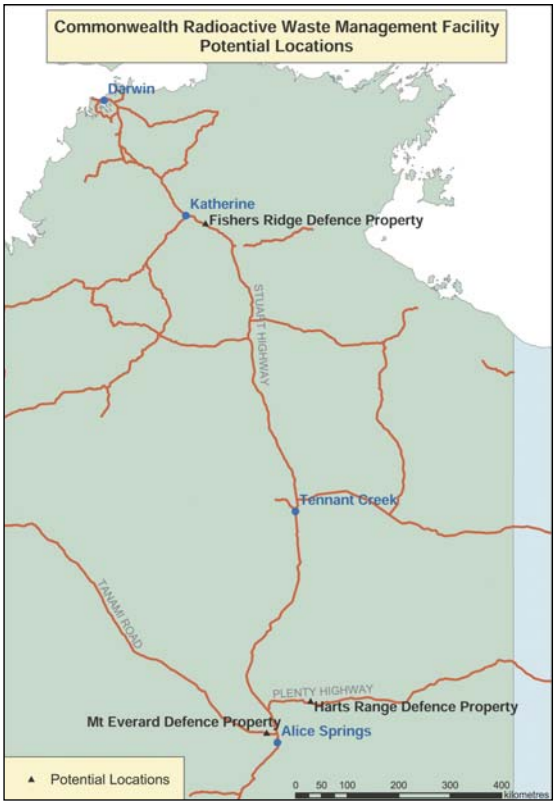


Fig. 1. Potential locations for a Commonwealth Radioactive Waste Management Facility.

At present there is 3700 m^3 (4000 – 5000 tonnes) of waste stored at over 100 locations around the country in metropolitan and regional sites. This material has been accumulated over the past forty years and a national facility is clearly needed. Dispersed storage of radioactive waste is not a viable long-term disposal strategy and is potentially hazardous, inefficient and impossible to secure.

Approximately 30m^3 per annum of low and intermediate level radioactive waste is currently generated by Commonwealth agencies, mainly by ANSTO, CSIRO and Defence. This comprises approximately 95% of the national production. It is therefore logical that the Commonwealth should be responsible for its storage.

Low level waste typically includes items such as laboratory gloves, clothing and glassware, luminous dials and contaminated soil. Intermediate level waste includes disused radiotherapy and industrial sources and approximately fifty cubic metres of waste incorporated in glass and cement that will return to Australia from overseas reprocessing of spent fuel from the HIFAR research reactor and the replacement OPAL reactor at Lucas Heights.

Field assessment at the three locations will now start to determine the most suitable site.

For more information see the website: http://www.radioactivewaste.gov.au/

Minister to abolish ARC Board

In July this year, Brendan Nelson, the Minister for Education, Science and Training, announced that he proposed to abolish the Board of the Australian Research Council.

The decision is an outcome of the recommendations of John Uhrig's *Review of the Corporate Governance of Statutory Authorities and Office Holders*. He recommended two models for governance; one where this is best provided by executive management, and the other where it is best provided by a board. The ARC was one of the first of some 170 government bodies to be assessed.

The Minister has decided that the functions of the ARC are best suited to the executive management template and has decided to retire the ARC Board by early 2006.

According to the Minister, the ARC will remain a statutory agency and will not return to the Department of Education, Science and Training. It will retain its vital peer review processes and the College of Experts will continue to be a vital source of independent advice to Government.

In practice this decision may not change the grant awarding processes, but it is clear that the Minister will have a more direct line of command over the ARC than he would have with a board in place. I have heard some cynics say that this is just another step in the government's pattern of taking more direct control of as many agencies as possible and

Cont'd from page 10

International Research Institute for Climate Prediction ★★★1/2
http://iri.columbia.edu/

This research institute was established between NOAA and Columbia University. The IRI focuses on social and environmental problems that are associated with climate variability, especially in developing regions around the world. It aims to improve human welfare and the environment through understanding and managing impacts of seasonal climate fluctuations. This site has a link to the publication Climate Information Digest which has a number of interesting stories on climate and its impact and outlook.

The Australian Meteorological and Oceanographic Society ★★
http://www.amos.org.au/

Fancy joining a meteorological society? AMOS is an independent Australian organisation which supports interest in meteorology and oceanography through its publications, meetings and courses. Membership is $60 per annum. There is a regional centre in every capital. See the website for contact details and more information on up coming meetings and events.

STAR RATING	
Content/information available on web pages	2
Navigation friendly	1
Aesthetically Pleasing	1
Currency	1
TOTAL	**5**

also reducing the diversity of ideas contributing to policy development. Time will tell.

Tasmania awarded $15M for Ore Deposits research

Congratulations to Ross Large and his team at the University of Tasmania on their successful bid for a Centre of Excellence in Ore Deposits.

The Commonwealth has just announced 11 successful Centres of Excellence in the 2005 round.

They will receive $122M in Commonwealth funding over the next five years and partner organisations have pledged to contribute $71M to support the work of the Centres.

The Tasmanian Centre receives the largest grant of $15M.

Its work will encompass a program of multidisciplinary research in ore deposit location, formation, discovery and recovery. The research focus will be on where ore deposits occur, how they form and their deep earth signatures. It will give our minerals industry a new scientific framework in which to search for ore.

The list of collaborators is impressive: three Australian universities (ANU, Melbourne and Queensland), three overseas universities (John Hopkins, Colorado and British Columbia), together with AMIRA, CSIRO, the MCA, Tasmanian Government and nine major mineral resource companies.

Well done CODES!

$100M Renewable Energy Program launched

A $100M fund to support cutting-edge renewable energy technology development was launched by Federal Industry Minister Ian Macfarlane in June.

The *Renewable Energy Development Initiative (REDI)* will provide matching competitive grants worth between $50,000 and $5M to Australian businesses developing renewable energy projects with significant greenhouse gas abatement potential.

The initiative will be administered jointly by the Department of Industry Tourism and Resources and the Department of the Environment and Heritage.

REDI will support renewable energy projects from early stage R&D right through to commercialisation.

Renewable energy technologies are defined as direct or enabling technologies developed for the purpose of deriving sustainable energy.

This can be derived from the sun; wind; geothermal; biomass (not fossil fuels); hydro systems; wave, tidal and ocean energy; or any other renewable energy source approved by the Australian Greenhouse Office.

The closing date for first-round funding applications is Thursday, 25 August 2005.

Further information on *REDI* can be found at <www.ausindustry.gov.au>.

$500M Low Emissions Technology Fund initiated

At the same time, submissions are being called from energy industry stakeholders as part of the consultation process that will determine the detail of the key low emissions program announced in the Australian Government's Energy White Paper last year.

A $500M Low Emissions Technology Demonstration Fund (LETDF) is being established to stimulate greater investment in demonstrating low-emission technologies across the full spectrum of energy sources.

According to Minister Ian Macfarlane the fund is likely to drive total investment of more than $1.5 billion in cleaner technologies ranging from renewable energies to more conventional fuel sources.

The LETDF key eligibility criterion is an ability to potentially deliver significant greenhouse abatement, with commercial uptake in the long-term. Funding assistance is available for up to 15 years.

More information can be found at: <http://www.ausindustry.gov.au>.

PMSEIC to investigate creativity

In one of the more bizarre studies being undertaken by the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), a working group has been established to prepare a paper on *The Role of Creativity in the Innovation Economy*.

The terms of reference are:

1. *Describe the extent to which creative processes influence and intersect with science, technology and engineering in Australia and elsewhere.*
2. *Identify how to leverage creativity in the innovation process for competitive advantage in the Australia context. Specifically, identify ways to:*
   - *i increase collaboration and robust linkages between the sciences, technology and engineering sectors and humanities, creative arts and social sciences;*
   - *ii develop an innovative culture in S&T research training to enable researchers to become more creative in their work; and*
   - *iii foster a broad based culture of creativity.*
3. *Consider how the adaptation of the creative process to the science, technology and engineering sectors has implications for the education system.*

Apparently the actions of the government's *National Innovation Council*, all the words about innovation written in the Chief Scientist's *Chance to Change* report and the government's own *Backing Australia's Ability* programs are not enough. We need more words! What is going on?

Chief Scientist needed

As reported in the June *Preview*, Robin Batterham has stood down after two terms as Australian Chief Scientist. The government has now called for expressions of interest for his successor.

Applications will have closed by the time this issue of *Preview* reaches your desks but is worth noting that, although this must be one of the more important government appointments, the position will remain a part-time post. This is unfortunate and could again lead to suspicions of conflict of interest, particularly if the appointee is recruited from industry.

It's time we had a full time Chief Scientist!

Towards creation of a national multi-depth electrical conductivity database

by David Allen
Allen Hydrogeophysics
david@allenhydrogeophysics.com.au
Tel: 02 63323895

Introduction

Electrical conductivity (EC) data are the principle source of salinity, clay content and sodicity parameters for Australian soils and aquifers. Low EC anomalies in aquifers beneath that soil represent valuable water lost from rivers, reservoirs, irrigation and rainfall infiltration either recently, or from prior climates that no longer exist. High EC anomalies generally represent salinity hazards and/or clay aquitards. Deeper EC anomalies indicate the presence of mineral deposits.

The various ground and airborne electrical conductivity dataset types are, it seems, currently considered by most in the environmental, groundwater and agricultural sectors as individual data types that are not integrable. Datasets are stored all over the place without a standard schema. A simple schema is proposed that allows integration of all this information. Many investigations may be conducted using a combination of EC imaging devices; if a common format is available that facilitates efficient visualisation of the data from multiple devices. I am requesting expressions of interest in development of a national multi-depth electrical conductivity database and associated visualisation tools. The database would be similar to the national magnetic, gravity and radiometric databases that currently exist. The schema given here is proposed as a basis for such a database.

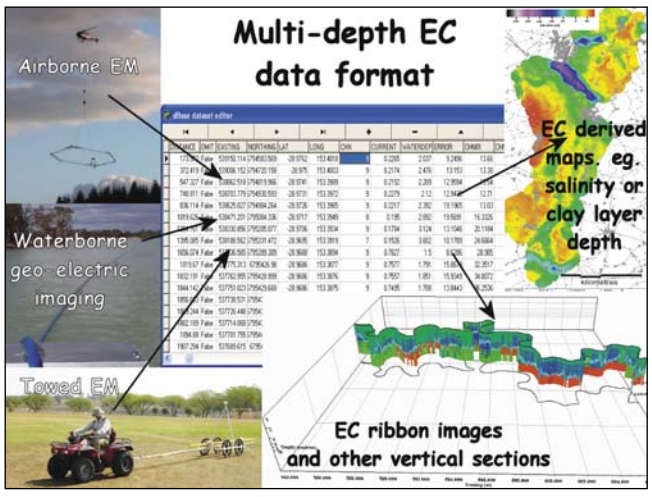
The schema records, along irregular transects, EC of stacked layers and depth to the bottom of each of those layers. As such, it is a useful medium for common archiving of:

- Towed geo-electric array data, e.g. waterborne arrays, Geometrics Ohm-mapper and the Aarhus University pulled array continuous geo-electric sounding system;
- Geo-electric array data including systems that involve roll along cables such as the ABEM/ Lund imaging system, the AGI sting swift system, the Zonge GDP32 roll along system, the Scintrex IPR12 and the Iris Instruments Syscal System;
- Frequency domain electromagnetic data such as the single and dual depth devices - DualEM 2 and 4, Geonics EM31 and EM38, the Geophex GEM2, L&R instruments proposed FDEM device and the various multi-depth devices that are beginning to emerge;
- TEM soundings, e.g. Protem, NanoTEM and TerraTEM;
- Towed TEM such as the Aarhus University PATEM system;
- Airborne EM. e.g. SkyTEM, VTEM and Dighem; and
- Summarized borehole EC logs (e.g. Geonics EM39).

The possibility of the proposed schema has arisen as a result of refinements in the way EC data are processed. Multi-depth EM and geo-electric data are now almost always converted to discretely layered EC data. Layer thicknesses are often allowed to float during processing so that they can accurately match distinct EC boundaries within the ground. Two and three dimensional modelling, often conducted on small datasets, also typically produces data that can be stored as layered models. Some data are converted to smooth layer models. These data can also be stored in the proposed schema. Lastly, some data such as EM31 data represent just a single depth range. By evaluating the signal contribution with respect to depth for such instruments, it is possible to specify a layer of thickness such that the bulk of the signal from such an instrument comes from that layer.

What existing EC data should be integrated into a national database?

A common repository and data format for all types of electrical conductivity data could make all that data much more useful. Gigabytes (possibly terabytes) of EC data, principally collected by contractors with Geonics EM31's and EM38's, have been collected and reside with individual irrigators and irrigation companies. Additionally government departments have collected airborne datasets which have not been published digitally for others to use. Most of the usefulness of those datasets is at farm scale and therefore agricultural consultants should be able to access them economically. Recently, 1000's of kilometers of multi-depth EC data have been collected under canals and rivers using geo-electric and electromagnetic equipment (Allen, 2005). EC data collected for mineral exploration needs to be confidential for some years but could be stored in an isolated part of a national database until it becomes public domain data.



A Multi-depth EC data schema

A multi-depth EC data format has been formulated in which data are stored in layers of variable thickness along transects which may be irregular or may form grids. This matches the way data may be acquired (with GPS) and is converted into multi-depth EC (using inversion). In each data file, there are two columns for each layer, one giving resistivity as Ω.m (an SI standard for storing EC data) and the other giving the depth to the bottom of the corresponding layer. There are various other columns, including one that stores the number of layers in each record. The data format currently used is ESRI point shapefiles with redundant geographic information in the associated dBase attribute files. Metadata and projection files accompany the shapefiles. This format is used because it is almost universally supported by natural resource managers in Australia. Additionally, it can be indexed and accessed non-sequentially. A full description of the format, its design and its benefits can be sourced from: david@allenhydrogeophysics.com.au. From the perspective of the user with no special software, this data format may seem frustrating as, with many data sets, viewing of EC at a particular depth requires a flow controlled, conditional, multi-column query.

If multiple instruments are to be supported, full integrity of the processed data is to be maintained, and optimal software performance is to be facilitated, then this is necessary.

dBase and shapefile formats have been chosen for storing data records and accompanying INI files have been chosen for unique variable storage. All these formats are both human and machine readable using widely available interfaces. Conversion of the INI files to files compatible with a future extension of the exploration and mining markup language - XMML (Cox, 2004) would be straight forward. Documentation of these file formats is publicly available and the formats are used extremely widely. Creation of dBase files is widely facilitated; they can even be read and written by MS Excel. Because ESRI shapefiles are an elaboration of dBase files, conversion to ESRI point shapefiles is simple. Even once the conversion is made, the dBase part of the shapefile is still available to programs that cannot read shapefiles. The conversion is readily made in ESRI ArcView software or using freeware components. No information is stored in the ESRI shapefile that does not exist in the associated dBase file and therefore only the dBase file needs to be stored. The shapefile just makes the dBase file easier to use in a GIS system.

Field	Units	Field Type	Size.Decimals
Distance	Metres	Floating Point	12.3
Omit	n.a.	Logical	
Easting	Metres	Floating Point	12.3
Northing	Metres	Floating Point	12.3
Lat	Decimal degrees	Floating Point	15.10
Long	Decimal degrees	Floating Point	15.10
Chn	n.a.	Numeric	3
Time (optional)	Decimal days	Floating Point	12.7
Current (optional)	Amps	Floating Point	12.5
WaterDep (optional)	Metres	Floating Point	12.3
Elevation (optional)	Metres	Floating Point	12.3
Error (optional)	User specified	Floating Point	10.2
Chn##	Normally Ohm.m	Floating Point	10.2
.			
.			
Depth##	Metres	Floating Point	8.3
.			
.			
Error## (optional)	User specified	Floating Point	10.2
.			
.			

Table 1. A proposed schema for multi-depth EC dBase tables.

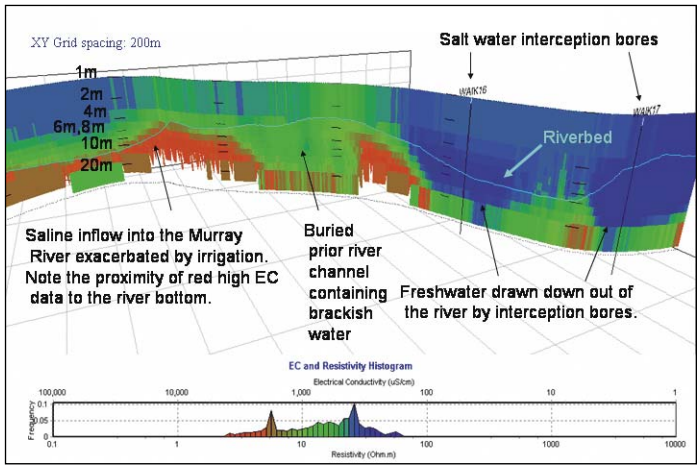


Fig. 2. Multi-depth EC imaging, presented in 3D, beneath the Murray River at Waikerie, SA showing proximity of saline water to the river bed (including contact at some points – saline inflow) as well as the effects of a deep prior river channel and saline groundwater interception bores.

Table 1 gives all the necessary and optional columns in the schema along with units, field types and recommended field formats.

A column headed 'Depth00' can be added to the datafile should a minimum depth for the first layer need to be specified. This is the case with some time domain electromagnetic transformations. If the column is missing, then the minimum depth shall be interpreted as zero or some fraction of 'Depth01' depending on the interpretation program.

The order of most of the columns is irrelevant since column indexes will be found by searching for their headers. However the 'Chn##' and 'Depth##' columns need to be in contiguous blocks so that software can find the first of such columns and reference the remaining columns using the index of the first of those columns.

The 'Error' column may contain an averaged error over whole soundings while the 'Error##' columns may contain errors or sensitivities for each layer in a sounding. There is no consistency in the way errors are reported by different inversion and transformation software packages so units of error are left as user specifiable. The units of error must therefore be listed in the metadata file.

All depths are to be positive (increasing downwards). All data should now be in GDA94 co-ordinates and an ESRI format projection file should accompany the data to document this co-ordinate system.

The filename, as well as the INI file should

indicate what quantity type the file holds (eg Ohm.m or Chargeability or Volt). The filename should include the quantity type as a suffix just before the .dbf in the filename (eg. *Ohm.m.dbf, *Chargeability.dbf, *Volt.dbf). Datafiles of unprocessed voltages may be stored by data providers but probably would not be submitted to a national database. Such files will not have 'Depth##' columns and the 'Chn##' columns should be replaced by 'V##' columns. Relevance of voltage columns should be stored in associated metadata files that record device configuration.

ESRI software facilitates geodatabases. The schema proposed here can logically be modified for use in geodatabases, however, the schema should be maintained, as is, for transfer of data between parties, many of whom will not have the software and skills needed to operate geodatabases.

A previous schema for EM data storage was devised by AMIRA. It was an ASCII file format in which all data were stored in one file. The flexibility of the format made it very hard to support fully. Because the ASCII files had to be read sequentially, they could not be integrated into efficient geoprocessing and visualisation solutions.

A working example of a multi-depth EC database

A working example of a national multi-depth EC database posted on a web site is available at http://www.gerda.geus.dk/ . The database is used as the principle tool for managing the groundwater resources of Denmark. It is MapInfo based rather than ESRI based, as suggested for Australia. The site does not include interpretive tools; however, screen dumps of the associated interpretive tools are available at www.SkyTEM.com . It includes user friendly queries for generating maps of depths to high EC (clay) layers, thickness of those layers, EC at particular depths and other possible maps but does not include a 3D ribbon viewer like the one that produced the EC ribbons in the figures presented here.

EC ribbon visualisation technique and a proposal for a national multi-depth EC database for data collected below rivers

The schema proposed was originally developed to manage and visualise multi-depth data collected along rivers. A visualisation solution we may call 'EC ribbons' was developed to thoroughly and efficiently present the multi-depth EC data. An example is shown in Figure 2. It was later observed that both the data storage schema and the associated visualisation technique were relevant to a much wider range of survey types. Multi-depth river EC surveys, when considered in the context of local geology give a detailed picture of river/aquifer connectivity and whether the rivers are losing fresh water or are gaining groundwater, which may be very saline at some locations.

It is proposed to continue surveying such river segments and adding them to a national multi-depth electrical conductivity database (which currently is not published). Water value savings could occur if water managers use the data to site or optimise saline inflow mitigation works and to model the effect of and balance out conjunctive water use. The data collected already provide a compelling case for refocusing irrigation away from certain sites that cause serious water degradation in the rivers due to induced saline inflow. Much water value can be saved by using such imagery to identify sites through which trading of water

should result in penalties due to losses or water degradation that occur during transport. The imagery does not quantify the losses/degradation, rather, it details the underlying aquifers through which the loss or degradation occurs. If groundwater is entering the river then the aquifer will appear more conductive than the river. If transmission losses are occurring from the river then the aquifer will appear as or less conductive than the river. Should the aquifers be influenced by adjacent land or groundwater use, then government may address those issues with the confidence supplied by detailed imagery of what is happening beneath rivers.

Use of EC ribbons in terrestrial EC surveying

A common schema for multi-depth EC data storage, along with appropriate visualisation tools, can open up new opportunities for more efficient provision of airborne data. In the past, airborne datasets collected for salinity mapping have been plotted predominantly as depth or time slices. Because the surveys have had to be conducted using line spacings that greatly exceed the spatial variability of most of the features being identified, the depth or time slices miss much of the detail. However, the data are however of sufficient value that they warrant viewing, as EC ribbons, plotted over airphoto and topography imagery. Small features, glazed over by depth slices, can be identified, by their geometry in the EC ribbons and, by relating the EC anomalies with features of the DEMs and airphotos. Vertical variation information is not clearly evident in sets of depth slices and often only is evident in EC ribbons.

Irregular transects of data collected on the ground, viewed as EC ribbons are useful as pilot datasets for airborne surveys and for filling in detail in areas of high interest identified by airborne data. Airborne data must be collected in bulk to be cost effective. Both before and after such bulk surveys, ground based surveys can be used to collect small amounts of data of more focused specialised interest to be integrated into the airborne dataset if a common data format is available.

A request for action

If any readers can help in lobbying government to get assistance with establishment of a national multi-depth EC schema and database set up, or, if they wish to comment on the schema proposed here, then please do so. It is hoped that this article will help by showing what is possible and by presenting a simple schema upon which a suitable database could be built.

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Cox, S. J. D., 2004, XMML – a standards conformant XML language for the transfer of exploration data: Extended Abstract, *Proceedings of the Australian Society of Exploration Geophysicists Conference, Sydney.*

90 Years Ago – some pioneering field trips *(Part III)*

George Dodwell and some geophysical co-operation

George Dodwell, the South Australian Government Astronomer was a skilled astronomer. He was also a very competent surveyor, meteorologist and pioneering field geophysicist, and he supported the Carnegie Institution of Washington, Department of Terrestrial Magnetism (CIW/DTM) global observation program to the fullest. In return for his assistance and allowing access to the Adelaide Observatory site, Edward Kidson of the DTM had loaned Dodwell a state-of-the-art magnetometer to perform work of his own choosing and it is this co-operation that led to a somewhat small field survey that is now recognised as a benchmark in the history of exploration geophysics in Australia.

The Musgrave Ranges Geological Survey Expedition

In late June 1914 Robert Lockhart Jack[1], the assistant South Australian Government Geologist and his party departed by camel from Oodnadatta for an extensive investigation of the remote Everard and Musgrave Ranges; an expedition specifically made to map and explore for both minerals and groundwater potential. George Dodwell made arrangements with Jack to join the party at a later date (in August 1914) and then to "*carry out a programme of magnetic work supplementary to the general magnetic survey of other parts of Australia lately undertaken by the Carnegie Institution of Washington*".

By the time Dodwell reached Jack at the remote Moorilyanna Well (in late September), Jack was already preparing to return home – the severe drought having forced him to curtail any further investigation in the region. It was the seventh straight year of drought in South Australia and there was just insufficient feed and water for the animals and for the expedition to continue (Figure 1).

Dodwell, despite having his work curtailed, had been busy and made magnetic, meteorological and atmospheric observations all the way from Oodnadatta and on reaching Jack he immediately began to assist with some astronomical surveying. Dodwell was to determine the exact locations and altitudes for a number of significant and previously unmapped topographical features.

On the track, Dodwell had, as one of his predetermined tasks, read his barometer every half hour which he was to later calibrate and then publish a pressure chart based on his observations. He also observed atmosphere clarity – as an astronomer he found the inland atmosphere exceptionally clear and most suitable for future observatory sitings.

Dodwell carried a wireless set and awkward antenna sections which he regularly erected to receive time signals transmitted from the Adelaide telegraphic station (Figure 2).

Dodwell's geophysical instruments

George Dodwell was really well equipped (most official scientific expeditions of the time were) and in addition to all his astronomical instruments, wireless receiver, chronometers, watches, barometers and thermometers he had been loaned the CIW/DTM theodolite – magnetometer No. 6 (an instrument with a history, being previously used by Alec Kennedy on Mawson's Antarctic expedition), a Barrow dip circle No. 38 (loaned by Prof. W.E. Cooke the Government Astronomer of NSW) and a modified compass that was used to make "on the run" declination measurements.

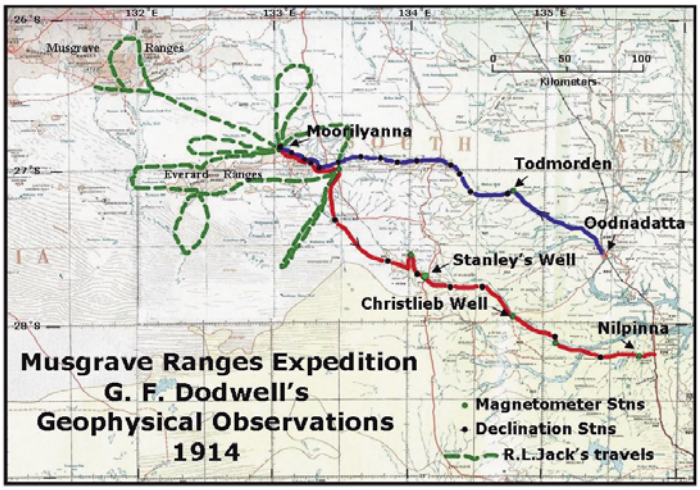

Fig. 1. George Dodwell's route by camel (in blue and red) from the overland telegraph line at Oodnadatta to R. L. Jack's camp in the Everard Ranges and his return to Nilpinna Head Station. Compiled by author.

Fig. 2. Nilpinna Head Station looking due West. Dodwell's observation tent at front and his wireless antenna at the right of homestead. Circa 3rd November 1914. Courtesy CIW/DTM – GL Library photo # 4648.

[1] Robert Lockhart Jack, later chief geologist for BHP, should not be confused with his father, the renowned explorer/geologist Robert Logan Jack (1845-1921)

Edward Kidson was impressed enough with Dodwell's modified compass to include a mention of it in his 1914 report on Australian operations to the CIW/DTM in Washington DC, he described it as:

"…(a) trough compass-theodolite to which a solar attachment had been added making essentially a small equatorial instrument mounted on a theodolite base. This furnished a ready means of determining the meridian by points on the Sun, the declination then being obtained directly by the compass…"

For those times, Dodwell's compass was a very practical magnetic field exploration instrument.

Dodwell's Magnetic Observations and Anomalies

So in addition to his absolute observations made with the DTM magnetometer (see Figure 3), George Dodwell's compass declination measurements are very significant as they appear to be the earliest "pre-planned" observations by any mineral exploration geophysical method in Australia; Dodwell had carried the instrument specifically for use as a geological tool. He said in his final report the observations were specifically "to ascertain if any large magnetic disturbance existed".

Dodwell made twenty declination observations with his compass from Todmorden (Figure 4) to Moorilyanna and then back to Nilpinna, which he then tied and adjusted to his absolute measurements, and according to Edward Kidson, despite their coarseness, the observations were extremely useful in showing the existence of "great magnetic disturbances". Dodwell did not find any "great magnetic disturbances" as described by Kidson but he did measure significant anomalies (see Figure 5).

The drought sadly curtailing the expedition but Dodwell summarised the significance of his few measurements as follows:

"The magnetic work of the Musgrave Ranges Expedition may… be considered as the beginning of a practical recognition of the very valuable services rendered by the Carnegie Institution in undertaking the magnetic survey of Australia … this survey is the more important, so far as South Australia is concerned, because

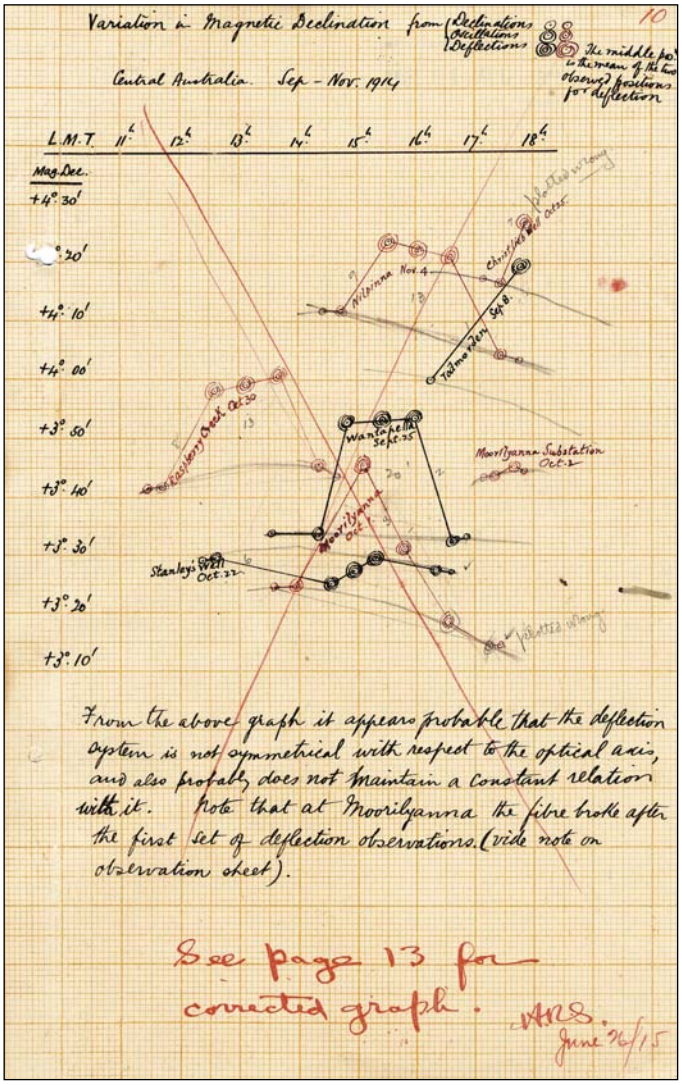

Fig.3. A work sheet from Dodwell's final report to the DTM, subsequently corrected by others. Note the diurnal drift in his absolute declination observations for each of his primary sites. Courtesy CIW/DTM-GL Library.

Fig.4. A rare photo of Todmorden Head Station showing Dodwell's observation tent – the drought conditions being very obvious. Circa 8th September 1914. Courtesy CIW/DTM-GL Library photo #4642.

it has brought to light the existence of marked areas of magnetic perturbation, which have an evident relationship with our geological and mineral-bearing formations. This fact clearly indicates the importance of the detail magnetic survey to which the Carnegie Institution has invited our attention."

Historic radio communications

Before leaving on his journey to join Jack's expedition, Dodwell had personally arranged for one of the Adelaide Observatory's standard clocks to be installed at the Adelaide Telegraphic Station where it was modified to send automatic coded time signals (Morse) by radio broadcast. He also arranged, in addition to his own wireless receiver in the field, to have a receiver set up at the Adelaide Observatory so that the time signals from the Telegraph Station could be corrected later using the observations from star transits. Dodwell had no trouble receiving these broadcast signals in the field and all his magnetic observation sites were later "post processed" along with all of his survey field station and other astronomical measurements from the expedition – it was all pioneering stuff.

"These experiments with a small receiving outfit in central Australia also support the idea that, by means of a comparatively simple and inexpensive wireless apparatus, settlers in the remoter parts of Australia might have the advantage of being kept in closer touch with the more populated parts."

APPENDIX II of Jack's report

Dodwell's results were published as an appendix to Jack's expedition report where Dodwell backgrounded his results with a number of paragraphs on the general connection between terrestrial magnetism and geological formations, mentioning the work of the Russians Mendeleef and Blumbach, the Swedish physicist Nordenström and the Canadian pioneering geophysicist Haanel. He was obviously reading the literature. He then goes on to summarise on the magnetic disturbances that had been located in South Australia by both the DTM and himself – he admitted the results were "tentative and provisional" and made a recommendation for a closer network of magnetic stations. He also goes on to suggest that selected areas should be mapped in detail although he does not specify either a site or region.

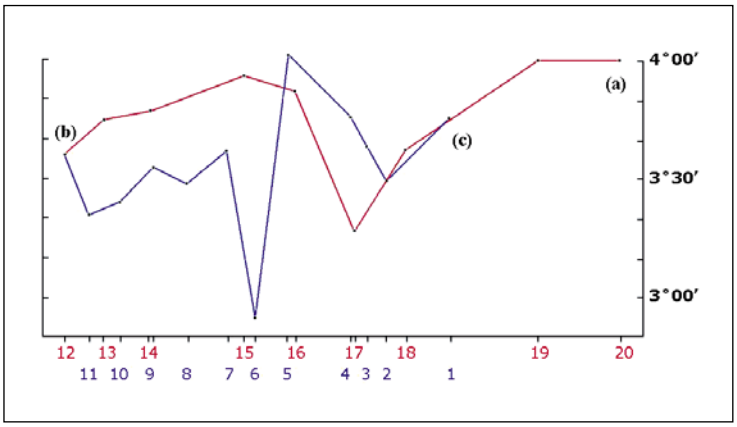

Fig.5. A plot of Dodwell's compass-declinometer readings, levelled to his primary observation stations extending from (a) Todmorden to (b) Moorilyanna and back to (c) Nilpinna. Possibly Australia's first onshore mag profiles? Compiled by author.

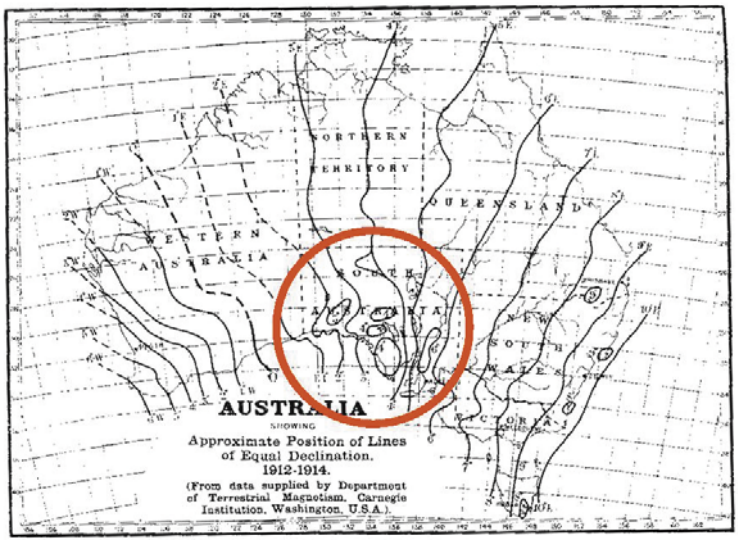

Fig.6. Dodwell's 1915 Declination map of Australia based on Edward Kidson and CIW/DTM's collated observations. Dodwell's influence in the South Australian region is obvious.

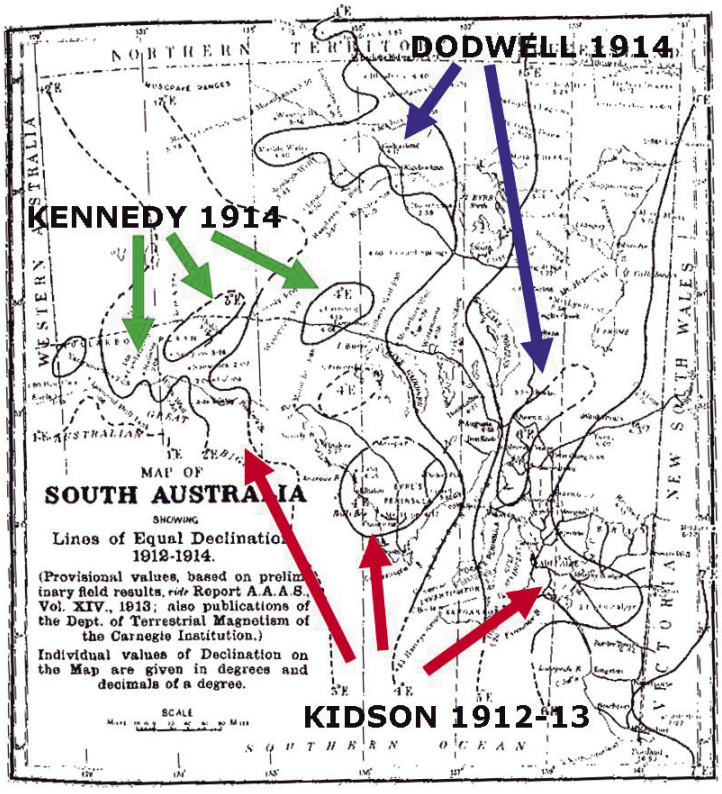

Fig.7. Dodwell's 1915 Declination map of South Australia. The observations for this map being mostly carried out by Kidson, Kennedy and Dodwell.

Dodwell's report contained a number of regional maps portraying the various mag field components for the State of South Australia (and Australia as a whole) and these are the first of their types for our continent. The declination maps are of particular interest because of the magnetic disturbances shown – Dodwell's "hybrid" maps in some respects are neither geological nor reference field portrayals but they certainly are the precursors to both (Figure 6), modern reference field maps for instance rarely portray regional anomalies (see *Preview 115* page 29) but Dodwell's maps are the first attempts to map regional geological anomalies and as such are historically significant – Dodwell used his own results and that of the other DTM observers to emphasise the magnetic disturbances in South Australia (see Figure 7).

Edward Kidson in his final report on the DTM operations in Australia in 1914 (a report which he hand carried to Washington before resigning and then going off to war) concludes by writing *"… (there are) considerable disturbances, particularly in South Australia. These disturbances can generally be traced to changes in the geological formation. The need for more detailed local surveys is most emphatically shown."*

Dodwell and Kidson understood the significance of their measurements and the relationship to geology and they both recommended more detailed surveys – it was a slow start but an industry was to develop from all of this.

More recent "camel-borne" surveys

The late ASEG member and lecturer Joe Williams was always known to the author as "Camel Joe", and I vividly recall him showing me, in the mid 1970s, then recent photographs of him taken near Tennant Creek observing with a proton magnetometer (a Geometrics G801 with long pole if I recall) from the back of a camel – the extra metres off the ground provided very clean results – I liked old Joe for many reasons – mostly because he made me laugh but also because he seriously considered the camel a geophysical tool!

The author again wishes to thank the Carnegie Institution of Washington, DTM-Geophysical Laboratory Library for both the access and permission to reproduce the old photos and worksheets. In particular I wish to thank their librarian, Shaun Hardy, for his continuing interest and co-operation and his supply of images.

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The BHP-Billiton Digital Gravity Gradiometer

By D.B. Boggs*, J.B. Lee*, R.A.M. Maddever*, E.H. van Leeuwen*, R.J. Turner*, M.A. Downey*, K.G. McCracken** and G. Liu*

E.H. van Leeuwen

Email contact for more information:

Edwin.H.vanLeeuwen@BHPBilliton.com

Introduction

BHP-Billiton has taken acceptance of a new digital version of the Lockheed-Martin gravity gradiometer instrumentation for use in airborne operational work. The new digital version of the instrument improves upon the previous design in several aspects, most notably reduced weight and increased sensitivity.

The system was developed at Lockheed-Martin's Wheatfield operation as a research and development project beginning in 2001, aimed at decreasing the footprint of the technology, and making it light enough to fly in a helicopter, as well as making a number of design changes to optimise the noise characteristics of the instrumentation.

The technology development program jointly undertaken by both Lockheed-Martin and BHP-Billiton has been successful in both aspects, the new system weighing in at just over 300 kg and boasting a noise level that is 5 times better than the original analogue system performance delivered in 2000, and approximately twice as good as the current analogue system's performance.

Development

The development of the digital gradiometer by Lockheed-Martin was initiated and funded by BHP-Billiton following the successful development and deployment of the first two analogue Falcon systems (van Leeuwen, 2000).

* BHP Billiton Mining & Exploration Technologies

** Jellore Technologies

Fig. 1. The Digital AGG system. The gradiometer itself sits inside the large "Binnacle" which houses a three-axis inertially stabilised platform and enables precise temperature control.

The project involved a complete reworking and miniaturisation of both the gradiometer and inertial platform control electronics from its 1980's analogue heritage to current state-of-the-art digital components. This reworking enabled most of the control electronics to be placed within the gradiometer and inertial platform, and removed the need for a separate rack full of computers, controller cards and power-electronics.

As well as reducing the system's footprint, the project provided the opportunity to optimise several aspects of the gradiometer design, based on analysis of aspects of the physics that govern the ultimate noise level achievable with the AGG system.

The System

To date, the Digital AGG system has been trialled for use in a Cessna Grand Caravan (the same as used for the analogue systems) and a Eurocopter AS350B3 helicopter. The latter allows lower, slower flying and thus the opportunity for increased resolution and signal. The helicopter also gives better ability to follow undulating topography and thus perform exploration in areas where terrain following would be difficult or impossible in an aircraft.

The system can be controlled via a web-browser interface, but is operator-less in normal survey operation. The automation of almost all aspects of the in-flight survey acquisition means that a helicopter survey can be performed with just a single pilot.

Testing

Development of all of BHP-Billiton's gradiometers has involved a rigorous testing program to ensure that all aspects of the system perform reliably and meet or exceed the specifications required for mineral exploration. The ultimate test used to benchmark system performance is a survey over an area known as Bulgary Ridge, a prominent hill in up-state New-York. The ridge is approximately 40 m high and was considered most appropriate, as its excess mass is analogous to, and representative of the type of mineral deposit that needed to be detectable in a mineral exploration survey. The relief over the Bulgary Ridge test area is shown in Figure 2, the data being derived from a laser-scanner that comprises part of each Falcon AGG system.

Vertical gravity gradient results from the digital and analogue surveys are shown in Figures 3 and 4 respectively. The current 2004 Digital AGG survey was conducted at a

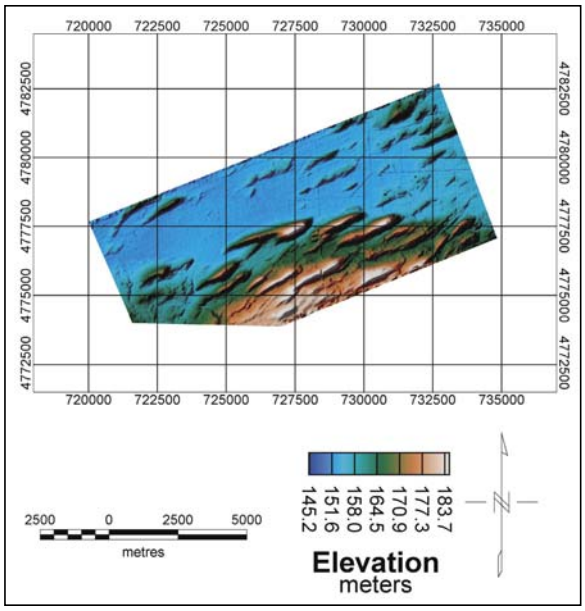

Fig. 2. Digital Elevation Model showing undulations in the area of the Bulgary Ridge test site.

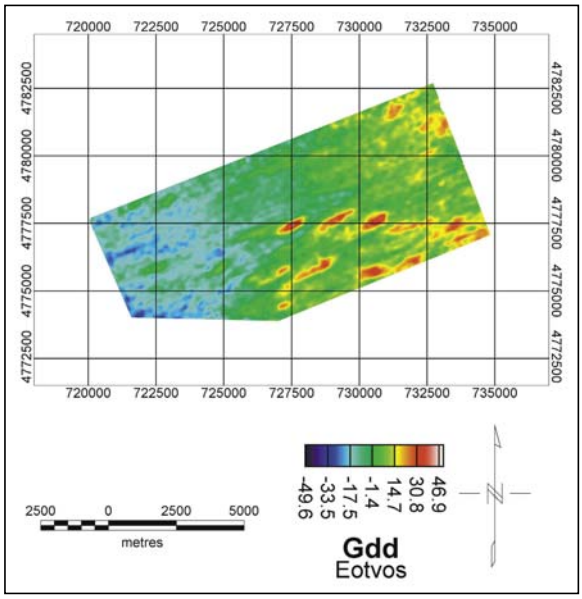

Fig. 4. Vertical gravity gradient measured over the Bulgary Ridge test site in 1999 with the first Analogue AGG system.

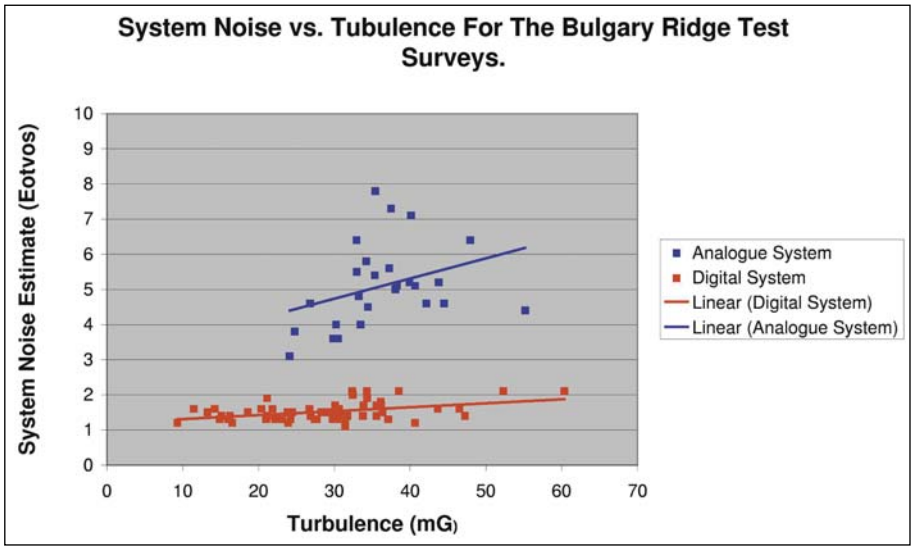

Fig. 5. Comparison of Digital AGG Noise vs Turbulence for the 2004 Bulgary Ridge survey with the Digital system (red) and the 1999 Analogue system survey (blue). The noise estimates are for the 0.18Hz restricted bandwidth normally used for Falcon surveys.

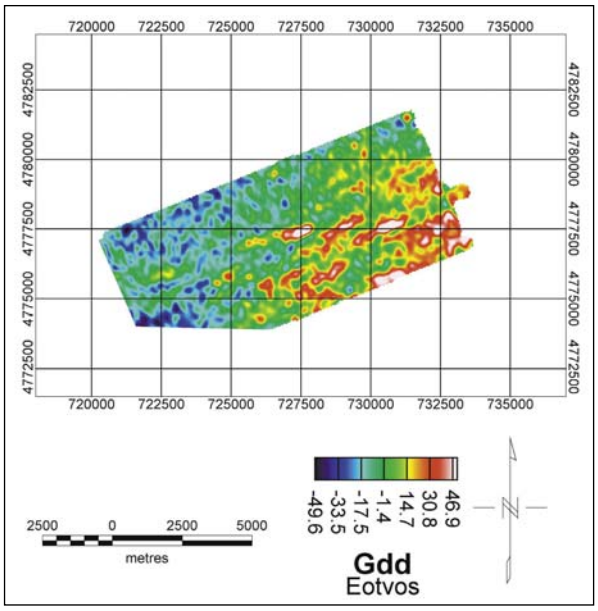

Fig. 3. Vertical gravity gradient over the Bulgary Ridge test area measured with the new Digital AGG system. The latest survey was flown at slightly increased elevation than the analogue survey (shown in Figure 4), resulting in slightly reduced gravity gradients from Bulgary Ridge.

slightly higher altitude than the previous 1999 analogue survey, due to flying height restrictions. This is responsible for the slightly reduced signal levels visible in Figure 3. Despite this, the results of the design changes in the digital system to achieve better noise suppression are obvious when compared to the analogue result (Figure 4).

The Digital AGG result are more impressive when it is noted that the analogue results in Figure 4 sit on top of more recent advances in BHP-Billiton's data processing software. Combined with recent changes in the acquisition methods for the existing systems, analogue system noise power has been reduced from around 50 E^2/rad/sec when initially delivered in 1999, to around 25 E^2/rad/sec today. However, the Digital AGG system is now delivering data with noise levels of around 5 E^2/rad/sec. Figure 5 summarises RMS noise in the survey lines from the digital and analogue versions of the Bulgary Ridge test surveys.

Conclusion

Development of the digital gradiometer system, capable of being deployed in a helicopter or other small mobile platform, increases the domains in which gravity gradiometery can be successfully applied. The bonus of having increased sensitivity with the digital instrumentation strengthens the case for using gravity gradiometery in exploration cases that might have previously been considered marginal. Delivering in two respects, the Digital AGG system represents a significant advance over previous analogue AGG systems.

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The Petrophysics of the Sydney Basin Triassic Narrabeen Group – preliminary results

By D.W. Emerson and D. F. Branagan

School of Geosciences, University of Sydney

Email contact for Don Emerson: systems@lisp.com.au

Introduction

The application of magnetic susceptibility to sedimentary basin studies has been discussed by Emerson (2000) and Emerson and Alder (2004) for the Sydney Basin Triassic Hawkesbury Sandstone (above the Narrabeen Group) and the Darling Basin Devonian clastics, respectively. The Narrabeen Group, a relatively little studied and imperfectly understood part of the Sydney Basin Triassic, is now being investigated. The aim is to improve our knowledge of the stratigraphy and the general engineering characteristics (groundwater, reservoir, geotechnical) of an important rock group that is encountered at depth and on the Sydney Basin perimeter in the form of coastal and mountain outcrops. An outline of the Sydney Basin Triassic is given by Branagan and Packham (2000).

Pacific Power's Eveleigh No.1 diamond drill-cored borehole at Redfern (central Sydney) provided 413 Narrabeen Group samples for a mesoscale petrophysics study, where induction-coil-measured magnetic susceptibilities, mass properties (grain, dry, saturated densities and water accessible porosities), rock quality indices, and palaeo-salinity indications are being investigated. It is planned to publish the integrated results on completion; here the magnetic susceptibilities are depicted in a depth section and their significance discussed.

Geology

Compared with the Hawkesbury Sandstone, the physical properties of the Narrabeen Group, relevant to facies studies and also those likely to be important to engineers, have been poorly documented. The upper part of the Narrabeen succession was penetrated in the drill holes put down during the planning and construction of the Sydney Offshore Sewerage Tunnels in the 1980s. Some physical testing of these cores gave useful predictions, although the behaviour of the rocks when exposed in the tunnels proved rather better than the predictions, probably because the rocks remained damp until artificial support was applied as required. Earlier the behaviour of rocks in the Kincumber Tunnel gave similar results. The availability of a complete core through the Narrabeen succession from the Eveleigh site presented the opportunity to carry out tests on a series of rocks which are likely to be increasingly penetrated, and opened up in the coming years for engineering purposes. The detailed petrophysical results should contribute to better and speedier correlation and prediction of rock mass and material behaviour.

In the past forty years there have been many detailed studies of the geology of the Narrabeen Group, especially of the coastal section north of Port Jackson. These indicate that the succession is a packet of sediments of essentially shallow water fluvial and estuarine origin.

While the uppermost parts of the Narrabeen Group probably consist of sediment derived from several sources, (north, south and west) the lower portions have been transported mainly from the north (New England Fold Belt). Over short lateral distances beds can be easily followed, but over longer distances there is lensing, facies change and innumerable variations, making correlation difficult. Consequently, while samples from a vertical drillhole can indicate vertical variations, it is essential to recognise that such changes in that particular core cannot be assumed to apply to another site, even if only one or two kilometres away. However, certain units prove more widespread and help to establish some confidence in the stratigraphic correlation across the Sydney region. The correlation depends to a large extent on the presence of several 'red beds' which might well be essentially 'time markers'.

The stratigraphic terms used in this drill log are those derived from the exposed section at Coalcliff, 60 km south of Sydney. These units were recognisable to some extent in drill holes put down during the planning and construction of the Offshore Sewerage Tunnels at Maroubra, Bondi and North Head. These stratigraphic terms have been applied to the Eveleigh core by Pacific Power and we have accepted these for the present summary report. However, more specific divisions are likely to be applied as the research continues and the physical property data analysed in more detail.

There are various rock types present including many sandstones composed mainly of rock fragments with quartz, with less quartz content in the more northerly sandstones (quartz rich sandstones occur on the western margin of the Basin). There are some conglomerates composed of a variety of rock materials (chert, siltstone and volcanic fragments). Shales and mudstones are interspersed in the sandstone successions. Of particular note are red and green shales, and mottled zones are frequent. There is considerable evidence of time breaks in the succession, particularly at the top of the finer-grained units. These are marked by leached zones, burrowing and fossil roots, sun-cracks, and even rain prints. Some clues on the depositional environment are given by the occurrence fossil plants, amphibians, fish and small bivalve fossils.

The overall environment suggested for the deposition of the Narrabeen Group, is that of a slowly subsiding broad deltaic plain, fronting a mountain region to the north. The plain was traversed by various ever-changing river courses and some researchers suggest that a successive number of rivers, formed as subsidence continued, can be recognised in the succession of sand units found within the Scarborough Sandstone. There were several shallow coastal lakes, which might at times have been invaded by the sea. To some degree the Lake Illawarra area could be considered as a small-scale model of the Narrabeen time conditions.

Magnetic Susceptibility Profile

Magnetic susceptibility (k) in the sandy, silty, clayey facies so far studied in NSW shows an inverse relationship with grainsize: relatively low mag k values tend to be associated with cleaner coarser sediments, and higher values with finer grainsizes. The relationship is never perfect e.g. conglomerates with considerable interstitial mud do not give very low readings, but both in a detailed and broad sense the mag k picture is quite useful in its own right, and as a supplement to the widely used natural gamma log, in clastic sedimentary basin studies. In this Narrabeen study the mag k indications have been corroborated by detailed inspections of sampled cores.

Mag k and gamma log profiles for the Triassic section from Eveleigh No.1 are shown in Figure 1, and a detailed mag k log (excluding extreme values) is shown in Figure 2 for the Narrabeen Group (tentative) subdivisions. The mag k profile does not have the detail of the continuous gamma log owing to the 1.5 m sampling interval, but the salient petrophysics characteristics are considered to be represented adequately. A mag k logging tool of appropriate resolution (to 1 x 10^{-5}SI) would provide extremely detailed information.

Superimposed on the oscillatory mag k variations, corresponding to coarser and finer facies, is an overall trend of increasing mag k with younging from the Coalcliff Sandstone at the base of the Narrabeen to well into the Bulgo Sandstone, then a change of trend corresponding to cleaner sandstones in the top Bulgo. The Bald Hill Claystone, comprising chocolate shales, silts and finegrained lithic sandstones, manifests a significant increase in mag k thought to be related to maghemite concentrations in palaeoweathering horizons, in addition to the usual rise in mag k for finer grained materials. Above the Bald Hill Claystone, the Newport Formation, containing quartz lithic sandstones of finer grainsize than the overlying Hawkesbury Sandstone, seems, in the mag k view, to be transitional to the Hawkesbury. This is not indicated on the gamma plot, where the apparently "hot" sandstones manifest themselves as a distinct gamma high. Above the top Narrabeen Newport, the Hawkesbury Sandstone is a sedimentary unit of distinctly low mag k, on average, with moderate mag k spikes due to thin interbedded shaly materials.

In preliminary detail there seems to be: three upward fining cycles to the base of the Newport, 910 to 730, 730 to 505, 505 to 355 m, which transgress the conventional stratigraphic

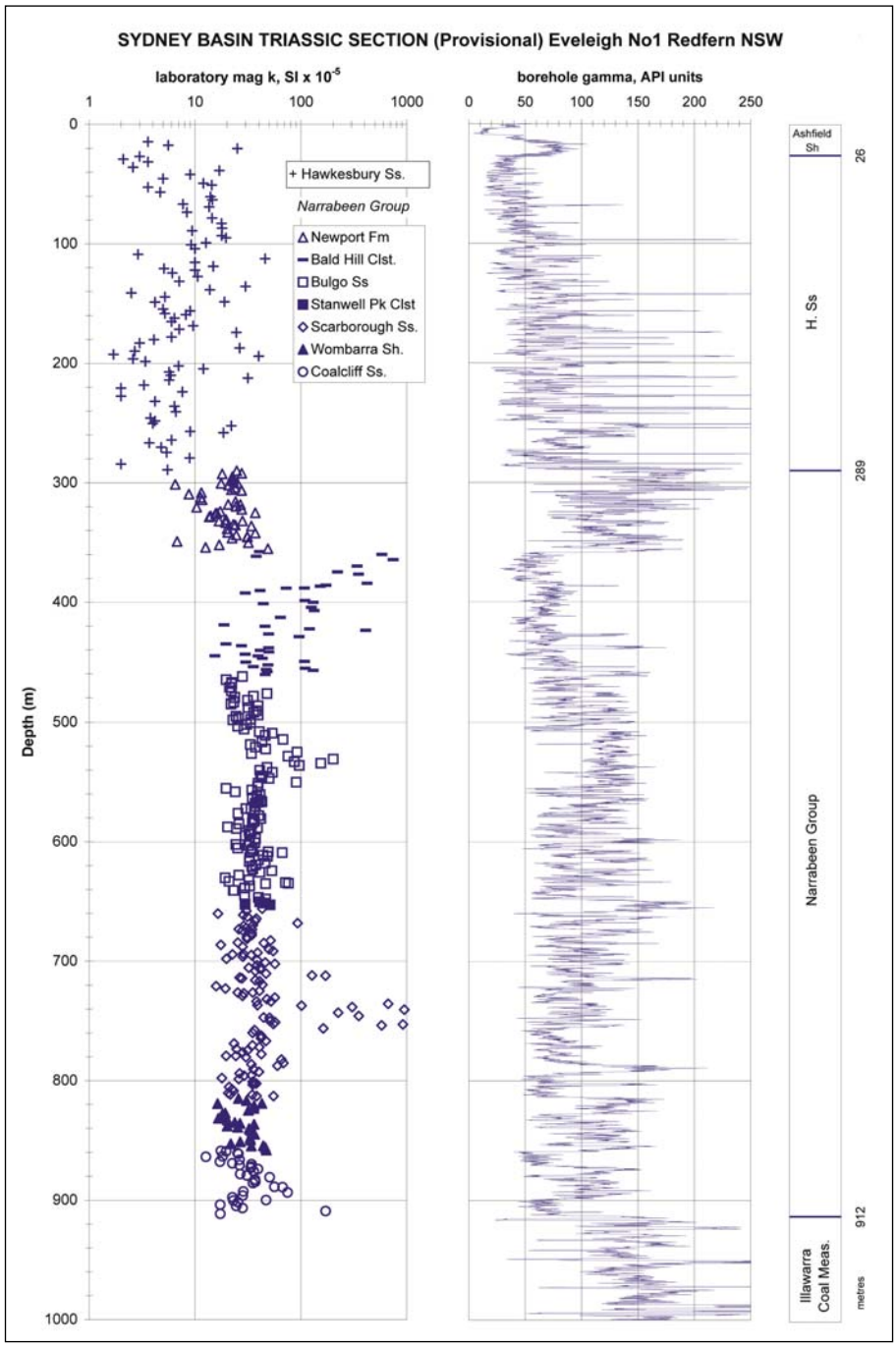

Fig. 1. Depth plots of laboratory measured core-sample magnetic susceptibility and borehole natural gamma response through the Triassic in Pacific Power's Eveleigh No. 1 cored hole drilled in the central Sydney Basin at Redfern (an inner city Sydney suburb). See Fig. 2. for detail of the Narrabeen Group.

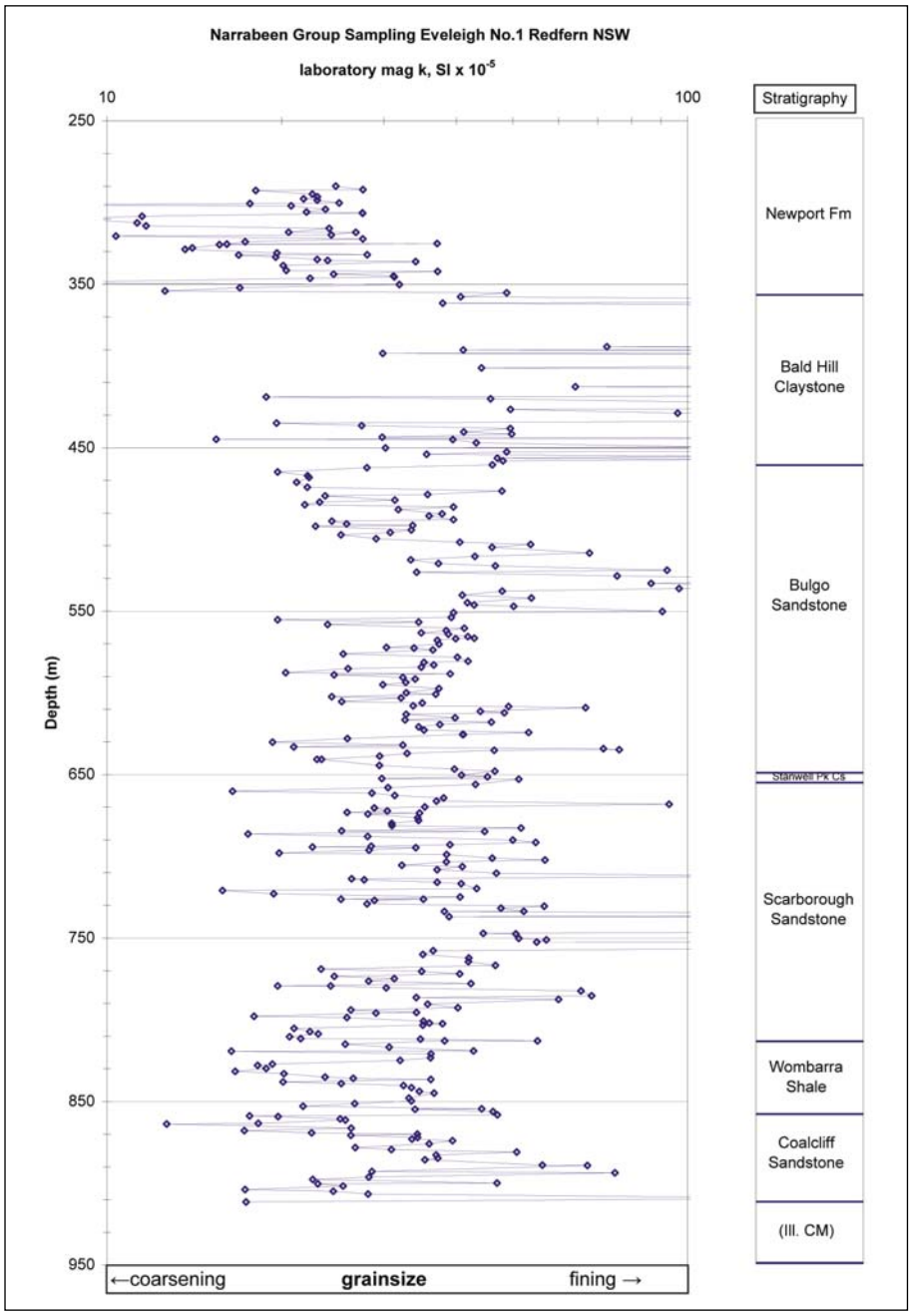

Fig. 2. Depth plot of laboratory measured core-sample magnetic susceptibility in the provisionally subdivided Narrabeen Group. The central Sydney Basin Eveleigh No. 1 drillhole provided 413 samples from the 289 to 912 m depth interval. High (>100 x 10^{-5} SI) and low (<10 x 10^{-5} SI) values have been omitted. The plot shows trends and discontinuities in magnetic susceptibility interpreted as being associated with broad upwards fining (overall increase of mag k with younging) to the base of the Newport Formation, and with formation and intraformation textural and lithological changes.

subdivision; and two coarse offsets in the top Bulgo 605 to 505 m (still fining upwards) and 505 to 465 m (coarsening upwards).

The mag k data and gamma log are in reasonable agreement except for the Newport trend change, the Bald Hill weathering manifestation, the Bald Hill fine grained lithologies, and the mag k increase at 750 m due to a prominent dark green shale in the Scarborough Sandstone.

Discussion

The magnetic characteristics of the Narrabeen are more complicated than the Hawkesbury. The Narrabeen sediments overall are "dirtier" (finer grainsizes), have a high lithic component (hence many individual fragments have finite mag k's compared to zero or negative for quartz), and their carbonate content is significant, especially the siderite component. Iron carbonate, $FeCO_3$, is paramagnetic with a mag k of around 500 x 10^{-5}SI. Although these are complicating factors they also impart a distinctive magnetic signature to the Narrabeen, at least in the Eveleigh location. The magnetic characteristics measured on outcrops, in excavations and boreholes should assist in elucidating the Narrabeen's sedimentary features.

One aspect of the Narrabeen magnetic response deserves special mention. This is the quite high ferrimagnetic susceptibilities recorded in thick beds around 410 m (about 3000 x 10^{-5}SI, not shown on Figure 1 to avoid scale compression) and 740 m (around 1000 x 10^{-5}SI). These values are comparable to those measured commonly in fresh basalts with about 0.5% volume titanomagnetite content and far in excess of the mag k values recorded for many of the Jurassic intrusives of the Sydney Basin. These mafic rocks are often altered and do not necessarily manifest typical basalt mag k's. Accordingly, surface or airborne magnetic interpretation for the location and delineation of such bodies in coal mine work or engineering studies should take cognisance of the possibility of magnetic highs in the Narrabeen.

Conclusions

Magnetic susceptibility data are proving to be very useful in the study of the sedimentary facies of the Sydney Basin Narrabeen Group. It is expected that a physical property based stratigraphic subdivision (using mag k, density, and other information) should facilitate study and understanding of this imperfectly known sequence.

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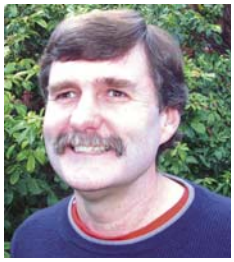
Acknowledgements: P. M. Cooney, NSW Dept Mineral Resources, arranged access to the Londonderry Core Library and S. Franks, L. Kalnins and P. Manning assisted with word processing, graphing and sampling work.

'To be or not to be' continuous – a look at near real time data transmission within the Australian National Seismic Network

By Robert Dabrowski

Geoscience Australia



Email: robert.dabrowski@ga.gov.au

Summary

"Near" real-time seismology and automatic earthquake alert systems, depend heavily on the availability and timeliness of near real-time data streams to enable accurate alert diagnoses. The Continuous Data Protocol 1.0 (CD 1) was developed in the mid-1990s by the Group of Scientific Experts (GSE) of the Conference on Disarmament for their third technical test. The 1995 GSETT-3 provided the technical basis for the Comprehensive Nuclear Test Ban Treaty (CTBT) being negotiated in 1996. The Alpha protocol, as it was known then, provided a mechanism for transmitting continuous data from Alpha or primary stations in near real-time. Another protocol known as GSE 2.1 (later IMS 1.0) was used for retrieving segmented data from Beta or secondary stations.

Introduction

The recording of continuous waveform data presents different challenges to the recording of event triggered segmented data or to the recording of semi-continuous yet "offline" data. Many formats in use today derive their origins from the earlier imperatives of such systems. This article will briefly classify such formats so as to better appreciate continuous format requirements. Following this a comparison will be made of continuous formats and the format adopted for use in the Australian National Seismic Network (ANSN) operated by Geoscience Australia. The CD 1 format in detail, its use and adaptation within the ANSN will come after this. Some contextual background on networking will be provided and this will then be wrapped up by a section on where the ANSN may go in the future with CD 1.

Digital Waveform Data Formats

There is a proliferation of digital seismic waveform formats in use today. These formats have evolved with time according to need and as a result of technical advances in IT and seismological instrumentation. The evolution of these formats can be better understood by grouping them into five classes as defined in the New Manual of Seismological Observatory Practice (IASPEI, 2002).

1) local formats in use at individual stations, networks or used by a particular seismic recorder (e.g., ESSTF, PDR-2, BDSN, GDSN)
2) formats used in standard analysis software (e.g. SEISAN, SAC, AH, BDSN)
3) formats designed for data exchange and archiving (SEED, GSE)
4) formats designed for database systems (CSS, SUDS)
5) formats for real-time data transmission (IDC/IMS, Earthworm)

The lower class formats, were, for the most part, proprietary manufacturer based formats. They followed the "bazaar" (cobbled together) approach to design without much thought for longer term data exchange. The later, higher class, formats have followed the "cathedral" (carefully planned) approach to design and have had much effort invested in them. These formats have also moved to an open and platform independent design. It was when closer scrutiny was paid to the GDSN (Global Digital Seismic Network) format, which had become a de-facto standard, that both the GSE and the Federation of Digital Seismic networks (FDSN) revealed its limitations and developed better designs.

The GSE's own format, IMS 1.0, is not a pure real-time format. It relies upon the underlying IT infrastructures such as ftp and mail (e-mail) servers. A software package known as AutoDRM (Automatic Data Request Manager) was developed in the early 1990's to provide a simplified mechanism for data exchange. AutoDRM is used to exchange IMS 1.0 formatted data and is still widely used today for segmented data exchange.

Continuous Data Formats

While there are no international standards for continuous data exchange, the CD 1.0 protocol is becoming the de-facto standard. CD 1 is used throughout the International Monitoring System (IMS) within the framework of the CTBTO (CTBT Organisation).

At Geoscience Australia, CD 1 has been adopted, from datalogger to data centre, as the mechanism for exchanging real-time seismic data within the ANSN. This has been possible because the GA-built Geophysical Data Acquisition System (GDAS) is an open design built from off-the shelf components (Figures 1 and 2). Data are stored directly in CD 1 format on the GDAS datalogger itself and subsequently, within a second or two, relayed

or forwarded directly to GA in CD 1. There are no intervening points for the data to travel through in terms of protocol exchanges.

Seedlink, Earthworm and Antelope have data exchange mechanisms built-in, based on their respective ring buffer paradigms and may lay claim to being capable of real-time data exchange. But these systems are most suited to exchanging data between regional hubs hosting the same respective systems. In all three, the weak link is the telemetry of raw data from the remote datalogger. Most dataloggers rely on data processors to support the telemetry of raw data in various proprietary formats. These data processors convert raw data into "higher level" formats such as MiniSeed and telemeter this to a SeedLink hub for instance. Depending on where the data processor resides, in the communications structure, this can lead to data availability problems and data timeliness problems. In the case of SeedLink, there is no strong policy to deal with transmission failure; it simply picks up where it left off. In near real-time situations sites could be down for considerable periods while old data were retrieved. By employing CD 1, the GDAS can combine datalogger and data processor activities into the one unit. Indeed, CTBTO alpha or primary stations have a datalogger and a data processor at the station itself.

The CD 1.0 protocol

The CD 1 protocol has these key features:

1) It is an application level protocol that only depends on a reliable TCP/IP communications layer.
2) It incorporates basic security mechanisms such as authentication signatures for public key private key data authentication.
3) When data connections have been established it is highly efficient at exchanging waveform data. Unlike ftp, there is very little protocol overhead. Packets are typically only ten seconds long.
4) It incorporates its own data compression scheme which is very flexible and can efficiently compress as few as twenty samples of data or multiples thereof.
5) The protocol incorporates a modified last in first out (LIFO) policy for data recovery. This is of great importance to real-time alert systems.
6) A single connection can support up to 100 channels of data in near-real-time.

Figs. 1 and 2. The GDAS installation at Mount Surprise in Queensland. The two green units under the solar collectors contain batteries on one side which is exposed in the picture and the GDAS on the other side shown on the right. Data, already encoded in CD 1, are telemetered via a radio link to a DDS (Digital Data Service) line.

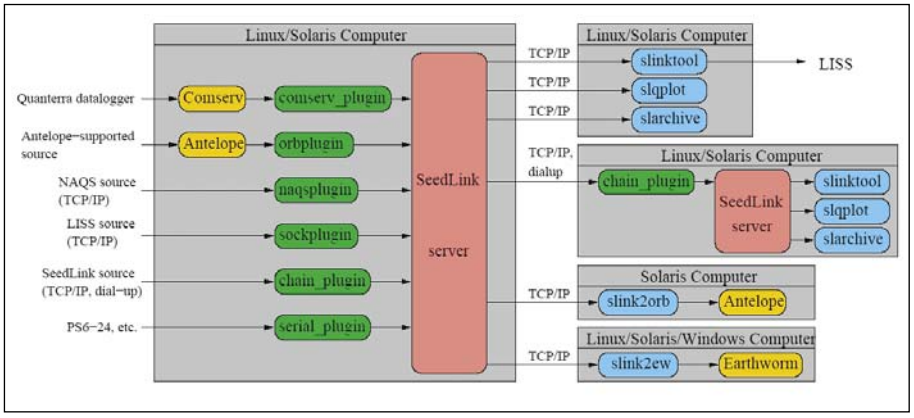


Fig. 3. Seedlink Connectivity with various connection points between datalogger and server. The data processor for the Quanterra datalogger is Comserv.

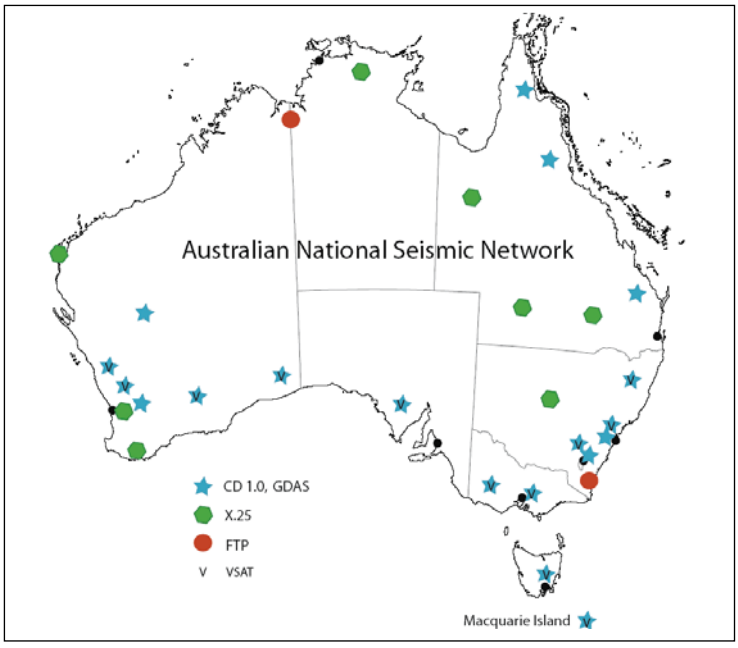


Fig. 4. Stations of the ANSN. Twelve stations have been converted to VSAT leaving sixteen stations on landline (DDS or DDS + Datel) with one station on IP radio. Other stations not represented here belong to the CTBTO, IRIS or AFTAC (American Air Force).

Formats and policies

The CD 1 protocol can be defined as the policy for exchanging frames (specially structured information). That is to say the protocol defines a method for sending continuous data from a data provider or station to a data consumer or data centre. Stations may also be consumers where there is an exchange of command information. The connection is terminated if this policy is not followed. Each individual protocol, or frame action, has a specific timeout.

Establishing a connection

The first phase of the protocol deals with how communications between data providers (senders) and data consumers (receivers) are established. Connections must be established under three circumstances:

1) When a station is first installed;
2) When operation resumes after a station failure; and
3) After a failure at the receiver end has been rectified.

When a provider attempts to establish a connection, the consumer is usually in a listening state, at a predesignated IP address and port number. The provider initiates a connection by issuing a connection or transmission request frame (TRF). Upon receipt of this frame the consumer or receiver attempts to validate this request and in turn issues a port assignment frame (PAF), which contains the IP address and port number to which the provider is to send data. The validation process is that:

1) The station code be announced;
2) The station code matches a known station code; and
3) The IP address of the sender is the same as that which is known for the station.

The provider begins transmission on the new IP address and port number after dropping the original request connection. The IP address is typically the same as that which the consumer has been listening upon but the port address will always be different. The consumer can however direct the provider to send data to a completely different address. The consumer will typically handle a multitude of stations and these stations will all be communicating on a series of different ports. GA is using a single receiver for ANSN stations known as Antelope. There are however multiple instances of a GA modified CTBTO receiver running to handle Australian CTBTO stations.

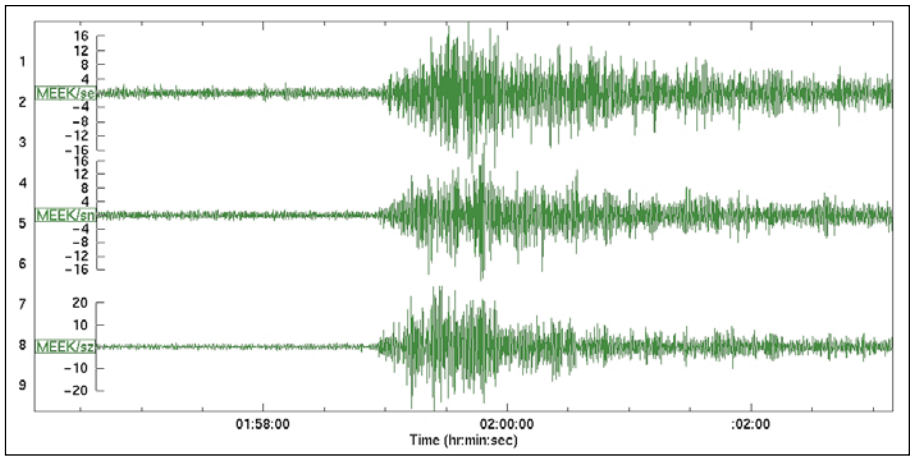


Fig. 5. Nias Earthquake, Indonesia (off Sumatra), 5 July 2005, recorded by a GDAS at Meekatharra in WA, Magnitude 6.7.

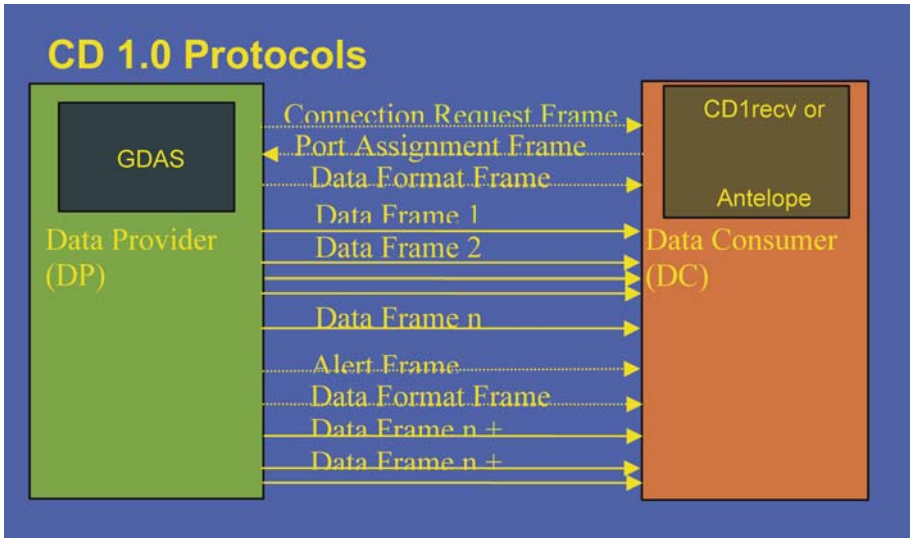


Fig. 6. The frame traffic between Data Provider and Data Consumer in the CD 1 protocol. The CD 1 protocol can be defined as the policy for exchanging frames.

Transmission of data

The second phase of the protocol deals with how data are to be formatted and transmitted. Two types of frames are used in this phase. Initially, a data format frame (DFF), which describes the data which will follow in data frames (DF), is sent. The data frames primarily contain raw waveform data. Data Frames continue to flow until an event occurs.

Transmission events

Events that occur in the middle of a transmission are indicated by alert frames (AF). These alerts indicate an alteration to a connection. They can be initiated by the sender or the receiver. Typically they would be used by a sender to alter the type and frequency of data or to terminate a connection. A receiver would use an alert to alter a port connection. A station that has issued an alert frame that changes the data format must issue a data format frame immediately afterwards. Data format frames are "expensive" frames taking up a couple of kilobytes of transmission bandwidth each time they are used. To avoid sending such frames, data frames should generally not be altered during transmission. At GA, state of health (SOH) information will be sent along with the continuous data embedded in the header of the data frame in the near future. It is cheaper to send these data continuously than to alter the connection each time a SOH transmission event occurs.

The CD 1 protocol assumes a perfect TCP/IP connection. The GA implementation of this, for the most part, works very reliably. The GDAS systems send data from 2400 bits per second, over PPP serial connections with intervening radio links up to 100 mega bits per

second using full Ethernet links. Although not intended for such low speed connections the GA implementation has been adapted to make this possible. The only limitations encountered have been at the data link layer of the TCP/IP protocol when connections were not properly terminated. Under these circumstances data could overflow and disrupt the connection. This has been rectified by properly terminating the connections for hardware flow control.

CD 1 frame formats

The frames mentioned above provide the protocol with its interface data structures. It is the formats or structures of these frames that provide the didactic elements to the providers and consumers engaged in exchanging data. There are five fundamental frame formats in CD 1. The first two, the transmission request frame and the port assignment frame, are used only in establishing connections, and, apart from their physical description, have been covered in the section above. These frames do not have any embedded identification as this is implicit in the protocol. The three remaining frames; the data format frame, the data frame and the alert frame do have explicit identification as part of their format. Once a data connection has been established it is necessary to be able to identify each of these three frame types as the protocol allows for different data formats within the same data connection. All data in the frames must be encoded in network byte ordered representation or IEEE forward byte ordered representation for all multi-byte values. That is to say that integer values must be encoded the same way they would be natively represented on a Sun computer system processor (SPARC). This is also known as big-endian format. Other processors such as the PowerPC processor used in Macintosh based computers are also big-endian. The GA GDAS system is not big-endian as it uses a GX-1 processor which is similar to the Intel processor used in PCs. Intel processors belong to a family known as little-endian architectures. The implication of this is that the standard implementation of the CD 1 protocol will not work on Intel architecture. The GA GDAS system incorporates a comprehensively revised implementation of the CD 1 protocol to overcome this endianess. While all calculations done internally are done in little-endian format the results are converted to big-endian format and the byte streams generated by GA GDAS stations are always in big-endian format. Indeed, the LIFO data buffer itself is stored in big-endian format. Storage of a mixture of floating point and integer data also has an effect on how the data are internally represented and must be compensated for.

The data format frame (DFF) contains a description of the data. In the protocol it is only sent once at the start of a transmission, or after the data format changes. The total size of the frame is 2020 bytes. The start of the frame consists of five 32 bit integer values, one of which is the frame's ID and one which represents the length of time that is spanned by each data frame. It does not include the start time of the frame. The GA implementation does not include the calibration and calibration period parameters. The repeating sequence of channel information is therefore 20 bytes long rather than 28 bytes long. As the channel section is a fixed record, allowing for up to one hundred channels, it accounts for 2000 bytes of the total. CD policy stipulates a maximum of 100 channels.

The data frame is the frame containing the raw time series data. It consists of a frame header which is followed by a channel sub-

frame for each channel being transmitted. The frame header contains the nominal epoch start time for all channels in the frame. There are two fields in the header which have not been used in the normal CD 1 implementation up until recently. These fields refer to a so called "frame description". This allows for any unformatted pseudo data up to one kilobyte in size to be packaged in the frame header. This description is where the GA GDAS State of Health (SOH) data will be inserted allowing for real-time diagnostics. This SOH information will be kept to a minimum and is not expected to exceed 30-40 bytes in length. It would be necessary to keep its size to a fixed length block at all times. If the SOH were only sent at periodic intervals or the SOH data block size varied, a series of frames would need to be exchanged between the sender and the receiver to negotiate a change in format. This would include sending two data format frames. As these frames are quite large, 2020 bytes, relative to the current bandwidth available to send them, it would impose an unnecessary overhead on communications for the sake of a few bytes of SOH data.

The data frame channel sub-frame contains the raw data. It too has a small header which includes a timestamp in epoch time, a 40 byte authentication signature field and a status field. CD policy stipulates that the timestamp must be within one sample period of the data frame's nominal start time. The authentication signature is used by CTBTO stations to verify their data and the 4 byte status field to indicate whether the datalogger has been tampered with. Neither of these are used in the GA GDAS datalogger. The raw data follow the sub-frame header for each channel.

The alert frame is very simple and its payload field (alert type) contains a key as to the type of action to be taken by either the sender or receiver in response to an event.

CD 1 data formats

The protocol stipulates that all uncompressed multi-byte data must be represented as forward byte ordered values. As mentioned, this applies to all frame format data as well. On the GA GDAS, formatting the raw uncompressed data this way is relatively simple compared to formatting the frame format data. In addition to uncompressed data, CD 1 stipulates it own compression algorithm. This is a similar algorithm to the CM6 and CM8 algorithms used in IMS 1.0. The compression algorithm used in CD 1 is known as Canadian Compression. The algorithm works by encoding the bits required to represent the second differences between the waveform samples. The compressed wave data has a series of indices, forming a header component to the compressed data array. The number of indices is proportional to the number of samples being encoded. These indices are followed by the encoded samples themselves. Each index provides a key to the encoding of twenty samples at a time. In turn these twenty samples are broken down into five groups of four samples. Each index is two bytes long. An uncompressed series of 20 x 32 bit integers would normally take up 80 bytes of storage. If all of these integers, expressed as second differences, could be represented by 16 bit values or fewer, the storage required for these samples would be almost halved. In practice, it has been found that Canadian Compression yields a little over 50% compression on the GA GDAS system. In contrast to the simple requirements of forward byte ordering uncompressed data, the Canadian Compression implementation was comprehensively revised to provide both compression and decompression on a little-endian architecture. This allows a standard receiver to decode a compressed byte stream without having to do any endian conversion.

CD 1 Policies

There are a number of CD 1 policies over and above the key policies which govern the protocol itself. These policies fall into the categories of descriptive information, size and time limits, grouping and ordering, and anything else. Of these, it is the data ordering policy which is very important in an alert context. This policy stipulates that data are to be provided to the consumer (receiver) in modified, last in first out (LIFO), order. A modified LIFO buffer enables current near real-time data to be relayed to its destination, following the loss of communications, at all times. Ordering data this way significantly improves data availability and timeliness. These are particularly important criteria in an alert system. The modified LIFO buffer prevents current data from being excessively fragmented during a communications breakdown. Such a breakdown may not be complete, involving the total loss of communications, but may be a partial loss or slowdown in communications. Under these conditions the modified LIFO buffer is designed to provide as many contiguous segments of data as possible. This improves data availability which makes the data more useful in an alert system as it allows automatic detectors to function more efficiently. Timeliness is also a great strength of the CD 1 data ordering policy. In an alert context data loses its value the older it is. The LIFO paradigm implies the most recent data is always provided first.

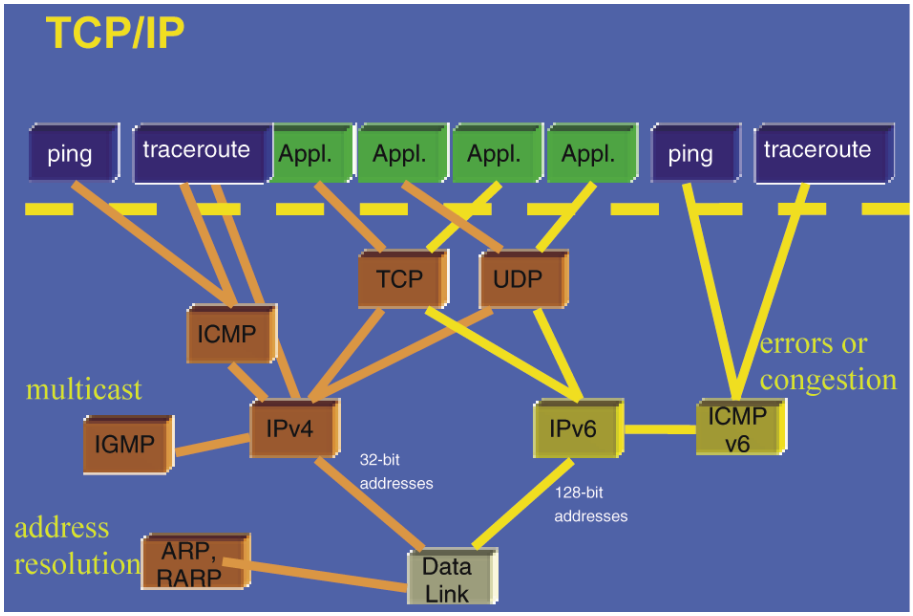


Fig. 7. TCP/IP and other IP protocols. This figure shows how the family of IP protocols interact with application level processes to control and route the movement of data between two machines. The data link layer (encompassing lower physical layer) can consist of ATM, Ethernet (IEEE 802.3), Frame Relay, X.25, WiFi, PPP, ISDN, RS232, DSL, 100BASE-T, T1, VSAT DVB-RCS etc. (see http://en.wikipedia.org/wiki/IEEE_802.)

To improve data availability, the modified LIFO employed in CD 1 adjusts the real-time window to within a couple of minutes. Once the modified LIFO window has been sent to the data consumer the data provider sends data in full LIFO format. That is to say the data provider will always send the most current packet of data first and whatever bandwidth is left over will be used to send any older packets of data, up until the next real-time packet has been prepared. Thus modified LIFO is capable of providing near real-time data, without sacrificing any old data. The modified LIFO policy is a significant advance over mainly FIFO systems currently deployed in most dataloggers and data processors. To provide proper alert capability FIFO systems would need quite small buffers. This would, of course, result in poorer data availability were a station inaccessible for any significant length of time. Many dataloggers do have relatively small data buffers, but the policies used by the data processors often negate this as they acquire data into larger ring buffers and forward this using a FIFO policy. Of course, much depends on the bandwidth between the data provider and the data consumer and the rate at which data are acquired. In the case of the GA GDAS, the modified LIFO buffer is capable of handling an outage of three and one half days. As the bandwidth available at most GDAS stations is very low (2400 bits per second), only one packet of old data can be transmitted in between every packet of new data. This will change as more and more stations are upgraded to faster VSAT (Very Small Aperture Terminal) satellite links.

TCP/IP, CD 1.0 and other application level protocols

CD 1.0 must not be confused with network protocols such as TCP/IP. It does not supplant these protocols rather it sits on top of them. TCP/IP provides the infrastructure for protocols such as CD 1.0.

Routing through an IP based network to the application layer is shown in Figure 7. The layering paradigm of network protocols is shown in Figure 8. The TCP/IP internet reference model only has four layers while the standard reference for describing network models, the Open Systems Interconnection (OSI) model, has seven layers altogether. The OSI model is often mapped onto the TCP/IP model. The OSI model was used to describe protocols such as X.21 and X.25. X.25 was used by a previous generation of GA datalogger known affectionately as the blue box. X.21 is still in use today for packet radio communications. The two different models can and do coexist today. The layering of these protocols can be compared to a Russian doll in which interaction takes place only between two adjacent layers.

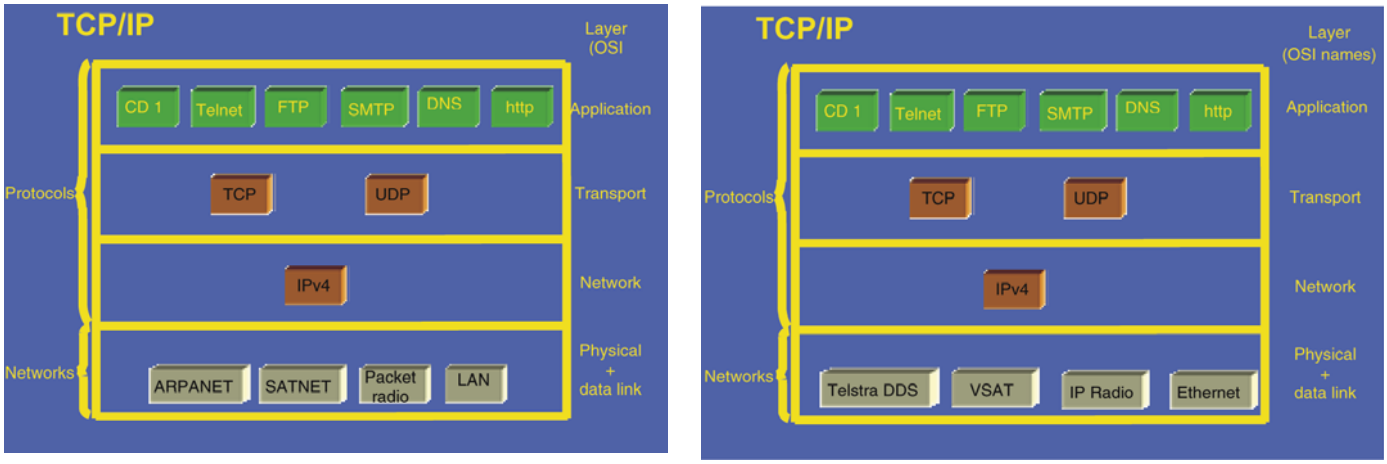
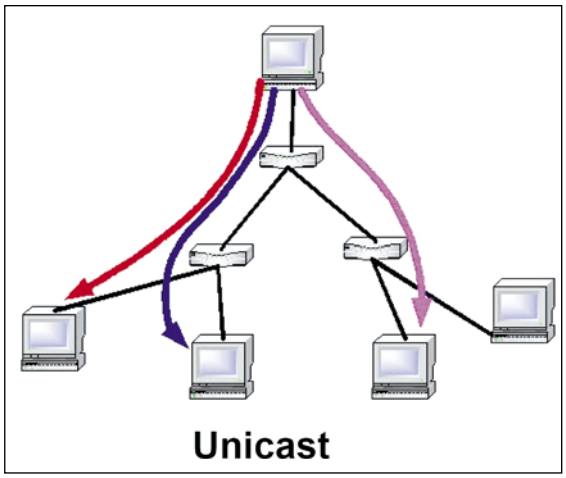
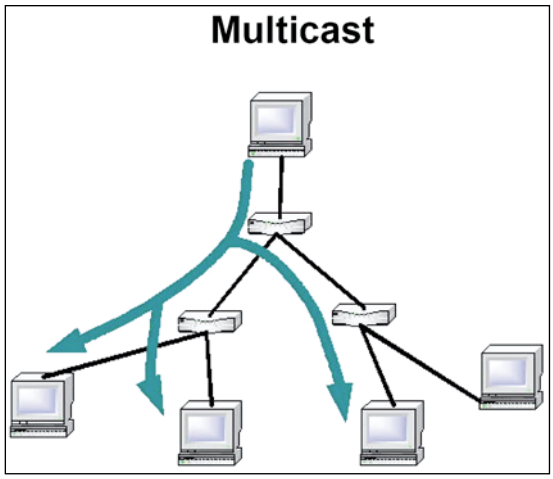


Fig. 8. OSI TCP/IP Layers. This figure shows how the layers of the TCP/IP protocol are mapped onto the layers of the Open Systems Interconnect reference model. The Host to Network TCP/IP layer is the equivalent of the OSI Physical plus Data Link layers. It is the OSI network layer of TCP/IP which has given its name to the "Internet". In getting data from a GDAS station to GA, packetised data may travel through one or more combinations of several physical networks such as IP spread spectrum radio, PPP, Ethernet, Telstra DDS leased line (X.21 bis) and VSAT DVB-RCS. In the case of VSAT satellite communications TCP/IP data is converted into a digital video signal (MPEG2) which makes better use of satellite resources. CD 1 can be seen at the application level of both of these network models and whatever occurs within these lower layers is meant to be transparent as far as the CD protocol is concerned.





Figs. 9 & 10. Unicast and Multicast data flows. Multicast data is replicated at appropriate routing points in the network whereas Unicast data would need to be replicated at the source. This means if data were to be sent to two different locations, using a Unicast model, twice as much bandwidth would be required and two copies of buffered data would need to be stored on the datalogger. True multicasting is much more complicated to implement particularly with LIFO buffers.

TCP

- Breaks data up into datagrams, these are fed into the network and can be broken up further into packets.
- Datagrams are reassembled at the other end.
- Each datagram is uniquely identified by a source and destination port and a sequence number. It is these sequence numbers which enables the protocol to reliably deliver datagrams.
- TCP provides a reliable end to end virtual connection.

UDP

- Is similar to TCP but cannot provide a virtual connection or deliver datagrams reliably as there is no exchange of control information.
- The overhead of the protocol is much smaller than TCP which is why it is used in data intensive applications.

IP

- Routes datagrams through the network without any regard for the relationship between datagrams.

Future Directions

Although CD 1.0 has been superseded by CD 1.1 it is unlikely that this will affect the GDAS datalogger. A drawback with CD 1.0 is that there is no acknowledgement of data packets at the application layer. This occasionally leads to a loss of data. Various improvements are being trialled which it is anticipated will overcome most communications problems and subsequent data loss. In addition to the standard data stream of 20 samples per second, development is now progressing on carrying 200 samples per second event data via CD 1. These data will be transmitted for short bursts, when required, and will not affect the standard data stream. Multicasting for data redundancy is also being investigated. Multicasting enables a single stream of data to be split by the network and sent to two different destinations. This is not the same as duplicating two streams of data at the source, known as double unicasting. Multicasting will not be feasible on the existing DDS (Digital Data Service) lines, or on the private VSAT service, currently being installed for some ANSN stations, as these lines terminate at GA. Multicasting would be useful over internet based lines using ADSL or dialup or using an internet VSAT service. One such VSAT service is currently operating at the ANSN station at Young and CD 1 data is being transmitted from this station to GA through the internet.

Additional work is required for both CD 1 and CD 1.1 to enable multicasting. In the short term, it may be more feasible for GA to double unicast data as the GDAS is capable of doing this very easily already.

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Geoscience Australia

Bremer Sub-basin seismic interpretations now available

Geoscience Australia is now making available preliminary interpretations of seismic data from the Bremer Sub-basin study. Interpretations are provided for 2 seismic surveys: Geoscience Australia's Southwest Frontiers Marine Seismic Survey (S280) acquired in October and November 2004; and ESSO Australia Pty Ltd Bremer Marine Seismic Survey (r74A) that was reprocessed by FUGRO MCS in 2001, to which Geoscience Australia holds the licensing rights. Interpretations cover the extents of the 2005 Bremer Sub-basin Acreage Release Areas W05-23 and W05-24. This is a preliminary data release from work in progress, and is intended to assist explorers assessing the Bremer Sub-basin acreage release areas. Interpretations include major and minor faults, and a set of 7 key horizons for both seismic data sets (Figure 1).

The horizons are provided as ASCII files using the Geoquest *2d_ci7m_gf.ifdf* format. Copies of both seismic surveys and the preliminary interpretations are available at the cost-of-transfer through the Geoscience Australia Data Repository (ausgeodata@ga.gov.au; Phone: 02 6249 9222). Final results from the Bremer Sub-basin study will be provided at Geoscience Australia's New Exploration Opportunities Workshop, October 13 and 14, 2005. For further information, please contact: Barry Bradshaw, Geoscience Australia, on email: barry.bradshaw@ga.gov.au.

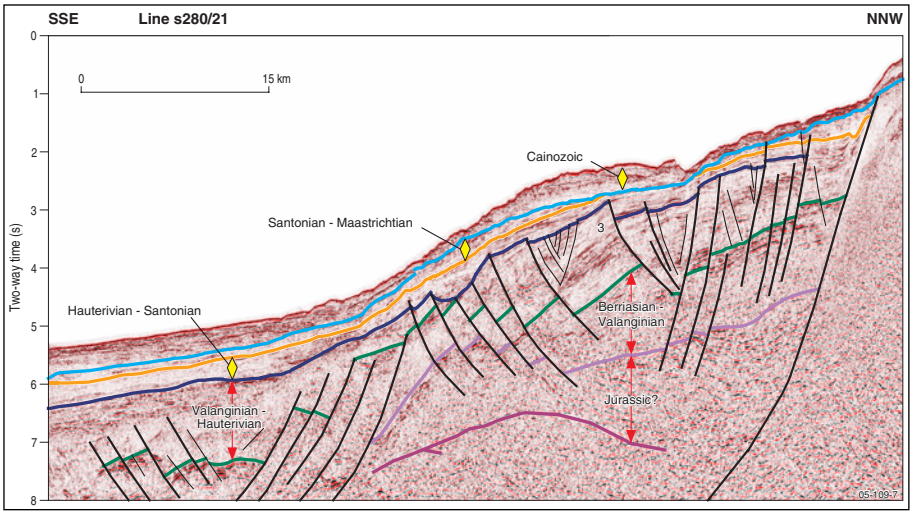

Fig. 1. Interpreted seismic line s280-21, from the central part of the Bremer Sub-basin.

Fig. 2. ANSIR vibrators in action across the Tanami.

Land seismic surveys

The data acquisition component for the **2005 Tanami Seismic Collaborative Research Project** was successfully completed in mid-July (see Figure 2). This involved the collection of 720 km of deep seismic reflection data along four regional traverses, the simultaneous recording wide-angle seismic refraction data along part of the main regional traverse 05GA-T1 and the collection of gravity data at 400 m station spacing along each of the seismic traverses. This deep seismic refection survey and wide-angle survey were acquired using the resources of ANSIR, Australia's Major National Research Facility in earth sounding. The Northern Territory Geological Survey acquired the gravity data for the project.

The project's collaborators, Geoscience Australia, the Geological Survey of Western Australia, the Northern Territory Geological Survey, Newmont Australia Pty Ltd and Tanami Gold NL, all report that the raw seismic field data are very exciting and promise to answer fundamental questions on the crustal architecture and mineral systems in the Tanami region of NT and WA.

Data processing of the deep seismic reflection data has recently started at Geoscience Australia and processing of the gravity and wide-angle data are scheduled to commence in the near future. The collaborators will begin data interpretation early next year with the integration of existing geological data with the new (and existing) geophysical data to develop and improve understanding of the 3D architecture of the Tanami region. This will include the regional geology, the geometry of key regional structures, and potential field modelling and their relationship with known gold mineralisation in the region.

The **2004 Curnamona Province Seismic Survey**, undertaken as a collaborative project involving the Office of Minerals and Energy Resources, South Australia, the Predictive Mineral Discovery Cooperative Research Centre and Geoscience Australia has been processed and an initial interpretation completed. The data will be released at a workshop in Adelaide in early December coinciding with the St Barbara's Day annual industry forum.

New South Wales Department of Primary Industries – Minerals Resources and Geoscience Australia are finalising plans to acquire approximately 270 km of deep seismic

reflection data in the Bourke-Wanaaring-Wilcannia region of northwest New South Wales. The **2005 Thomson-Lachlan Seismic Survey** project aims to solve some of the key mysteries in the Tasmanides such as the location and nature of the east-west boundary between the Lachlan and Thomson Orogens. This survey promises to not only address fundamental crustal evolution problems but also provide information on potential new metallogenic provinces as well as information on the geometry of several hydrocarbon prospective basins. For further information, contact Bruce Goleby, on e-mail: bruce.goleby@ga.gov.au.

Western Australia, Northern Territory, Queensland and Geoscience Australia

New airborne geophysical surveys

East Yilgarn and Gascoyne WA Airborne magnetic and radiometric surveys

The Geological Survey of Western Australia is conducting surveys in two areas of Western Australia. The surveys commenced in August 2005.

Fugro Airborne Surveys has been engaged to acquire 164,000 line-km of magnetic and radiometric data over an area of approximately 58,000 square kilometres in the East Yilgarn region (Figure 3).

UTS Geophysics has been engaged to acquire 106,000 line-km of magnetic and radiometric data over an area of approximately 36,000 square kilometres in the Gascoyne region (Figure 4).

The new data will be acquired on east-west lines spaced 400 m apart with a ground clearance of 60 m above ground level. Geoscience Australia will be managing the flying program.

When completed, the projects will release a total of more than 267 000 line kilometres of magnetic and radiometric data to the public domain.

For further details, contact David Howard by telephone on 08 9222 3331 or by e-mail at david.howard@doir.wa.gov.au or murray richardson by telephone on 02 6249 9229 or by e-mail at murray.richardson@ga.gov.au.

Update on geophysical surveys

Paterson Province WA – airborne magnetic and radiometric surveys

Fugro Airborne Surveys completed data acquisition on the Paterson North survey on 1 June. When the survey is completed approximately 64,700 line-km of new data will be released to the public domain.

UTS Geophysics commenced data acquisition on the Paterson Central and Paterson South-East surveys on 24 June. Approximately 123,000 line-km of magnetic and radiometric data will be acquired over an area of approximately 42,000 square kilometres.

Maryborough/Gympie Qld – airborne magnetic and radiometric survey

At the end of June UTS Geophysics had completed 60% of this survey. Approximately 20,000 line-km remained to complete the data acquisition phase of this survey. The survey has been delayed by the unseasonal wet weather experienced in the Maryborough region.

The new data are being acquired on east-west lines spaced 400 m apart with a ground clearance of 80 m above ground level. Geoscience Australia is managing the flying program. The survey is expected to acquire 43,400 line kilometres of magnetic and radiometric data.

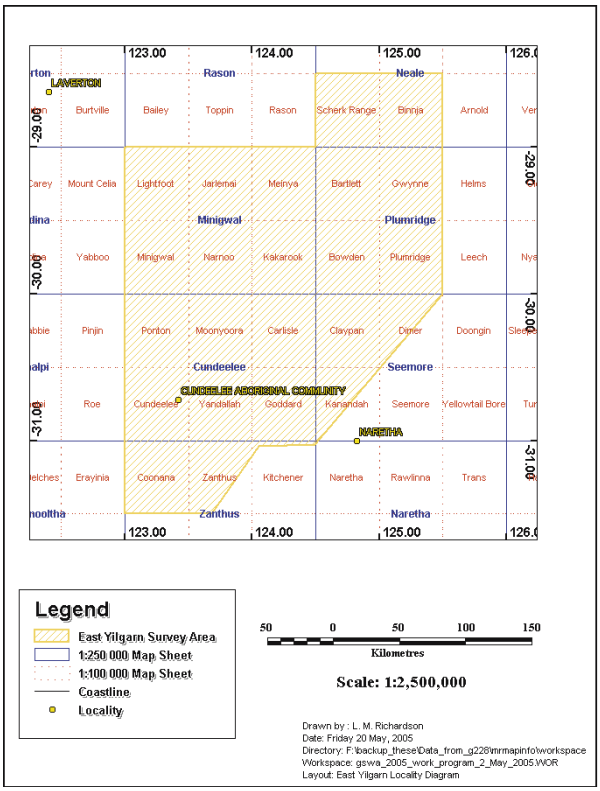

Fig. 3. Locality diagram for the East Yilgarn Airborne Geophysical Survey.

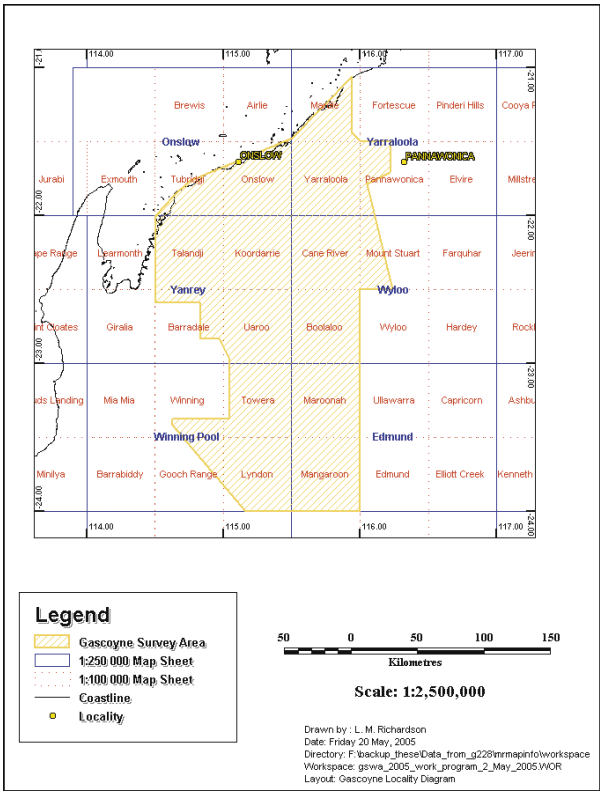

Fig. 4. Locality diagram for the Gascoyne Airborne Geophysical Survey.

Birrindudu NT – gravity survey

The data acquisition phase of this project was completed on 18 June. When the survey is completed approximately 3,728 new gravity stations on a 2 kilometre by 2 kilometre grid will be released to the public domain.

Queensland

Smart Exploration initiative

Queensland has launched a $20 million ***Smart Exploration*** initiative by the Department of Natural Resources and Mines to stimulate exploration investment in Queensland over the next four years.

It builds on earlier funding initiatives that acquired gravity and airborne geophysical data to update the Department's geological mapping capabilities.

The Smart Exploration initiative is targeting four areas (see Figure 1) with the highest potential for the discovery of additional mineral and energy resources. These are:

- Mount Isa region, north-west Queensland
- Drummond Basin, central Queensland
- Bowen and Surat Basins, central and south Queensland
- Mount Rawdon corridor, south-east Queensland

Mount Isa region

The Mount Isa region is expected to experience the closure of 7 major mineral mines out of 15 that will close across the State by 2015.

If new mines are not opened, the region will be directly affected not only by the mine closures, but also by the consequent contraction of mineral processing facilities. Closure of mines would also significantly affect the local communities including those along the transport corridor to Townsville.

The acquisition of new geological and geophysical data accompanied by enhanced data manipulation and modelling techniques will assist in the delineation of new exploration targets and the discovery of new mineral resources.

Drummond Basin

The Drummond Basin in central Queensland has the potential for uncovering significant gold deposits as indicated by the Vera Nancy and Pajingo gold mines located south-west of Charters Towers.

The region is prospective for epithermal-style gold mineralisation and currently contains Queensland's largest operating gold mine.

New data acquisition and assessment will upgrade the knowledge of mineralisation in these complex geological environments, thus enhancing future exploration success.

Bowen and Surat Basins

The Bowen and Surat Basins in central and south Queensland respectively, are major energy provinces in the State, with abundant reserves of coal and coal seam gas. Expansion of coal production is planned for many existing mines and there is likely to be accelerated development of new mines in these provinces to meet growing world demand for coal.

Although most of the large coal resources have been identified there are still opportunities for small economic deposits to be delineated. Detailed geological mapping is required to complement existing geophysical data to identify more exploration targets.

The Surat Energy Resources Province, in the area between Toowoomba and Injune, in southern Queensland is attracting Australian and overseas interest in its thermal coal and coal seam gas resources. The initiative will update knowledge of the geology of the main regions of coal and coal seam gas and their extensions into the deeper parts of the basin.

Production of coal seam gas from both of these energy provinces is likely to significantly increase in the next few years as petroleum companies capitalise on the market opportunities arising from the Government's '13 percent gas scheme' and the shift by industry to cleaner sources of energy.

Rawdon Corridor (South-east Queensland)

Airborne magnetic and radiometric data are currently being be acquired over an area to the south-west of Childers near the currently operating Mount Rawdon gold mine. This work will complement a mapping program to improve the geological understanding of the area, and its potential to host undiscovered mineral resources.

The area contains Queensland's second largest operating gold mine, new developments at Goondicum, and the northern extension of the Gympie Group. The area is highly prospective for minerals of all types including mesothermal and epithermal gold and porphyry deposits.

Geological and geophysical data acquisition

Geological data

The acquisition of new geological data for the Mount Isa region will involve the remapping of the 40 1:100 000 Sheet areas that cover the outcrop areas of the Mount Isa region and a further 58 Sheet areas comprising potentially mineralised basement under shallow younger cover rocks.

The new mapping will make use of modern interpretation of fully integrated airborne geophysics, gravity data captured to agreed

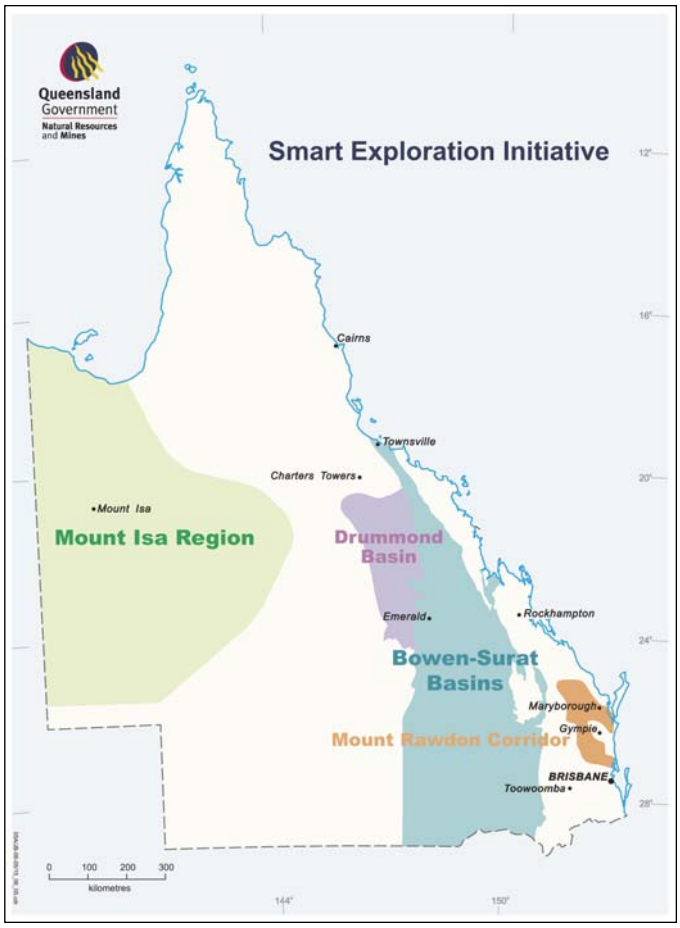

Fig 1. Four target areas in the Smart Exploration Initiative

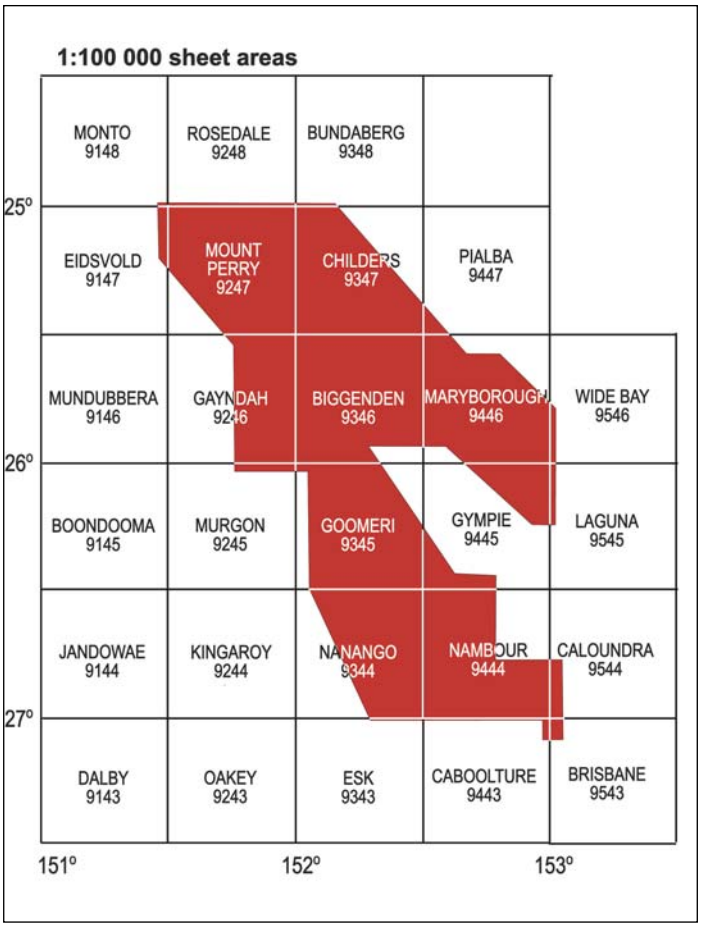

Fig. 2. Location (in red) of the Maryborough-Gympie geophysical airborne survey.

national standards, deep seismic survey and hyperspectral data.

Remapping of the Bowen Basin in central Queensland is aimed at updating the geological knowledge of the outcrop areas. This involves 33 1:100 000 Sheet areas that were originally mapped during the 1960s and early 1970s. It will incorporate company information acquired as a result of later exploration programs, and the interpretation of the modern geophysical data acquired as part of this initiative and from previous programs.

The geological maps covering the Surat Basin were compiled during the 1960s. The proposed new geological data acquisition will focus primarily on the Sheet areas that cover known coal and coal seam gas resources. This will involve updating 23 1:100 000 Sheet areas.

The completion of this geological remapping program will result in an increase in the digital seamless geological data coverage of the State from 26.5 to approximately 50%.

Geophysical data

Airborne magnetic and radiometric data will be acquired over the three target areas and the remainder of the Mount Rawdon corridor in south-east Queensland. Gravity data will be acquired in the Mount Isa region and the Surat Basin.

Some seismic survey and hyperspectral data may be acquired to aid the interpretation of deep structures and subtle surface alteration features.

The magnetic component of this airborne data is of particular importance in the Mount Isa region and Drummond Basin, where highly prospective outcropping formations continue under the cover of younger rocks. The area of outcropping rocks in the Mount Isa region was geophysically surveyed by exploration companies in the 1990s. The geophysical data acquired will be used in conjunction with the earlier data to upgrade geological mapping of both outcropping Mount Isa rocks and their extension under cover.

The acquisition of gravity and airborne geophysical data in conjunction with the geological mapping will enable the development of accurate 3-dimensional geological models for all target areas. These models will form the basis for identifying potential coal, coal seam gas and mineral targets.

The proposed acquisition of the new geophysical data to currently accepted industry standards will increase coverage of Queensland:

- magnetics to approximately 50%;
- radiometrics to approximately 45%; and
- gravity data to approximately 40%.

This significant increase in geophysics coverage will act as a major incentive to attract exploration to the State.

Data conversion

Data conversion will involve the assessment and capture of archival data from exploration company reports into easily accessible data in modern formats. Three separate areas of data conversion will be undertaken.

Mineral exploration expenditure continues to increase, petroleum remains flat

Minerals

Big increase in search for Ni/Co but decline in Au

Figures released in June 2005 by the Australian Bureau of Statistics showed that the trend estimate for total mineral exploration expenditure increased by 4.4% to $265.5M in the March quarter 2005. The estimate has risen in the last six quarters and is now 31.6% higher than the March quarter 2004. However, in CPI adjusted numbers, it is still more than 20 % lower than the peak reached in March 1997.

Figure 1 shows the expenditure estimates from March 1997 through March 2005. Figure 2 shows the longer term trends from March 1986; interestingly it indicates a gradual decline in real terms over the last twenty years.

All states showed stable or increasing expenditure levels during this quarter. Western Australia had the largest increase ($7.0M or 4.7%), making a total 'trend' expenditure of $156.5M or about 60% of the national total; Queensland followed with $42.8M and South Australia with $19.2M.

Perhaps the most significant change was in the Greenfield/Brownfield ratio. In the December 2004 quarter the ratio was 108/153, where the numbers are in millions of dollars but in the March 2005 quarter the ratio was 84/142 – a drop from 70% to 60%.

The drilling results for the March quarter were quite good. They increased from 1104 km in March 2004 to 1341 km in the 2005 March quarter – a very positive trend.

In terms of commodities, exploration for gold continued to decline. In the last year it has fallen from 55% of the total of $167.3M to 36% of $225.8. In the corresponding period the expenditure on the search for Ni and Co has increased from 9% of the total to 19% or $43.3M.

The fall in gold exploration must be cause for concern and Tim Shanahan of the WA Chamber of Mines did not mince his words when commenting on the March 2005 numbers. "Australia is losing market share while our competitors, such as Canada, are overtaking us. Once the global leader in minerals exploration, Australia is now outpaced by Latin America, Canada, Africa, and countries classified in the 'Rest of the World' category."

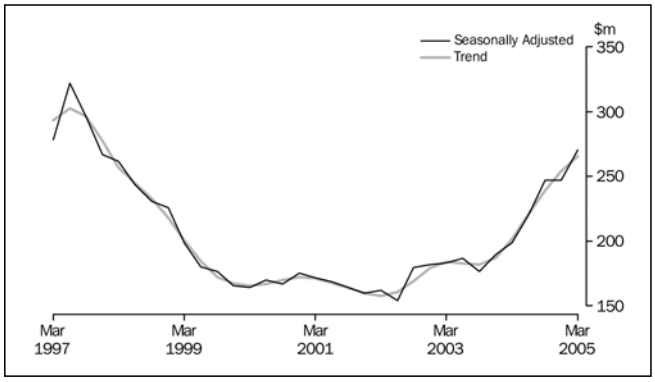

Fig. 1. Trend and seasonally adjusted quarterly mineral exploration expenditure from March 1997 through March 2005. (provided courtesy of the Australian Bureau of Statistics).

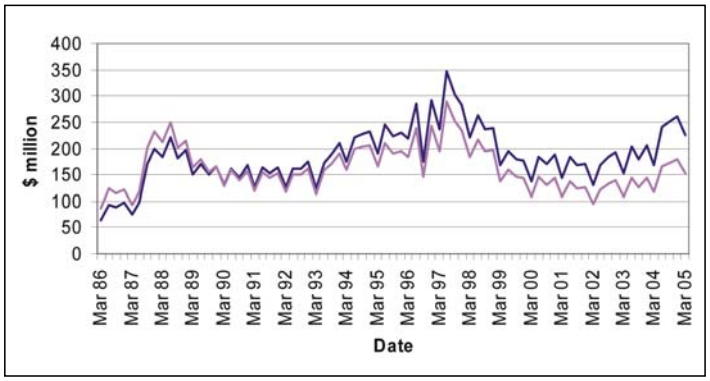

Fig. 2. Quarterly 'actual' mineral exploration expenditure from March 1986 through March 2005. The black curve represents actual dollars spent and the purple curve shows the CPI adjusted (to 1998/99) number. Notice that the CPI adjusted long-term values indicate a slight downward trend.

Cont'd from page 36

Surface and drill hole geochemistry data

Surface and drill hole geochemistry data is fundamental in delineating zones of anomalous metal concentrations, which may indicate the presence of economic mineral deposits at depth. Currently only 30% of this data has been compiled in readily accessible formats and is a high priority for completion over the high priority areas within this initiative.

Seismic Data Tape Transcription

Seismic data is a fundamental data set used in the petroleum industry to facilitate prospect delineation and field development. Transcription from current decaying seismic data tapes to a stable storage medium will preserve this valuable data source, and make it available to industry for reprocessing and reinterpretation which would require many hundreds of millions of dollars to replace if the tapes were to become unreadable. The transcription of the remaining 35,000 tapes will complete a project commenced in the early 1990s.

Maryborough-Gympie airborne data

New geophysical data from Maryborough – Gympie area

A new airborne geophysical survey is currently being flown over the Maryborough/Gympie area. Approximately 51 176 line kilometres of magnetic and radiometric data are being collected over an area of 18 020 km^2. It is being flown at a line spacing of 400 m from a height of 80 m (see GA contribution in this *Preview*).

The survey extends previous surveys, is partly funded by the Queensland Department of Primary Industries and Fisheries, and is adjacent to known gold occurrences - the Gympie Goldfield (see Figure 2).

It is being flown by UTS Geophysics from Perth, Western Australia and project management is being carried out by Geoscience Australia.

For more information contact:David Searle at david.searle@nrm.qld.gov.au or on 07 3362 9357.

He called for increased efforts to implement the package of measures in the joint industry-government Mineral Explor-ation Action Agenda, which recommended urgent government action to address the significant downturn in the exploration industry which has occurred since 1997.

"Key elements of the package of measures to reinvigorate our mineral exploration industry include a flow-through shares scheme and increased funding for pre-competitive geoscientific information," Mr Shanahan said.

Petroleum

Expenditure still flat

Expenditure on petroleum exploration for the March quarter 2005 decreased by $17.4M (6.1%) to $269.2M. However, it was about $100M more than the expenditure for the March 2004 quarter. Perhaps the increase in the price of oil is eventually translating into exploration activity.

Expenditure on exploration on production leases decreased (by $21.1M or 38.1%), while exploration on all other areas increased slightly by $3.7M or 1.6% this quarter. There was a small increase of $5.2M (2.5%) in offshore exploration, while onshore exploration expenditure decreased by $22.6M (30.1%).

As can be seen from Figure 3, there is considerable scatter in the medium term trends, but overall the investment in petroleum exploration has remained roughly constant during the last ten years.

Santos has record $1.02 billion first half revenue

Record second quarter sales revenue reported by Santos in July has driven its first half revenue for 2005 above $1 billion for the first time.

Total sales revenue for the three months to 30 June 2005 was a record $553M - a 19% increase on $466M in the first quarter and up 66% on $334M in the second quarter of 2004.

The higher revenue reflected increased production and sales volumes, combined with continuing higher oil and gas prices.

Total production for the second quarter of 13.8M barrels of oil equivalent (mmboe) was 10% above the strong first quarter result and 19% above the previous corresponding period. A very encouraging result.

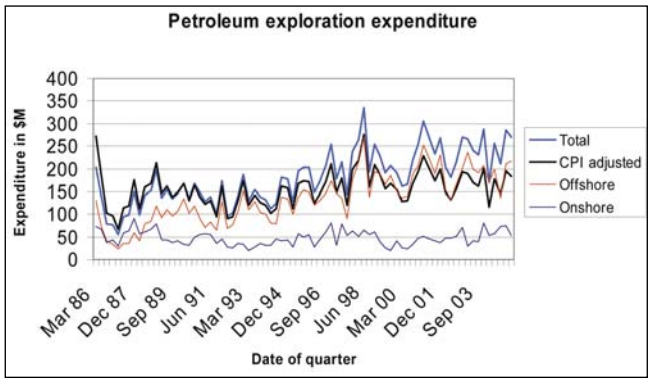

Fig. 3. Quarterly petroleum exploration expenditure from March 1986 through March 2005, for onshore and offshore areas. The individual offshore and onshore numbers are actual dollars spent, not CPI adjusted. Notice that over the last ten years the CPI adjusted (to 1998/99) numbers are roughly constant.

Hot Rock drilling progresses near Olympic Dam, SA

Green Rock Energy's geothermal exploration well, Blanche No. 1, located 8 km from Olympic Dam passed 300 m in July and accessed the Pandurra Formation. This forms part of the sedimentary cap overlying the target granitic basement rocks.

On 21 June, the pre-collar was completed at a depth of 266 m.

Blanche No. 1 is the first cored geothermal exploratory well the Company will drill on its geothermal energy licences near the Olympic Dam mine over the next few months.

The Company also intends to deepen existing mineral exploration drill holes to depths ranging from 1500 to 2000 m.

On completion of the well drilling program, a suite of geophysical logs, temperature and core measurement data will be collected and analysed. This information will enable the Company to select the optimal location for its first deep geothermal energy well, and establish a pilot circulation cell to facilitate trial electricity generation.

Blanche No. 1 is 5 km from a 275kV electricity transmission line that traverses Green Rock's GEL, and connects Olympic Dam to the Adelaide and South Eastern Australia electricity grids.

McCuaig to head Centre for Exploration Targeting, University of WA

One of SRK Consulting's Directors, Dr T Campbell McCuaig, has been appointed Head of the newly established Centre for Exploration Targeting in WA. The CET was announced earlier this year as a joint initiative between the UWA and its School of Earth and Geographical Sciences, Curtin University of Technology and the exploration industry, with funding from the State Government, through its State Centres of Excellence in Science and Innovation Program.

Dr McCuaig is a structural geologist with 18 years of academic and industry experience, of which the past nine years have been as a consultant with SRK. He is an expert in applied structural geology, ore deposit evaluation and exploration strategy, as well as an experienced trainer in applied structural geology and the analysis of mineral deposits. His role in SRK was expanded in 2004 when he was appointed as a Director.

The appointment with the CET will be effective from 8 August 2005.

Implementing the Minerals Exploration Action Agenda

Since the launch of the Minerals Exploration Action Agenda (MEAA) in July 2004, the Implementation Group has met three times to progress actions under the four key strategies. An important aspect of the Groups' most recent meeting held on 20 April 2005, was a presentation made to Dr Ken Henry, Secretary of the Department of Treasury, regarding Finance issues specific to the exploration sector. The Minister for Industry, Tourism & Resources, Ian Macfarlane, has also participated in two of the Group's meetings and is regularly kept informed of progress. The next meeting of the Implementation Group will be held in Perth on 22 September 2005.

The following briefly outlines progress in implementing each of the MEAA strategies.

Finance Strategy

The Finance Strategy Implementation Group continues to pursue investment incentives (including flow-through shares (FTS)) and options to remove unnecessary regulatory burdens, particularly on small minerals explorers.

A series of work was commissioned during the period November 2004 – March 2005 to analyse capital raisings and the relative importance of IPO's for minerals exploration in Australia, and also to investigate regulatory burdens on small explorers listing on the Australian Stock Exchange (ASX).

Based on the findings of this work the Group is now investigating the possibilities of restricting any FTS proposal to expenditure on new ("grassroots") exploration by "junior" companies with no income from production. The final details a new FTS proposal will be agreed at the next MEAA meeting in September.

The Group is also pursuing further work to benchmark the cost of raising capital for exploration in Australia, against our major competitors such as the Toronto Stock Exchange and London's Alternative Investment Market. This benchmarking exercise will inform the Group's deliberations on whether the cost of raising capital in Australia is excessive and whether options for reducing these costs for small explorers are justified.

The Group will also work cooperatively with the ASX in addressing the issue of re-establishing a resources index as a means of raising the profile of the sector within the capital market.

Land Access Strategy

In pursuing the Land Access Strategy the following progress has been made. The Ministerial Council on Mineral & Petroleum Resources (MCMPR), in consultation with industry has prepared a framework for community engagement strategies which will provide guidance to industry and governments on suitable principles to be addressed in the engagement process. Also, amendments to the *Aboriginal Land Rights (Northern Territory) Act 1976* have been prepared and are with the Australian Government for consideration.

To implement the remaining actions under the land access strategy, a working group has been established under the MCMPR. This group met for the first time on 26 July 2005, in Canberra. Specific issues which the group will address include Native Title and Cultural Heritage.

Human & Intellectual Capital (H&IC) Strategy

To ensure greater involvement by the entire minerals exploration sector in implementing the MEAA, the group recently commissioned the Australian Bureau of Statistics to send information about the MEAA to all explorers listed in their data base. The letter went to some 1100 companies and individuals either active or recently active in minerals exploration in Australia. To date the letter has received a positive response, with many small un-listed companies contacting the MEAA Secretariat for more information.

Given the current focus on skills shortages for the mining industry, members of this group are also directly involved with the Mining Industry Skills Shortages Working Group which was established under the National Skills Shortages Strategy in 2004 and funded with $500,000. On 31 May 2005, the group released the report *Prospecting for Skills: The Current and Future Skill Needs in the Minerals Sector.* The report found that the sector is currently experiencing skills shortages but there is a fair level of variability in their extent and impact.

The H&IC Group is also developing a proposal for a *discovery@depth summer school* to provide specialised professional development for geophysics graduates especially in the search for deep earth resources. Funding for the summer school will be sought through the Dept. of Education, Science and Trainings' Collaboration & Structural Reform (CASR) Fund. It is expected that the proposal will be submitted through the next CASR application round later in 2005.

In a cooperative effort between industry, government and the research community, significant work is being undertaken to develop the standards that will enable the deployment of interoperability technology. This technology provides a standard interface to data sets and will vastly improve the accessibility of pre-competitive geoscience information, allowing minerals explorers to extract geoscience data in standardised formats from a wide range of data suppliers via the internet in real time.

Pre-competitive Geoscience Strategy

The MEAA Implementation Group recognises the importance of high quality pre-competitive geoscience data to enable better area selection and targeting for detailed exploration by industry, particularly under surficial and sedimentary cover. The Group is continuing to pursue additional Australian Government funding for a National Onshore Pre-competitive Geoscience Program.

*This information was provided by Lisa Richards (*Lisa.Richards@industry.gov.au*) at the Department of Industry, Tourism and Resources*

$160 million boost to offshore petroleum exploration

The award of eight new offshore petroleum exploration permits in waters off Western Australia and Tasmania will see an additional $160 million invested in offshore exploration over the next six years.

Federal Industry Minister Ian Macfarlane announced on 21 July 2005 the new permits as part of the government's ongoing program of releasing offshore acreage for petroleum exploration.

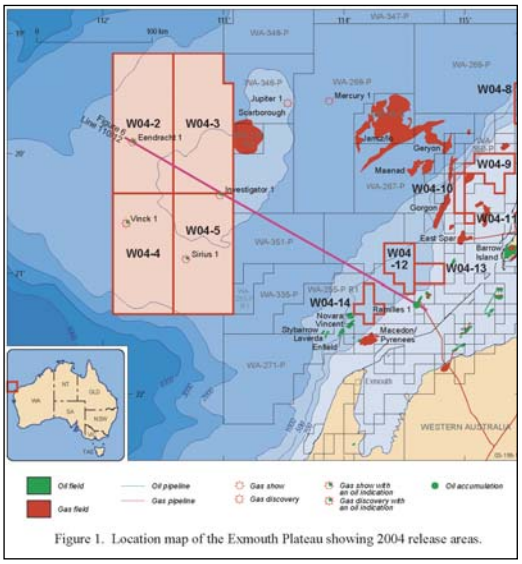

Fig. 1. Locations of areas let for offshore petroleum exploration (W03-5 and W03-6).

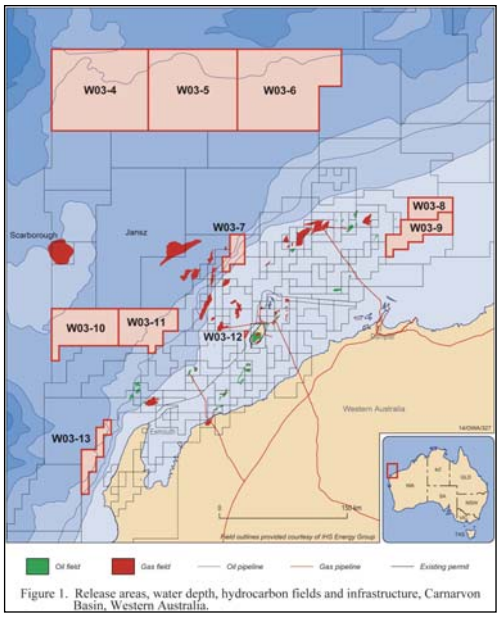

Figure 1. Release areas, water depth, hydrocarbon fields and infrastructure, Carnarvon Basin, Western Australia.

Fig. 2. Locations of areas let for offshore petroleum exploration (W 40-2, W40-3, W40-4 and W40-5). W40-2 and W40-4 are Designated Frontier Areas and attract a 150% tax deduction for exploration expenses.

Six of the new permits are located in the Carnarvon Basin of Western Australia (see Figures 1 and 2). Two of these are located over Designated Frontier Areas, which allow an immediate uplift to 150 per cent on petroleum resource rent tax deductions for exploration expenditure.

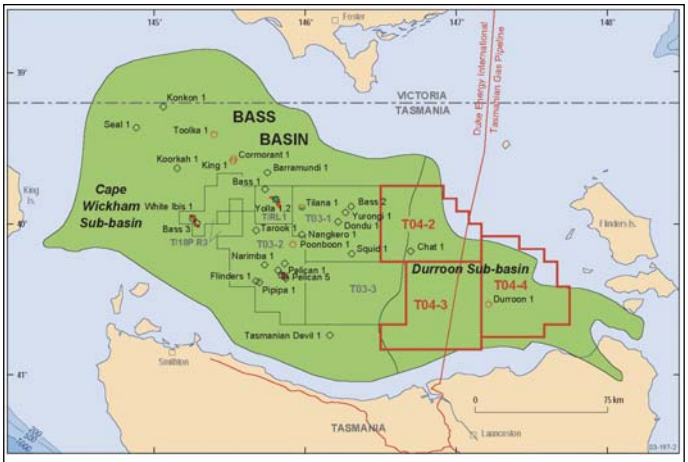

Figure 2. Location map of the Bass Basin showing the 2003 and 2004 Acreage Release areas, current permits, exploration wells, fields and the Duke Energy International Tasmanian Gas Pipeline across Bass Strait.

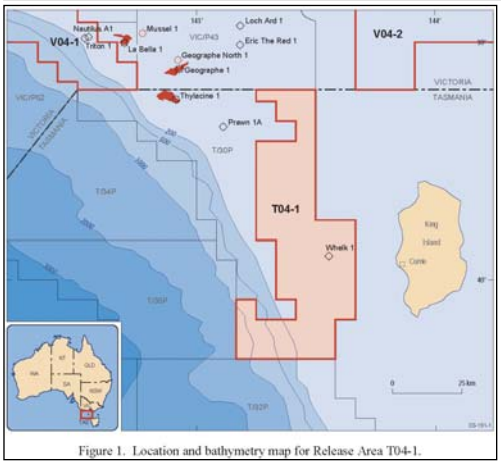

Figure 1. Location and bathymetry map for Release Area T04-1.

Fig. 3. Location of Bass Basin permit area T04-2 let for offshore petroleum exploration.

Fig. 4. Location of Otway Basin permit area T04-1, let for offshore petroleum exploration.

Designated Frontier Areas represent a push by the Government to encourage the investment climate for petroleum companies exploring in offshore waters.

The remaining two permits are located in offshore Tasmania in the Bass and Otway Basins (see Figures 3 and 4). Both areas have significant petroleum potential and are close to the major gas markets of south-eastern Australia and existing production and pipeline infrastructure.

The table below summarises the results of the bids and the exploration programs being proposed.

Permit Area	Operating Companies	Exploration Program
Carnarvon Basin, Permit WA/362P (re-release area W03-5) See Fig. 1.	Octanex NL, Strata Resources NL, and Gascorp Australia Ltd	Primary work program of 2D seismic reprocessing and 1100 km of new 2D seismic at an estimated cost of $2.2M. The secondary program consists of seismic interpretation and one well, estimated to cost $18.6M.
Carnarvon Basin, Permit WA/363P (re-release area W03-6) See Fig. 1.	Octanex NL, Strata Resources NL, and Gascorp Australia Ltd	Primary work program of 2D seismic reprocessing and 1100 km of new 2D seismic at an estimated cost of $2.2 million. The secondary program consists of seismic interpretation and one well, estimated to cost $18.6 million.
Carnarvon Basin, Permit WA-364-P, released as W04-2 See Fig. 2.	Chevron Texaco Australia Pty Ltd and Shell Development (Australia) Pty Ltd	Primary work program of 2D seismic reprocessing, 1010 km^2 of new 3D seismic and 1011 km of 2D at an estimated cost of $6.8M. A secondary program of studies and one well at an estimated cost of $15.3M.
Carnarvon Basin, Permit WA/365P, released as W04-3 See Fig. 2.	Chevron Texaco Australia Pty Ltd and Shell Development (Australia) Pty Ltd	A Primary work program of studies, and 2D seismic reprocessing, 2511 km^2 of new 3D seismic and two wells, estimated to cost $44.8M. A secondary work program of studies at an estimated cost of $450 000.
Carnarvon Basin, Permit WA/366P, released as W04-4 See Fig. 2.	Chevron Texaco Australia Pty Ltd and Shell Development (Australia) Pty Ltd	A primary work program of 2D seismic reprocessing and 1010 km 2D seismic at an estimated cost of $1.5 M. A secondary work program of studies and 2000 km of 2D seismic estimated to cost $2.5M.
Carnarvon Basin, Permit WA/367P, released as W04-5 See Fig. 2.	Chevron Texaco Australia Pty Ltd and Shell Development (Australia) Pty Ltd	A primary work program of studies, 2D seismic reprocessing, and 3011 km of new 2D seismic, at an estimated cost of $3.8M. The secondary work program consists of studies, and 1000 km^2 of new 3D seismic surveying estimated to cost $5.55M.
Bass Basin, Permit T/41P, released as T04-2 See Fig. 3.	3D Oil Pty Ltd	Primary work program of 200 km 2D seismic reprocessing, 2200 km of new 2D seismic and studies, at an estimated cost of $4.36M. The secondary work program of recording and processing 3D seismic data, studies and one well, estimated to cost $11.6M.
Otway Basin, Permit T/40P, released as T04-1 See Fig. 4.	Santos Offshore Pty Ltd	Primary work program of 800 km of new 2D seismic surveying, seismic reprocessing and studies, at an estimated cost of $4M. The secondary work program of acquiring new 3D seismic, studies and one well at an estimated total cost of $18.7M.