Preview

Australian Society of Exploration Geophysicists

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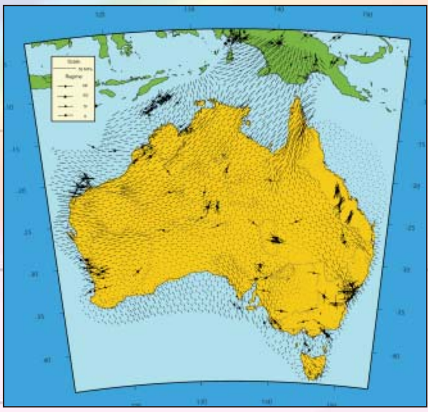

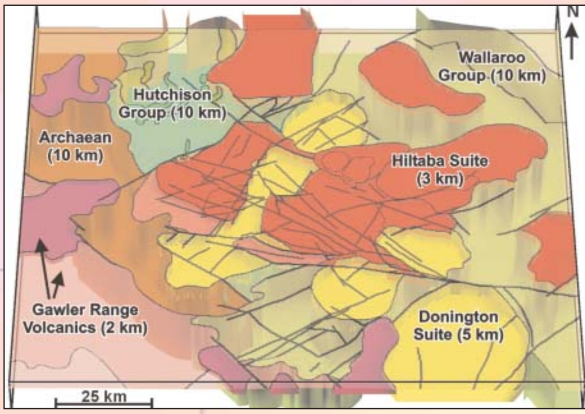

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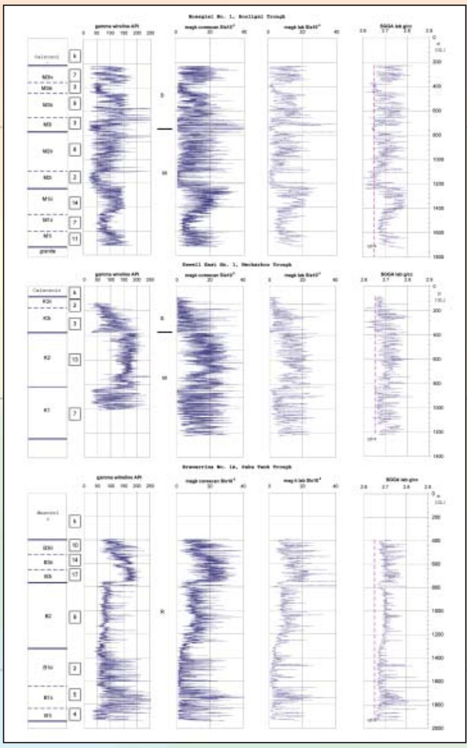

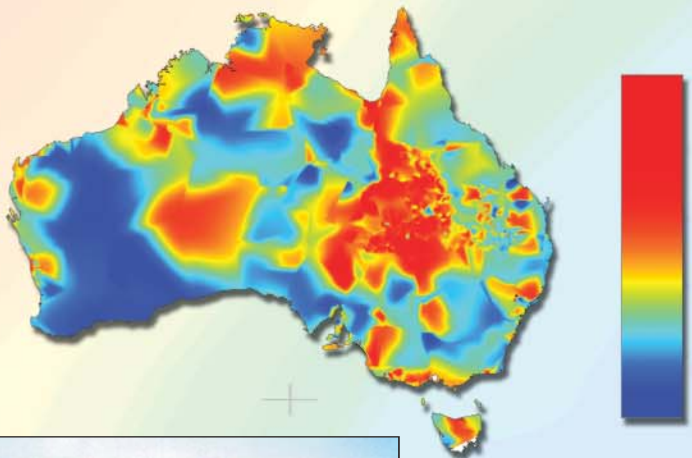

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106 days to go for Sydney

David Denham

By the time this issue of Preview hits your desks, the ASEG/PESA international conference and exhibition there will only be a little over 100 days to go before the Sydney meeting.

The theme of ***Integrated Exploration in a Changing World*** could hardly be more appropriate. Exploration is now a multi-disciplinary activity involving many different skills and technologies. Furthermore, the world just keeps on changing more rapidly from year to year. Issues such as climate change, petroleum reserves, energy supply, water resources, land degradation, sustainable cities and of course the not so changeable hunt for diamonds and gold will become more important and will continue to rely on quality input from geophysicists.

As Phillip Cooney points out in his letter published in this issue of Preview, conferences such as the forthcoming Sydney event are very important in maintaining our skills and networks to meet these challenges. So make sure you all register early and go to Sydney prepared to actively participate.

Difficulties with SEG registration

You certainly need to apply early, for visa applications, to attend the 74th annual meeting of the SEG, which takes place from 10-15 October this year at Denver, Colorado. The SEG has advised that obtaining visas to visit the US now takes several months. So it recommends obtaining the visa as soon as possible, even before one registers for the conference. I suppose this is the price to pay for safety.

Geophysical anniversaries

In this issue we are starting a new column, written by Doug Morrison, which brings to our attention some of the more significant geophysical events that have taken place in times past. His first article describes the geophysical observations made in a balloon 200 years ago and also the first fixed-wing airborne geophysical survey, which was made sometime later.

These contributions make interesting reading and I think we can look forward to several articles in the future.

In this issue

As well as Doug's contribution we have articles on heat flow, rock properties, 3D modelling and stress in the Australian Plate. So there should be something of interest to everyone.

I would also like to take the opportunity to congratulate Kathy Hill, on her appointment to head up the new ***Geoscience Victoria*** Branch in the Victorian Government. We now have three geophysicists in charge of state/territory geological surveys: Kathy Hill in Victoria, Richard Brescianini in the Northern Territory, and Ted Tyne in New South Wales. It shows the value of a geophysical training.

David Denham

Preview Information

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

Deadlines

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

Advertisers

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

Advertising copy deadline is the 22nd of the month prior to issue date. Therefore, the advertising copy deadline for the June 2004 issue will be 15 May 2004. A summary of the deadlines for future issues is shown below:

Preview Issue	Text & articles	Advertisements
110 June 2004	15 May 2004	22 May 2004
111 Aug 2004*	***3 July 2004***	***19 July 2004***
112 Oct 2004	15 Sep 2004	22 Sep 2004
113 Dec 2004	15 Nov 2004	22 Nov 2004

*Conference Issue, abstracts and biographies to be submitted by 28 May 2004

Geophysical Globalisation

Globalisation - the very word is evocative in the extreme. To some it conjures up visions of a utopian world where trade and ideas flow freely and barriers are demolished in the interest of the common good. To others it evokes images of a ruthless hegemonistic machine running roughshod over the last remnants of culture in the world, serving up perpetual diets of cheap labour, Big Brother and McDonald's. I have my own views on this, as do many people, but in this piece I want to discuss the somewhat less controversial topic of globalisation - or perhaps internationalisation has a nicer ring - of the geophysical profession.

Most branches of science, and geophysics in particular, transcend borders almost by default. From the Schlumberger brothers to Fugro, from GPS positioning to radar measurements on Mars, geophysicists have been quintessential ignorers of borders from very early on. Our own ASEG Past-President, Klaas Koster, a Dutch-born long time resident of Australia , recently moved to New Orleans in the USA. I personally know a Cameroonian geophysicist doing research in Australia, an Australian geophysicist exploring for minerals in Brazil, an American geophysicist plying her trade in Kuwait oilfields, and of course the list goes on.

Professional organisations catering to geophysicists have long recognised that the wave equation is just as valid in Waikiki as in Waga Waga, and the gravitational field is measured the same way in Gaborone as it is in Ganzhu. To this end, the ASEG has extended its reach by entering into reciprocal agreements with several international organisations. Agreements are currently in place with the Society of Exploration Geophysicists (SEG), the Society of Exploration Geophysicists of Japan (SEGJ), the Korean Society of Exploration Geophysics (KSEG), the European Association of Geophysicists and Engineers (EAGE), and talks are in progress with the South African Geophysical Association (SAGA).

These affiliations make for more than an impressive collection of acronyms. These agreements provide for exchanges of journals, availability of space at each other's technical conferences and exhibitions, and opportunities for scientific exchanges such as Distinguished Lecturer workshops, for joint publications, like the upcoming ASEG-SEGJ-KSEG environmental geophysics joint publication, and international collaboration on projects such as translation of the 'micro-tremor' book, originally in Japanese, translated and edited by ASEG and financed by SEG. Perhaps most importantly, these inter-society arrangements provide an easy point of contact for any member who feels that his or her professional development would benefit from interaction with their counterparts from around the globe.

More and more geophysicists continue to regularly trot the globe, surf the web, utilise research from international academic institutions, hire the best available employees and contractors from wherever they hail, and interact regularly with international colleagues. I relish the challenge of working with the membership to continue nurturing relationships with other geophysical societies while maintaining the ASEG's unique focus on Australian geophysics and geophysicists.

Howard Golden

The politics of globalisation will continue to provoke controversy in lounge rooms, pubs, and in streets during WTO meetings. At the same time, the globalisation of the geophysical fraternity should provoke controversial discourse on innovative ideas, spirited discussions on the industry and the way forward, and a cross-cultural understanding between colleagues from quite different origins with a common passion for geoscience.

In my next piece, after consultation with the State Branches and the Federal Executive, I will outline my vision for the coming year, a year that should be an exciting one featuring the international relationships as outlined above, the ASEG/PESA Conference and Exhibition in Sydney, Distinguished Instructor Courses, and other initiatives to serve the membership and the geophysics profession in Australia.

Howard Golden

Council Meeting and AGM

I would like to take the opportunity in this issue's Executive Brief to cover the proceedings of the ASEG Extraordinary Council Meeting and Annual General Meeting, both held in Perth, on 2nd March. The meetings were attended by representatives of the Federal Executive, some State Branch Presidents, the Secretariat, and other interested parties.

Business transacted in the Annual General Meeting included the following:-

- Acceptance of the minutes from the 2003 AGM;
- Adoption of the financial statements and Auditor's Report, for the year ended 31st December, 2003;
- The appointment of HLP Mann Judd as auditors for 2004;
- The adoption of the new constitution, and
- The election of Federal Executive office bearers - President: Howard Golden, President Elect: Terry Crabb, Vice President: Jenny Bauer, Secretary: Lisa Vella, Treasurer: John Watt.

The Extraordinary Council Meeting was an opportunity to review the activities of 2003 and make plans for 2004. Successes for 2003 included the establishment of DISCs (Distinguished Instructor Courses) in three states (WA, ACT and QLD), signing of agreements of understanding with a number of international geophysical societies (EAGE, KSEG, SEGJ, SAGA), completion of the new constitution and a review of Secretariat and publishing costs. At the same time, it was recognised that more work needed to be done in the areas of signing up corporate members, completion of the procedures manual, and increased interaction between the Federal Executive and the State Branches, among other things. Future plans include digital and web publishing of Exploration Geophysics, continued expansion of relationships with international geophysical societies and further work in the area of scholarships, student support, support of geophysics in developing nations and the provision of greater benefits to society members.

More on the review of Secretariat costs. As members are aware, AMCO has been performing accounting and Secretariat duties for the society, for a number of years now. Their existing contract is due to expire on 30th April, 2004, and it was considered that now would be a good time to assess Secretariat costs. AMCO and another organisation, CASM (Centre for Association Management), were invited to quote on new, longer-term contracts, for the provision of accounting and Secretariat services. Appraisal of these organisations and their quotes resulted in the decision being made to transfer the Secretariat from AMCO to CASM, effective 1st May, 2004.

It should be stressed that the decision not to renew our contract with AMCO was purely a financial one and we have been very pleased with AMCO's efficient handling of ASEG affairs. I would like to take this opportunity to thank Kirby Leeke, Glenn Loughrey and Kate Bell for the valuable contribution they have made to the running of this society and wish them all the best in their future endeavours.

I would also like to introduce the new Secretariat, CASM, represented by Louise Middleton, Ron Adams and Jerry Lee Jones. For members unfamiliar with CASM, they also provide Secretariat services to the AIG (Australian Institute of Geoscientists), among other associations. While a few teething problems may be expected during the transition, we are looking forward to a long and successful partnership with CASM.

Lisa Vella
Federal Secretary

First joint issue of journals of the three societies
Exploration Geophysics - Butsuri-Tansa - Mulli-Tamsa

Koya Suto, Terra Australis Geophysica Pty Ltd
Toshiyuki Yokota, Geological Survey of Japan/AIST
Yoonho Song, Korea Institute of Geoscience & Mineral Resource

In March 2004, over 3000 geophysicists around the western Pacific Rim and other parts of the world received their familiar journal with an unfamiliar cover. The cover displayed three titles Exploration Geophysics (Vol 35, No.1) of the Australian SEG, Butsuri-Tansa (Vol. 57, No.1) of the SEG of Japan and Mulli-Tamsa (Vol.7, No.1) of the Korean SEG. This issue contains sixteen articles from the three societies on one topic - High Resolution Engineering and Environmental Geophysics in the Western Pacific. This article tells how it happened.

Discussions started in October 2001, at the SEGJ's conference in Fukuoka. During this meeting, Dr Okubo, Chairman of the SEGJ's International Affairs Committee, approached Suto to see if it would be possible to establish a joint journal between SEGJ and ASEG.

Although SEGJ's journal Butsuri-Tansa allows papers in English, the papers are published predominantly in Japanese and its circulation is mostly confined to SEGJ members in Japan. Japanese authors want to reach more readers by publishing their papers in English. While English is universally used in technical fields, it is a foreign language to the Japanese authors. If native speakers in the ASEG could help refine the English to publication quality, it would provide significant assistance.

The ASEG was considering expanding its activities in South East Asia, and Suto considered that a joint journal covering the Western Pacific would be an ideal opportunity to promote geophysics to the region. While SEGJ would get a new English journal in addition to their current Butsuri-Tansa in Japanese; what would be the benefit for ASEG, as it already has an English journal Exploration Geophysics? It was considered that such a publication would make a positive contribution towards collaboration for western Pacific Rim, as we have several common interests.

In June 2002, the SEGJ executives (Prof Ashida, President; Mr Ohya, former President and Dr Okubo) met Andrew Mutton, Chairman of the ASEG Publication Committee, at the EAGE Conference in Florence. They considered an alternative plan of making a special "one-off" publication on a specific topic.

The SEGJ delegates met ASEG executives at the ASEG Conference in Adelaide in February 2003 and joint publication was discussed again. The centre of discussion was "If we make a separate special publication, who will buy it?" Publication for the sake of publishing does not make good sense to the authors or the societies. Papers should be published to be read as widely as possible.

The idea of a joint-issue of the regular journals emerged as the preferred option. The regular journals reach all the members, and joint-issues will reach double the number of readers. Papers by Australian authors reach Japanese readers and those by Japanese authors reach Australian members.

Initially, the joint journal was planned for the last issue of 2003. However, when the design of the cover and layout of the pages were discussed, we noticed a little problem: page numbers. SEGJ publishes six issues of Butsuri-Tansa and ASEG four Exploration Geophysics per year. Each journal has page numbers through the volume. The page numbers in the last issue must follow the previous issue. We therefore decided to make the joint-issue the first one of 2004. In this way, the first page of the joint issue is page 1 of the new volume.

In May 2003, at a meeting in Tokyo, the Korean SEG (KSEG) was invited and agreed to participate in this joint issue. Prof. Kim, Vice-President, represented KSEG at the meeting and the papers from each society were finalised. These were to be peer-reviewed within each society with the ASEG editors. It was also agreed that each society nominates an editor for this special issue to work with the Managing Editor Lindsay Thomas. They were Prof. Cull (ASEG), Prof. Ushijima (SEGJ) and Prof. Kim (KSEG).

The number of people involved became quite large. In addition to the editors and authors, each society has a publication committee, international affairs committee and many executives of different capacity expressed interest. If everyone sent an Email to everyone, the communication would be tangled and confusion would be endless. We decided to make one contact person in Japan, Korea and Australia. All the correspondence apart from the editorial and technical matters was to be handled by them. The writers of this article took this role and the system worked well thanks to Email and the small time difference between the three countries. It was not uncommon for us to send Emails around midnight and to receive replies within a few minutes.

The papers were selected from the SEGJ 6th International Symposium (January, 2003) and ASEG 16th Conference and Exhibition (February, 2003). The authors wrote full-scale papers and these were reviewed by referees of each society. All the papers were sent to Lindsay Thomas. He reviewed all the manuscripts and suggested ways to refine English expression. His effort must be noted with "thanks" in big letters. Thanks are extended to all those involved from initiation, planning, organisation and execution of the publication process.

The output is a combined issue of three journals with sixteen papers on the common topic of engineering and environmental application of various geophysical techniques. We hope the joint issue is appreciated by the members of the three societies and draws attention of the geophysical community beyond western Pacific Rim.

2004

17–21 May
Joint Meeting: AGU and the Canadian Geophysical Union (CGU)
Sponsors: AGU, CGU
Venue: Montreal, Canada
Website: www.agu.org/meetings

7–11 June
66th EAGE Conference and Exhibition
Venue: Paris, France
Website: www.eage.nl

15–19 August
ASEG, in collaboration with PESA
17th International Conference and Exhibition,
Theme: Integrated Exploration in a Changing World
Venue: Sydney Convention Centre, Sydney NSW
Website: www.aseg-pesa2004.org.au

19–22 September
PESA Eastern Australasian Basins Symposium
Venue: Adelaide Convention Centre, Adelaide
Website: www.eabs.info
and
Pacrim 2004
Theme: Hi Tech and World Competitive - Mineral Success Stories Around the Pacific Rim
Adelaide, SA
Website: www.ausimm.com
Note, both the above events will take place at the same time at the same venue.

27 September – 1 October
SEG 2004
Theme: Predictive Mineral Discovery Under Cover
Sponsor: Society of Economic Geologists, Society of Geology Applied to Mineral Deposits and Geoconferences (WA) Inc.
Venue: Perth, WA
Website: www.cgm.uwa.edu.au/geoconferences/seg2004/index.asp

10–15 October
SEG International Exposition & 74th Annual Meeting
Venue: Denver, Colorado, U.S.A.
Website: www.seg.org

13–17 December
2004 AGU Fall Meeting
Venue: San Francisco, California, U.S.A.
Website: www.agu.org/meetings

2005

10–13 April
2005 APPEA Conference & Exhibition
Perth (at the new Convention Centre facility)
Contact: Julie Hood
Email: jhood@appea.com.au

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

2006

2-7 July
ASEG, in collaboration with GSA; ASEG's 18th International Conference and Exhibition, and GSA's 18th Australian Geological Convention
Venue: Melbourne, Vic.

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

Howard Golden

Terry Crabb

Howard Golden: Federal President

Howard Golden was born and raised on the Mississippi River in the central United States of America. He earned a BA from the University of Utah and an MSc at the University of Leeds. After an early foray in the gas fields of Germany with Schlumberger, he has spent the past 23 years in mineral exploration. With BHP Minerals from 1981 through to 1999, he worked as exploration geophysicist based in the US and the UK, and as country manager in Côte d'Ivoire, West Africa.

Howard currently lives and works in Perth where he moved to in 1999 to take a position with WMC Resources, working as Project Leader and Chief Geophysicist. His career in geophysics has involved primarily electrical and potential geophysics applied to mineral exploration on six continents. He is a member of the ASEG, SEG, EAGE, AGU, and a fellow of the Geological Society of London. Howard has served on the ASEG Research Foundation, Technical Committee and the Bowler Ministerial Inquiry Committee, and is currently ASEG President.

Terry Crabb: ASEG President Elect and Publications Chairman

Terry graduated from Adelaide University in 1972 with a BSc in Geology and Geophysics and ended a SANFL career with the Tigers by moving to Arizona to work with Phelps Dodge at the invitation of George Rogers, exploring the southwest USA looking for copper.

This was the beginning of a journey as he travelled the world (playing rugby, tennis, squash and H3) whilst employed by Geoterrex (Sydney and Ottawa) and Uriran (Tehran), before returning to Perth to join Geosearch and then ECS in geophysics management roles, as well as playing more footy and to run his first marathon.

Adelaide beckoned, and Terry joined the SADME (now PIRSA) in 1983, as a Principal Geophysicist, and during the following 13 years held positions as Chief Geophysicist, Inspector Petroleum, Manager Information Services, Controller Computing Services and commenced studying for an MBA, and played more footy, tennis, squash and ran his last marathon.

From 1984 through 1987, Terry was active on the Federal Executive of the ASEG as Treasurer and Secretary and worked closely with Exploration Geophysics legendary editor Don Emerson, under the Presidencies of industry greats Reg Nelson and Bob Smith.

A year back in Canada with Scintrex as Chief Geophysicist (a tentative attempt to tryout with the local Aussie Rules team, plus some competitive tennis) before returning to Perth as CEO of Australian Geophysical Surveys in 1997, a year made more memorable by the Crows first AFL Premiership, and his first effort at swimming triathlon legs.

With the demise of AGS, during the resources slowdown, and the absorption of most of the Airborne Geophysical Contractors by Fugro, limited opportunities in the geosciences in 2000 saw Terry join SMS Management and Technology in Canberra (Aussie Masters swimming, a bit of touch football, volleyball and tri swims). As a business management consultant, he put his MBA to good use with contracts at the Australian Transport Safety Bureau and the Health Insurance Commission.

Terry is now back in Perth working as Inco Resources' Australian representative, and is suffering from previous sporting excesses, preparing for a hip replacement whilst hobbling around the golf course and tennis court, and doing the annual Rotto mile swim.

He is a member of the ASEG, SEG, PESA, AIM and PMI and is a fellow of the Aus IMM, and was the 2003 Joint Master of the Perth Hash House Harriers.

In 2003, he took over the role of Chairman of the ASEG Publications Committee from stalwart Andrew Mutton, and was suddenly made aware of how much the ASEG owes Andrew for his efforts over the past five years in this role.

Terry is looking forward to working with Howard Golden and his team in continuing the excellent efforts of the past executives and committees in moving the Society forward, especially in the area of electronic publication of Exploration Geophysics.

New Members

The ASEG welcomes the following new members to the Society. Their membership was approved at the Federal Executive meetings on 28 January and 25 February 2004.

Name	Organisation	State
Bahman Boyat	Curtin University of Technology	WA
Drew Breen	University of Queensland	Qld
Antonio D'Orazio	Geoimage Pty Ltd	WA
Leon Dahlhaus	Schlumberger	WA
Silvana Evangelina Geuna	Universidad de Buenos Aires	Argentina
Karen May Gilgallon	Southern Geoscience Consultants	WA
Christopher William Luxton	Sandstone Consulting	SA
Karryn Lynne Mitchell	Encom	NSW
Roberto Moraes	University of Brasilia	Brazil
Emma Jane Nelson	Australian School of Petroleum	SA
Adalene Moreira Silve	State University of Campinas	Brazil
Nigel Stafford Smith	Apache Energy	WA
Karoline Mae Stark	Hamersley Iron	WA

Name	Organisation	State
Robert Stuart	Geoinformatics Exploration	WA
Venkateswara Rao Tammireddy	University of Tasmania	Tas
Ainslie Williams Sydney	University of Technology, NSW	
Ziqiu Xue	Research. Institute of Innovative Technology for the Earth, Kyoto	Japan

Call for nominations: ASEG Honours and Awards

During the 17th ASEG Conference to be held in Sydney in August 2004, several categories of Honours and Awards will be presented to members who merit recognition for distinguished service to the Society and to Exploration Geophysics. ASEG Members are invited to submit nominations for the following awards:

1. ASEG Gold Medal

"For exceptional and highly significant distinguished contributions to the science and practice of geophysics by a member, resulting in wide recognition within the geoscientific community." The nominee must be a member of the ASEG.

2. Honorary Membership

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

3. Grahame Sands Award

"For innovation in applied geophysics through a significant practical development of benefit to Australian exploration geophysics in the field of instrumentation, data acquisition, interpretation or theory." The nominee does not need to be a member of the ASEG.

4. Lindsay Ingall Memorial Award

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

5. ASEG Service Medal

"For outstanding and distinguished service by a member in making major contributions to the shaping and the sustaining of the Society and the conduct of its affairs over many years." The nominee will have been a member of the ASEG for a significant and sustained period of time and will have at some stage been one of the following:

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

6. ASEG Service Certificates

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

Nomination Procedure

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

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

Chairman, ASEG Honours and Awards Committee,
8 Kearns Crescent
Ardross WA 6153

Email: bill@sgc.com.au
Tel: 08 93162814
Fax: 08 93161624

Applications will close on June 15th 2004

Australian Capital Territory - by Jacques Sayers

The ACT Branch held their annual general meeting on the 10th March at Geoscience Australia's premises. David Robinson, the Branch President, opened the meeting and gave his annual President's report. Of particular note and interest to members was the summary of guest speaker talks given at our branch by local and interstate geophysicists. The talks themselves ranged widely, so as to cater for the interests of geophysical specialists located in Canberra. Canberra's ASEG Branch also hosted the Distinguished Instructor Short Course, and the local branch was delighted to have Olivier Dubrule talk to us on 'Geostatistics for Seismic Data Integration in Earth Models'. Over 20 people attended. The ASEG President also reported on the number of people from the ACT that attended and presented at the ASEG Conference in Adelaide last year.

Following the President's report Trevor Dhu happily reported that all was well on the Treasury side of things.
The members' forum subsequently elected the 2004 Committee. David Robinson announced that he would not be continuing in the President's position; all were grateful for his last two years service. The new committee consists of Ben Bell as President, Alice Murray as Vice President, Jacques Sayers as Secretary and Trevor Dhu, who continues to give us his expertise and industry as Treasurer.
Contacts for the above are as follows:

- President: Ben Bell, Tel: 02-6249 9828, ben.bell@ga.gov.au;
- Secretary: Jacques Sayers, Tel: 02-6249 9609, jacques.sayers@ga.gov.au;
- Treasurer: Trevor Dhu, Tel: 02-6249 9076, trevor.dhu@ga.gov.au;

The address for the above people is 'Geoscience Australia, GPO Box 378, Canberra ACT 2601'; and

- Vice President: Ms Alice Murray, Tel: 02-6254 1372, alice@geocreation.com, GPO Box 1241, Canberra ACT.

ASEG's ACT Branch welcomes all visitors to our branch meetings and/or special function meetings, so if you are in town feel free to give any of us a bell. This year should shape up to be a good one with a number of geophysicists, both young and old, joining Geoscience Australia and enrolling at the ANU's School of Geology and at the Research School of Earth Science. Hope we see you all at the meetings and special functions.

New South Wales - by Naomi Osman

To synchronise with the Federal AGM, the NSW Branch held its AGM on 18th February. The office bearers for 2004 are Michael Moore (President), Roger Henderson (Treasurer), Naomi Osman (Secretary) and Peter Gidley as Web Master. Carina Simmat from Sydney University is continuing in her role as head of student liaison.

Following the AGM Roger Henderson gave a fascinating and informal talk entitled 'From cosmic geophysics to geophysical dust'. Roger discussed a variety of interesting topics ranging from how geophysics is revealing impact craters to animals using magnetics in navigation and finishing with a description of the smallest geophysical sensors now in use, called 'smart dust', and ending with a quote from T.S. Eliot, *"We shall not cease from exploration..."*

The next few months will prove to be quite a busy time for many of our members who are helping with the ASEG-PESA Conference here in Sydney in August. The branch is also aiming to create a stronger link between industry and university students. In particular, we want to encourage greater student participation at the monthly meetings and to help students who wish to gain work/field experience. Speakers planned for future meetings include Vladimir David from the DMR, Chris Carty of Eastern Star Gas, Phil Schmidt of CSIRO and Tara Deen from Macquarie University.

We would also like to issue a standing invitation to interstate or overseas visitors to attend NSW meetings if they happen to find themselves in Sydney. The meetings are usually held on the third Wednesday of the month from 5:30 pm at the Rugby Club, Rugby Place (near Pitt & Alfred St).

Australian Departments of Land Planning and Environment

By Margarita Norvill

Email: margarita@geophy.curtin.edu.au

Departments of Land Planning and Environment provide valuable web references for practicing geophysicists, needing land information such as digital spatial data, maps, aerial photographs, drafting and survey control marks. These data sets contribute significantly to the management of land, water and forestry resources. Apart form being a useful tool, the sites are full of interesting facts and tourist information as well as environmental tips.

Department of Lands, New South Wales ★★★★½
http://www.lpi.nsw.gov.au

The Department of Lands is the key provider of land and property information for NSW. It provides mapping, land titling, valuation, survey and related land information services. The Land and Property Information Division uses source information from organisations and individuals to compile maps, databases and registers of land and property information including information on locations, parcel descriptions, values, ownership, restrictions and financial interests.

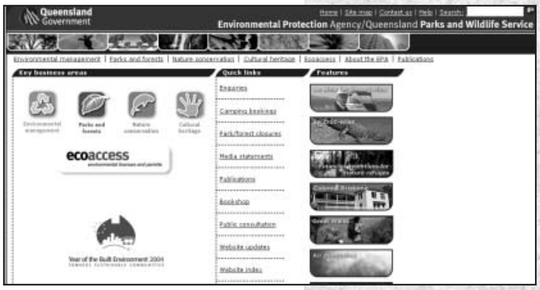
The LPI section of the site collects and maintains a wealth of land data as a comprehensive and authoritative range of digital and hardcopy mapping products and services. As the main source of land information for NSW, LPI maintains a digital cadastral database of the State, which shows legal and other approved boundaries applying to land, as well as a digital topographic database, which shows the physical and surface features of the landscape. The data are stored in the topographic database and used to create maps. This information can be viewed on line at the TopoWeb section of this site.

Northern Territory Department of Infrastructure, Planning and Environment ★★★★½
http://www.ipe.nt.gov.au

The Department of Infrastructure, Planning and Environment administers transport and roads, planning, building and land management, maps and surveys, government road building infrastructure, environment and heritage, parks reserves, biodiversity and bush fires, land and water resources management for the Northern Territory.

The land and water resources sector examines ground and surface water theory, shows the locations of the main aquifers and their likely yield. The Surface water in the Territory is monitored by a network of telemeter gauging stations primarily for the purpose of providing flood forecasting advice. These gauging stations are connected to the telephone network and provide "near-real-time" river heights and rainfall. Review the dry land salinity hazard map of territory. This project has attempted to identify areas which might be prone to dryland salinity if broadscale clearing were to take place. This was accomplished by mapping various physical factors known to contribute to the development of dryland salinity. The ones chosen include; groundwater salinity, vegetation type, rainfall, aquifer yield, the presence of thick, clayey soil profiles.

Environmental Protection Agency, Queensland ★★★★
http://www.epa.qld.gov.au



The Environmental Protection Agency is responsible for environmental management, parks and forests, nature conservation and the cultural heritage of Queensland. Learn about the Australian crocodile. Australia is the only country inhabited by the freshwater crocodile, and the estuarine crocodile is a threatened species. Unprovoked attacks by a freshwater crocodile have never been reported. The estuarine crocodiles are very dangerous. Be very careful throughout central and north Queensland at rivers, swamps, billabongs and when swimming in the sea. They are large, efficient predators which can kill or seriously injure people. Their bite can easily crush the bones of a pig or buffalo.

Department for Environment and Heritage, South Australia ★★★½ - http://www.denr.sa.gov.au

The Department of Environment and Heritage provides access to land and maps, aerial photography, image data, land and property information, spatial datasets and products, maps, crown land, geocentric datum shift and provides free image downloads.

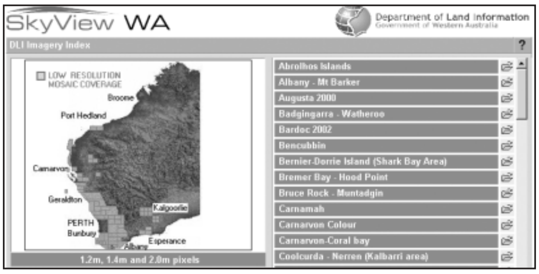
The Department of Environment and Heritage consists of the departments for biodiversity, botanic gardens, coast and marine, environment protection, environment reporting, heritage, land and maps, parks and wildlife and sustainability.

Primary Industries, Water and Environment, Tasmania ★★★★½ -http://www.dpiwe.tas.gov.au

The Department of Primary Industries, Water and Environment is the third largest Tasmanian State Government Agency, managing the State's natural resources; air, land, water, plants and animals. Information available on the web includes; quarantine pests and disease, food and agriculture, water land information and planning, sea fishing and aquaculture, parks and wildlife, environment and cultural heritage.

Check out the ship wrecks off the Tasmanian coast. Lying in the path of the winds known as the 'Roaring Forties', the waters around Tasmania have proved treacherous to mariners. Since the wreck of the ship Sydney Cove in 1797, around 1000 vessels of all sizes are known to have been lost in Tasmanian waters up to the present day. Currently the locations of 10% of the ships are known. Read and view images of some of the more renowned ship wrecks of Tasmania.

Department of Land Information, Western Australia ★★★★★ - http://www.dola.wa.gov.au



The Department of Land Information provides land and property information, land titles and land valuation the principal business is land and property information. Geospatial data are gathered from ground surveys, aerial photographs and satellite imagery. This information is used to produce a wide range of digital and hard copy data.

View aerial photography online through SkyView WA, the majority of the populated state area is covered by high and low resolution images, very voyeuristic.

Department of Sustainability and Environment Victoria ★★★★ - ttp://www.dse.vic.gov.au

The Department of Sustainability and Environment is responsible for the management and education (as well as providing online resources) of the coast and marine resources, conservation and environment, fire, forestry, heritage, land and water, parks and reserves, planning, plants ands animals, property, titles and maps, recreation and tourism and research. It is linked to http://www.land.vic.gov.au, which provides information to land and property in Victoria as well as maps, images, geodesy, and surveying information.

Australian Environment and Heritage Portfolio ★★★★ http://www.deh.gov.au

The Australian Environment and Heritage portfolio consists of the Department of the Environment and Heritage, including the Australian Antarctic Division and the Supervising Scientist Division, five statutory authorities: the Australian Heritage Council, the Director of National Parks, the Great Barrier Reef Marine Park Authority, the Office of Renewable Energy Regulator and the Sydney Harbour Federation Trust. It also includes three Executive Agencies: the Australian Greenhouse Office, the Commonwealth Bureau of Meteorology and the National Oceans Office.

There are many databases available on the site covering themes from natural resources, atmosphere, biodiversity, coast and oceans, human settlements, inland waters, land, natural and cultural heritage. There is a comprehensive environmental reporting tool with interactive GIS database of Australia and a great image catalog to peruse.

Australian Capital Territory Planning and Land Authority ★★★★ - http://www.actpla.act.gov.au

ACTPLA is responsible for the Territory Plan, the Land Release Program, development applications, leases and licences, regulating development and the building industry, land use, community consultation and public education.

Available on the web is the Canberra Spatial Plan, which is the key strategic planning document for directing and managing urban growth and change. It sets actions for 30 years and beyond to achieve this. The Canberra Spatial Plan outlines a strategic direction to achieve the social, environmental and economic sustainability of Canberra as part of The Canberra Plan.

Star Rating

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

Three reports on knowledge and innovation released by government - but don't hold your breath!

On 22nd March, Brendan Nelson, the Minister for Science, Education and Training, released three Australian Government reports relating to publicly funded research and research training.

The reports relate to an evaluation of the *1999 Knowledge and Innovation* reforms to higher education research and research training, the work of a national taskforce on the provision of funds for research infrastructure, and a review of the scope for closer collaboration between major publicly funded research agencies.

These were commissioned back in mid-2003 and meant to be a key ingredient into *Backing Australia's Ability (II*), which has to be part of the 2004/05 Budget because the time frame covered by *BAA(I)* has only two more years to run. It is therefore essential that commitments are in place to continue the R&D investment strategies. Otherwise we could be facing a nasty hiatus.

Backing Australia's Ability was a research and innovation package worth $3 billion over five years and science and innovation funding now amounts to more than 3% of total government outlays, even though it is still below 3% of GDP.

According to Minister Nelson, the three reports he launched will provide an important contribution to the Government's planning for future policy development. They are:

The Evaluation of the Knowledge and Innovation Reforms, chaired by Professor Chris Fell, which provides an assessment of the arrangements by which the government distributes block research funding to Australia's universities. The evaluation focused on the operation of the university research funding mechanisms: the Research Training Scheme (RTS), the Institutional Grants Scheme (IGS), and the Research Infrastructure Block Grants Scheme (RIBG).

In examining these schemes, the evaluation assessed the validity of current research performance indicators, and the extent to which they are driving enhanced connections between the university system and the private sector, strengthening the strategic management of research, and improving the quality of research training. It contains 17 recommendations.

The National Research Infrastructure Taskforce, chaired by Dr Mike Sargent, considered what might constitute the important elements of an Australian research infrastructure strategy. World-competitive research increasingly depends on access to sophisticated and expensive equipment. In many cases, the cost of what is needed far exceeds the resources of individual institutions. The taskforce recommends a framework for university and publicly funded research agencies' investments in large-scale research infrastructure that seeks to enhance institutional collaboration and to maximise value from government investments in infrastructure.

It contains 42 recommendations, of which the main one is to Establish a National Research Infrastructure Council to further develop, implement, review and monitor the National Research Infrastructure Strategic Framework and, in particular to develop and implement a national process to identify and prioritise research infrastructure needs and to advise government on priorities fro current research infrastructure funds and any new research infrastructure funding programmes that may be introduced.

In other words more and more bureaucracy.

The Research Collaboration Review, chaired by Mr Donald McGauchie, examined the scope for closer collaboration between universities and publicly funded research agencies.

The review encompassed Australian public universities and four major Publicly Funded Research Agencies - the CSIRO, the Australian Nuclear Science and Technology Organisation, the Australian Institute of Marine Science, and the Defence Science and Technology Organisation.

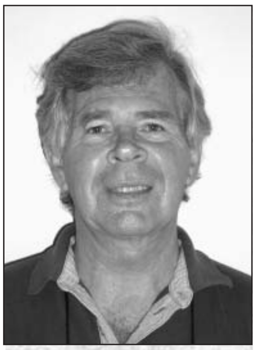
The review assesses the potential for greater synergies between research providers, possible models for closer collaboration, scope to promote a greater focus on commercialisation of research through collaboration, and possible alternative funding models to achieve more effective use of resources and to promote excellence across the national research effort. It only contains four recommendations, one of which is to Establish a Strategic Research Council to enhance collaboration and coordination across the research system.

So here we go again, even more and more and more bureaucracy.

It appears that we could well have a situation where the administration of R&D investments by the Commonwealth could become increasingly complex, without any real commitment to increasing the outputs we need to increase our wealth and maintain sustainability.

The reports are available online at: http://www.dest.gov.au/highered/research/index.htm.
Science Industry Action Agenda launched in February

Yes we have another Action Agenda. This time it is for the science industries. Chris Fell, the Past President of FASTS and leader of the recently completed Evaluation of Knowledge and Innovation Reforms Consultation Report, now has the task of leading the Strategic Industries Leaders Group which is heading up this Actions Agenda.



By Doug Morrison

Joseph Louis Gay-Lussac

Jean Baptiste Biot

A couple of very significant anniversaries in the history of exploration geophysics, remote sensing and aviation occur in 2004 and it would be remiss not to acknowledge them.

200 Years ago

Cartoon of Gay-Lussac (L) and Biot in full flight.

On the 24th August 1804 the famous French chemist/physicist Joseph Louis Gay-Lussac accompanied by his equally famous friend, the mathematician/ physicist Jean Baptiste Biot, ascended by balloon from the grounds of the Conservatoire des Arts et Métiers on what was the first balloon ascent undertaken solely for scientific reasons (see Figures 1-3).

The prime purpose for the flight was their desire to determine whether the Earth's magnetic intensity decreased with altitude - a subject that was a matter of some debate at the time. Gay-Lussac and Biot reached the not inconsiderable altitude of 3900 m and, amongst other activities, observed the period of oscillations of their dip-circle needle. They concluded, when the needle was activated, there were no discernable changes in the oscillation rate of the needle or any decrease in magnetic intensity as a consequence.

They also carried a barometer, thermometer, hygrometer, instrumentation to measure atmospheric electricity and equipment to collect air samples. It was truly a significant event in the history of geophysics. (Ref: Dictionary of Scientific Biography, II, pp.134-135 & V, p.318 and personal research by DM).

60 Years Ago.

In late April of 1944 a Beechcraft D17S biplane towing a modified AN/ASQ-3A fluxgate magnetometer, successfully, flew a formal airborne magnetometer survey area, for geological purposes, near Boyertown, Pennsylvania USA (see Figure 4). The aircrew were - pilot/navigator Ed Canfield, electronics guru Homer Jensen (both civilians from Aero Service Corporation) and J. R. Balsley of the USGS. The sensitivity of the magnetometer was about 1nT.

At the request of the USGS, the magnetometer had been specifically modified to measure the Earth's magnetic field from the then secret anti-submarine warfare MAD (Magnetic Airborne Detection) AN/ASQ-3.

Interestingly the first successfully built MAD system (October1941), designated AN/ASQ-1 had an exploration geophysics origin, having been based off a Gulf Research and Development Company design by physicist Dr J.D.C Hare and electrical engineer Victor Vacquier.

It should also be mentioned here that the Russians, for exploration purposes, had experimented from as early as 1936 with induction coil magnetometers in aircraft but they can only be considered experimental as their sensitivity in an unstable platform was in the hundreds of nanoTeslas.

The Boyertown survey was the first.

(Ref: Jensen, Homer "Scientific American" Vol.204, pp151-162, 1961 and personal research by DM).

The first aeromagnetic survey aircraft, Beechcraft D17S Staggerwing" NC18575 is still flying in 12004. Photo courtesy of the owner, Mike Greenblatt, Columbus, Georgia, USA

He is joined by 17 other members (mostly from industry) to identify and develop strategies to overcome any impediments to growth in the industry.

And, if you don't know what the science industry is then it is defined as:

Research and development, production and distribution of scientific goods, services and intellectual capital used for measurement, analysis and diagnosis in the industries such as agri-food, resource extraction and processing, energy, marine resources, environmental monitoring, manufacturing, medicine, health care, biotechnology, information technology, defence, space, aerospace, and education.

In other words it covers almost all the S&T industries in Australia. How this is going to focus on a few key issues that really matter has yet to be seen.

The government has yet to respond to the House of Representatives' report, which was released in June 2003, and contains 48 recommendations on what should be done to increase business investment in R&D. Furthermore,

The Australian Earth and Ocean Network (AEON)

By Dietmar Mueller
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University of Sydney
Email:
dietmar@geosci.usyd.edu.au
www.aeon.org.au

AEON vision

Global climate change and shrinking resources have heightened our sense of dependence on the Earth as a dynamic and complex system. The AEON network aims to provide a unifying context for enhancing our understanding and appreciation of the workings of the Earth system and, in particular, the dynamic relationship between the continents and the oceans. AEON will take full advantage of the enormous potential of the world-wide-web, the unprecedented amount of digital geodata and the rapidly growing availability of open-source software. This network will develop and provide access to a distributed digital geolibrary and modelling software which allows users to turn observational and computational Earth and ocean data into knowledge. AEON will facilitate collaborative multi-disciplinary research, policy making for wise stewardship of our planet, and education and outreach at all levels of the community.

Inception of AEON

AEON has formed as a merger of five Australian ARC network initiatives:

1) EON-ITnet (School of Geosciences and Institute of Marine Science, The University of Sydney, convener: Dietmar Müller)
2) The Earth System Dynamics Network (Research School of Earth Sciences, Australian National University, convener: Gordon Lister)
3) The Intelligent Modelling Network (Monash University, convener: Louis Moresi)
4) The Multimedia IT Network (School of Information Technology, The University of Sydney, convener: Jesse Jin)
5) The Dependable Distributed Enterprises and Services Network (School of Information Technology, The University of Sydney, convener: Albert Zomaya)

AEON is linked to three overseas/global networks:
GEON (http://www.geongrid.org/),
the GeoFramework (http://www.geoframework.org/)
and IODP (http://iodp.tamu.edu/).

AEON Scope

Enormous opportunities for Australia lie with the resources contained in its continental crust, vast unexplored ocean territories, and continental shelves, extending from the tropics to Antarctica. Onshore sub-surface and marine data are difficult and expensive to obtain. The methods for analysing and displaying sparse numerical, textual, map- and time-oriented data are necessarily diverse and complex, and in most situations no single data set provides all the information necessary to solve a particular problem. Exploration and mining, as well as the safeguarding of marine Australia, will depend on effective multidimensional data integration and computational analysis. Readily available consumer computer hardware and software now allows the modelling of complex processes, ground-truthed by their observations. This field is in its infancy, so there is scope for advancement in all areas from novel techniques for data collection and imaging, that maximizes the potential value of data at later stages, to new IT protocols for storing, accessing and simulating data. The necessary tools are often available, but we lack cross-fertilisation between isolated disciplines to leverage their common technology base. For example, the Earth exploration and geodynamics communities have developed novel tools for integration of multidimensional data with process simulation tools (www.agcrc.csiro.au/4dgm, www.geoframework.org, www.gplates.org) which are potentially applicable in the marine area, whereas the marine community is developing novel digital library concepts (www.anmdg.gov.au, www.nsdl.sdsc.edu) which could be applied to solid Earth research.

AEON Aims

- Link Australia to a global effort to deal with large, important planetary-scale problems that can only be resolved by development of cross-disciplinary e-science to share data, concepts and design, but with an Australian sustainability focus, and at all scales.
- Transform individual research efforts into a nationwide effort, and to link it to international centres of excellence, building on Australia's culture of integrative science.
- Help development and implement coherent and integrated research plans among researchers working independently and in small teams on topics of common interest.
- Nurture the careers of young investigators and research students by promoting a sense of community, collaboration and strong, effective mentoring, and encourage them to shape the future direction of the research fields.
- Link with actual and potential end users, and with the broader community, especially in respect of the development of research plans, the absorption of international and national know-how, and the adoption of new discoveries made by researchers in the Network.
- Develop and provide free access to a distributed digital geolibrary and open-source modelling software, which will include multidisciplinary data of the Earth and oceans
- Construct an "Exploratorium" - an intelligent, interactive, web interface, both for scientists and non-

scientists (e.g., policy makers, educators, students, environmentalists) to learn about the foundation on which we live. The Exploratorium will facilitate open exchange of information and sharing of resources, based on open-standard web services and data-information-process model-knowledge connections.

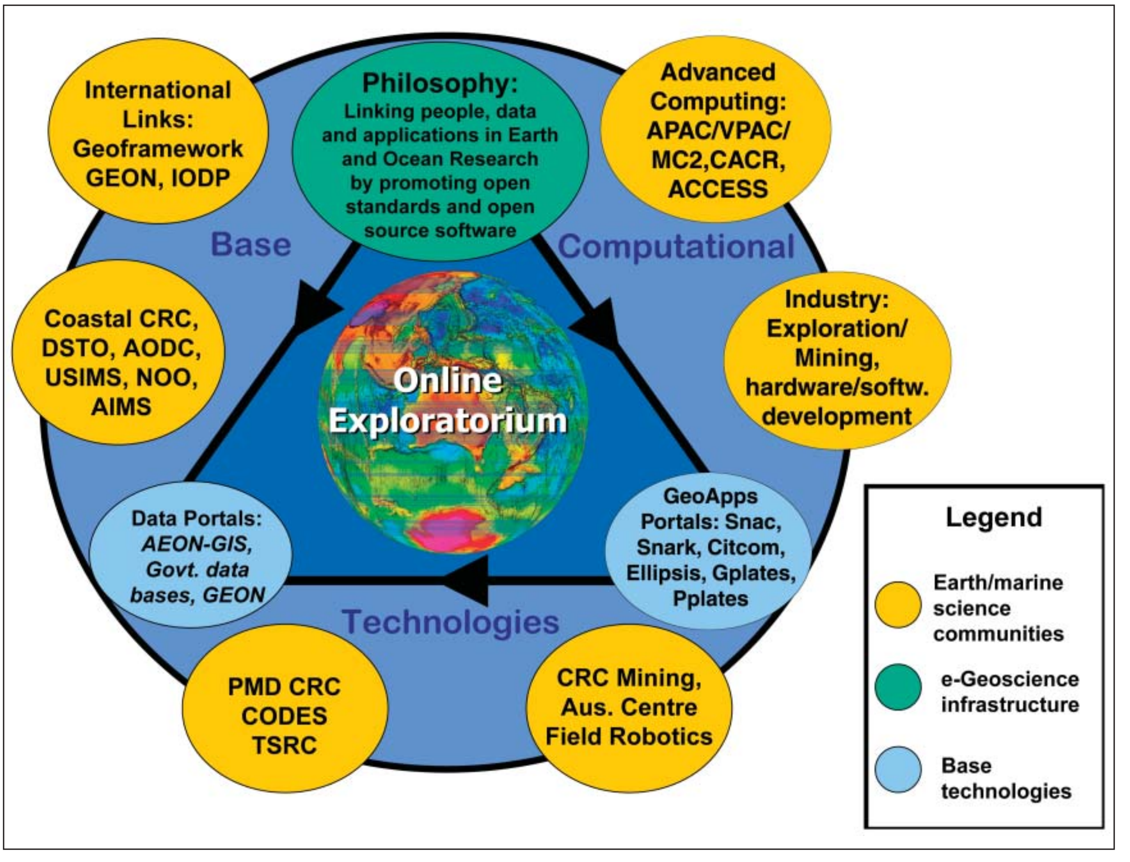


Fig 1. A preliminary sketch of the structure of AEON.

North Ryde Laboratories

Update of status of facilities and staff at CSIRO Exploration and Mining - North Ryde Laboratories[1]

In June 2003, CSIRO Exploration and Mining (EM) announced that it would significantly reduce its presence at North Ryde with a view to closing down the site in the longer term.

Following is a summary of the current status and plans for activities and facilities.

1. Isotope and other analytical facilities

1.1. *Radiogenic Isotope Facility:* this consists of a state of the art ultra - clean laboratory, two thermal ionisation mass spectrometers and ancillary equipment. It has traditionally been managed by EM on behalf of all CSIRO users, particularly CSIRO Petroleum Resources (CPR) and the Centre for Isotope Studies (CIS) which is a consortium of eastern Australian Universities. In EM this laboratory principally supports Pb isotope research.

- *Plans for Staff:* of the five current staff, three will be made redundant at the end of a current AMIRA project (P618) at the end of May, 2004. Graham Carr, will reduce his management responsibilities in the Division and work 50% in Pb isotope research in order to maintain some of the Divisions capability in this area.
- *Plans for Equipment:* EM is negotiating with CPR to transfer responsibility for the laboratories and equipment and we anticipate this will also be finalised in the next few weeks.

1.2. *Stable Isotope Facility:* this consists of specialised laboratories and an Isotope Ratio Mass Spectrometer (IRMS). It also has been managed by EM on behalf of other CSIRO divisions, particularly CPR, and the CIS.

- *Plans for Staff:* the two staff members in this facility will be made redundant by June 2004.
- *Plans for Equipment:* EM has negotiated to transfer its equity in the equipment to a new company set up by the two staff members

[1] Based on information provided by Graham Carr in February 2004

(Environmental Isotopes Pty. Ltd). The company will be operated out of Macquarie University.

1.3. *Heavy Ion Analytical Facility (HIAF):* This consists of a linear acceleratory and a number of beam lines with experimental apparatus. Currently the only active apparatus is a Nuclear Microprobe (NMP) which was designed and manufactured by CSIRO in the late 1990s. The project was financed by CSIRO and also by the Australian research Council, through Macquarie University. An earlier development, the AUSTRALIS accelerator mass spectrometer, was decommissioned in 2002.

- *Plans for Staff/Skills:* in 2002 there were five staff in the facility. One redundancy resulted from the decommissioning of the AUSTRALIS instrument. A further staff member was made redundant in late 2003 and another resigned to take up a company position. One staff member will relocate to Melbourne in March 2004 and another will be made redundant by June 2004.
- *Plans for Equipment:* the NMP will be relocated to Melbourne University accelerator facility during March 2004. It is anticipated that down-time will be of the order of two months. In the longer term it is hoped to find financial support from a consortium including the Victorian Government to relocate the linear accelerator to a new facility at CSIRO Clayton, adjacent to the new Australian Synchrotron.

1.4. *U-Th/He Laboratory* is jointly managed by EM and CPR, and has been transferred to Perth together with the three staff members.

1.5. *X-Ray Diffraction Laboratory* will be transferred to CSIRO Energy Technology (CET) in May of this year - one staff member will be made redundant.

1.6. *ICP-OES* facility was transferred to CSIRO Energy Technology (CET) in December 2003, and one staff member was made redundant.

2. Geophysical Capabilities

2.1. *Palaeomagnetic Laboratory and Advanced Magnetics Research*

- *Plans for Staff/Skills:* the two staff members chose not to apply for positions in Perth and will be made redundant. Both plan to offer their services to the exploration industry on a consulting basis, including future work on GETMAG. This is a CSIRO project to develop a tensor gradient magnetometer, which is now project managed within CSIRO Telecommunications and Industrial Physics.
- *Plans for Laboratory:* the palaeomagnetic laboratory currently housed at the North Ryde laboratories includes CSIRO and Macquarie University equipment. It will remain there in the short term with the longer term aim of transfer to Macquarie University.

2.2. The *Electromagnetic Modelling* capability, led by Dr Art Raiche, will remain at North Ryde.

2.3. The *Radiometric Laboratory* at North Ryde will be closed and plans are being developed to locate it at Macquarie University.

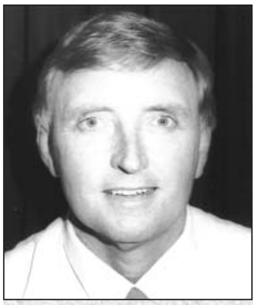
3. Sea Floor Research

The manager of this project has decided not to take up an offer of a position with CSIRO in Perth and will be made redundant. The research will continue at a significantly reduced level in Perth, led by Chris Yeats who will transfer from North Ryde at the end of 2004. The focus will be on land-based applications to exploration of the sea floor research. Another staff member, Joanna Parr, plans to transfer to a non-scientific role in a CSIRO corporate area.

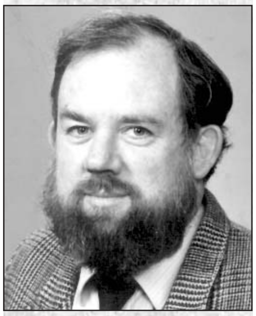
4. Mineral Mapping Technologies and Hyperspectral Equipment

This research area will remain at North Ryde for an indefinite period. There is a long-term plan to co-locate this work with other research in Perth and/or Brisbane.

Magnetic Susceptibilities of Devonian clastics from the Darling Basin, New South Wales



D. W. Emerson[1]



J. D. Alder[2]

[1] Systems Exploration (NSW) Pty Ltd, Australia
Email: systems@lisp.com.au
[2] formerly New South Wales Dept. Mineral Resources, Australia

Preamble

Magnetic susceptibility compares well with natural gamma ray responses in laboratory measurements on Darling Basin Devonian red-bed, grey-bed, and white-bed sequence core samples. The magnetic susceptibility method offers: convenience, high resolution, information on mineralogy and lithology, insights into depositional settings, and correlation between boreholes. The method can be applied to bore core, depth calibrated borehole chip samples, and to outcrop sections. It is especially useful in providing an economical geophysical log of cored boreholes that, for various reasons, have not been wireline logged, or that, owing to hole collapse, have been only partly logged. The application of the technique to other types of sequences seems promising, but requires further study.

Introduction

Magnetic susceptibility data from Devonian clastics reported here form part of a study of the little explored Devonian strata of western New South Wales. A petrophysics program undertaken by the NSW Department of Mineral Resources has investigated the mass magnetic, radiometric, galvanic electrical, and acoustic properties of available core and is using this data in conjunction with geological, seismic and wireline log information to obtain a better understanding of mid Palaeozoic features and prospects.

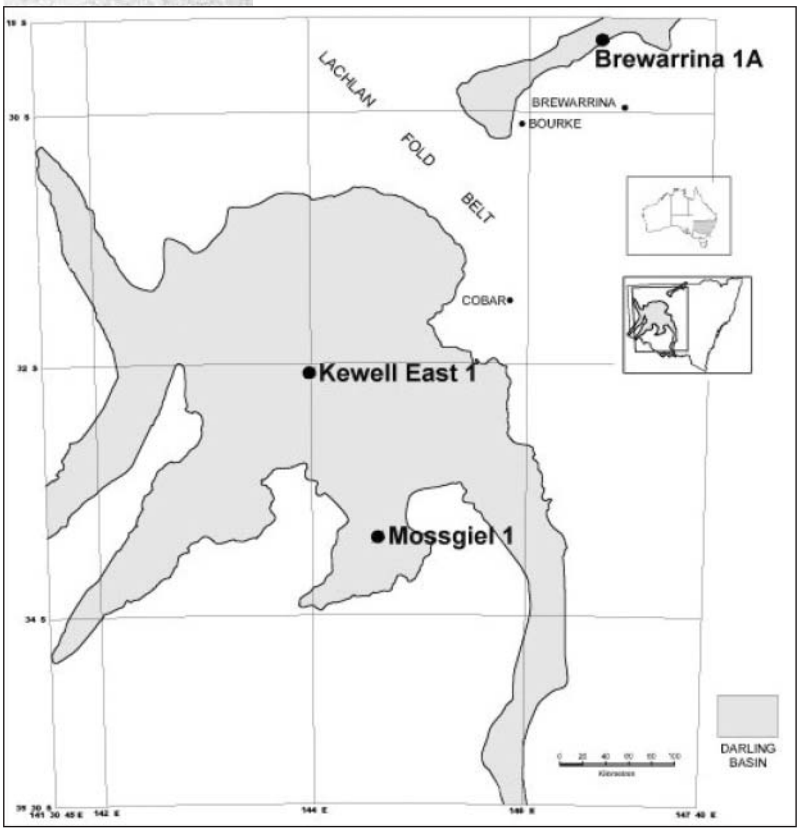


Fig. 1. Locality map showing the three diamond drillholes subject to core-based petrophysical studies of red bed and grey bed Devonian clastics: Mossgiel-1, Kewell East-1, Brewarrina-1A in different fault troughs of the Darling Basin, New South Wales, Australia. The drillholes are widely separated; the distance from Mossgiel-1 to Kewell East-1 is 152 km, and from Kewell East-1 to Brewarrina-1A is 384 km.

In sedimentary rocks trace amounts of ferrimagnetics (e.g. magnetite), antiferromagnetics (e.g. hematite, goethite), and paramagnetics (silicates and carbonates containing Fe) impart magnetic properties that have not been extensively investigated from an exploration viewpoint. In this core-based study the magnetic features of Early Devonian sections are outlined and compared with natural gamma responses and estimated grain densities to demonstrate the utility of magnetic susceptibility in basin petrophysics.

Ellwood *et al*. (1999) used magnetic mass susceptibility measurements from marine limestones and shales of the Middle-Upper Devonian of southern Morocco to infer global sea level transgressive and regressive cycles. Our paper addresses the use of magnetic volume susceptibility measurements in local or regional sedimentary clastic facies studies.

Geology

The intracratonic, fault bounded, trough fragmented Darling Basin contains Palaeozoic sediments up to several km thick and covers an area of 90 000 km^2 in central western New South Wales, Australia (Fig. 1). It is a remote region of sparse drilling and poor outcrop. The Devonian sequence contains prominent red beds and comprises conglomerates, sandstones, siltstones and claystones of mainly metasedimentary provenance, deposited in alluvial fan, braided stream, and in marginal marine environments often at quite fine scale (cm or less), but the average bed thickness is a few metres. Evans (1977), Bembrick (1997) and Alder *et al*. (1998) have outlined the known geology. The basin-wide sequence stratigraphy has been divided informally on regional scale into three major seismic units: the Winduck, Snake Cave, and Ravendale Intervals ranging in age from latest Silurian/earliest Devonian to Middle/Upper Devonian.

Three diamond-cored drill holes supplied HQ (64 mm) core for this study. The widely separated holes were located (Figure 1) at Mossgiel-1 (Booligal Trough), Kewell East-1 (Neckarboo Trough) and Brewarrina-1A (Paka Tank Trough) where 1495 m, 1140 m, 1545 m, respectively, of Devonian sediments were encountered under Mesozoic-Cainozoic veneers. The Devonian comprised kindred and coeval (but not directly correlatable) sedimentary units occurring in different basin domains. The Mossgiel hole bottomed in Silurian granite. The Mossgiel and Kewell East strata have been subject to burial metamorphism, and Brewarrina to lowest greenschist. Borehole collapse resulted in

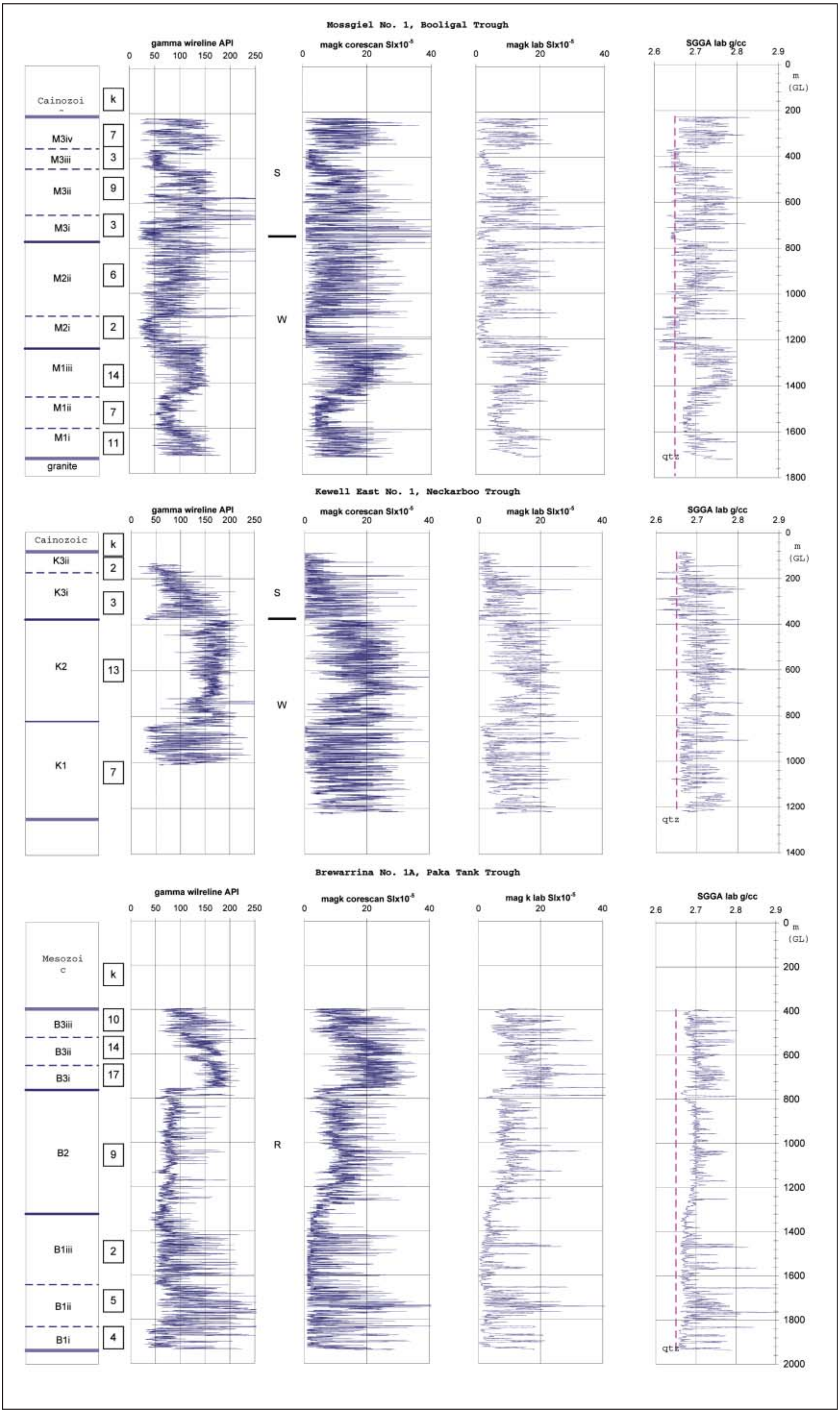


Fig. 2. Depth plots of magnetic susceptibility (k) core scan at 0.5 m intervals, laboratory measurements of magnetic suseptibility (k) and apparent grain density (SGGA) at 2 m intervals, and wireline gamma (API) for Devonian clastic sequences in Darling Basin drillholes Mossgiel-1, Kewell East-1, and Brewarrina-1A. For each location the petrophysical information has a coherent appearance. Magnetic susceptibility, grain density and gamma response generally increase in muddy sediments and decrease in sands. Physical formations and their sub units are shown as M, K, and B zones with the geometric mean of lab. mag k values (SI x 10^{-5}). The nominal, 2.65 g/cm^3, grain density of common low (alpha) quartz is indicated by the dashed line. These zones were delineated from the petrophysical data supplemented by lithological and palaeontological information. Interpreted (unconformity based) intervals in the regional seismic stratigraphy are also shown.
(R: Ravendale, later Devonian; S: Snake Cave, mid Devonian; W: Winduck, earlier Devonian).

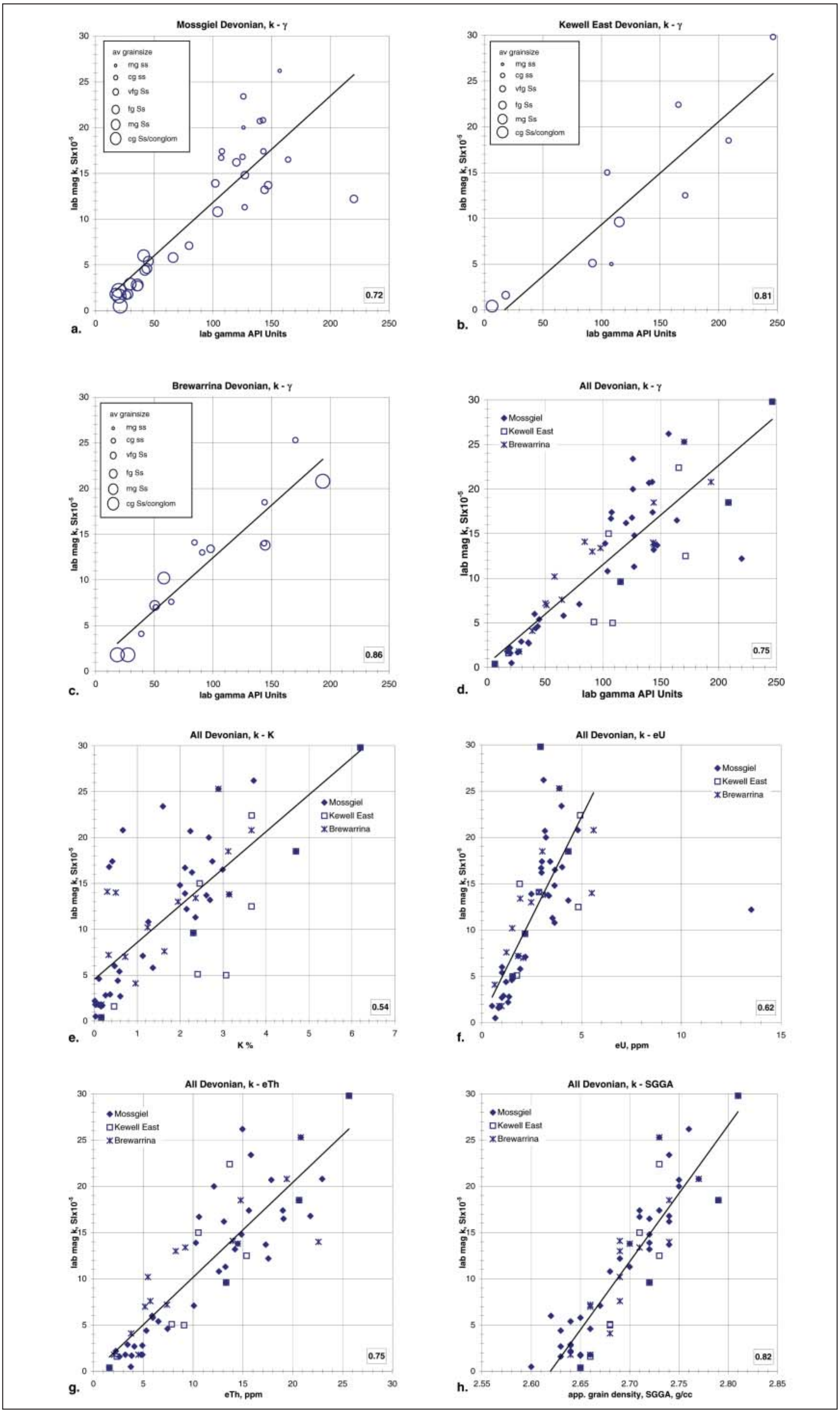


Fig. 3. Crossplots of laboratory data: magnetic susceptibility (k, SI x 10^{-5}), gamma response (API and radioelement estimates K, equivalent uranium and thorium) and apparent grain density (g/cm^3) for 58 representative samples selected throughout the Devonian sequences encountered in Mossgiel-1 (n=33), Kewell East-1 (n=10), and Brewarrina-1A (n=15). The numbers on in the boxes (lower right-hand corner) give the correlation coefficients (r^2) for the co-linear variation of the plotted parameters [the k-eU plot's outlier point (vfg green Ss, Mossgie-I) was omitted]. The mean grain sizes were determined optically for the siltstone (ss), sandstone (Ss), and conglomerate sediment categories as shown.

unsatisfactory wireline logging in Mossgiel and Kewell East. Quartz, illite, and hematite are the main sedimentary minerals. Minor carbonates (calcite, ankerite) often occur as primary, cementing, and vein material. Other detritus includes alkali feldspar, muscovite, biotite, metasedimentary lithics, and small amounts of heavy minerals: magnetite, tourmaline, zircon, rutile, apatite (Barron; 2001a, b). The term quartz embraces primary, secondary and opaline silica. Typically, a medium-grained red siltstone has quartz, illite, hematite and carbonate in the proportions 0.8, 0.15, 0.03, and 0.02, respectively, giving a composite grain density of ~2.74 t/m^3 if solid mineral densities of 2.64, 2.70, 5.26, and 2.71 are ascribed, respectively. Note that the illite here is a form of poorly to moderately crystalline mica with a density at the low end of the mica range (Grim, 1968). A clean sandstone manifests a grain density near that of quartz *i.e.* 2.65 t/m^3, if the opaline silica content is low.

Sampling and Measurement

Magnetic volume susceptibility of a rock sample is a dimensionless ratio describing the magnetic moment acquired per applied field per unit volume and often cited as SIx10^{-5}. It is a dynamic quantity measurable in an induction coil. When multiplied by the Earth's field (thousands of nanoteslas) it gives the induced magnetisation (IND, mA/m) that adds vectorially to any natural remanent magnetisation (NRM, a static quantity) present. Magnetic petrophysics and measurement techniques have been discussed by Clark (1983, 1997), Clark and Emerson (1991) and Yang and Emerson (1997).

A scan of magnetic susceptibility was undertaken at 0.5 m intervals on core carefully laid out in a minimum magnetic noise location on wood and plastic trestles and holders in the NSW Dept of Mineral Resources' Core Library. A hand held, stable, analogue meter was employed for this purpose. This meter was halfspace calibrated so for volume corrections readings were multiplied by two to give *approximate* values of susceptibility suitable for relative use only.

The core sequences were sampled at 2 m intervals to provide about 40 cm^3 of material for grain density estimation and for accurate (calibrated to 0.1x10^{-5}SI) induction coil magnetic susceptibility measurements at 460 Hz. The applied field was generally parallel to bedding. Magnetic anisotropy effects were not investigated in detail; they seem to be minor.

NRM's measured on a selection of unoriented samples in a spinner magnetometer showed that the induced magnetisation, operating through the susceptibility, generally exceeded raw remanence. For 28 samples the average Koenigsberger ratio (NRM/IND) was 0.72. Remanence studies employing magnetic cleaning techniques on oriented samples could be a useful (if slow) technique for Devonian dating and tectonic information, but were not investigated further.

Mass properties were measured by vacuum saturation and oven drying (105°C) to give dry bulk density, effective (water accessible) porosity, and apparent grain density (SGGA, t/m^3) assuming minor occluded voids. Mass properties and imbibition measurement techniques have been discussed by Emerson (1990), and Dorsch and Katsube (1999).

Spectral gamma counts were carried out on a limited number of representative samples to provide K, and equivalent U and Th values from which API units were derived. The laboratory system (in the CSIRO Exploration and Mining, Aerial Geochemistry Laboratory) recorded spectral responses, usually for 4000 s, from 200 gm samples placed in a lead castle. Limited data indicate similar values for radiometrically and chemically determined radio-elements and hence radioactive equilibrium.

The laboratory values of magnetic susceptibility were in the low range, <100x10^{-5}SI (compare with typical basalt: ~1000x10^{-5}SI). Red mudstones commonly gave readings of the order of 25x10^{-5}SI corresponding to about 0.01 % by volume equivalent magnetite or about 25 % hematite or about 100 % ankerite or appropriate combinations of these minerals. Quartz rich sandstones gave readings of the order of 1x10^{-5}SI. Occasionally negative readings were recorded in very clean sandstones as a consequence of pure quartz's diamagnetism.

The 2 m laboratory sampling interval is regarded as adequate for providing useful and representative information on the physical formation units, but that information, although deemed sufficient for the broad purposes of this study, is not complete. Detailed magnetic susceptibility measurements on centimetre slices of core over several sections showed that individual fine beds and laminae have recordable and resolvable magnetic character.

Results

The approximate core scan and accurate laboratory magnetic susceptibilities are presented as depth plots of the Devonian in Figure 2 together with the wireline gamma (incomplete for Kewell East), apparent grain densities, and the physical property zonal interpretation of the Devonian based on the petrophysical data supplemented by lithological and palaeontological information (discussed in Emerson, 2002). The geometric means of the laboratory magnetic susceptibilities of these zones are given by the boxed k values. The presentation gives a coherent magnetic, radiometric, mass property picture with the various responses showing good agreement in character and amplitude at the scales depicted, for each hole.

Laboratory data from 58 samples selected throughout the Devonian are crossplotted in Figure 3 where linear regression fits between magnetic susceptibility and gamma response (API units), and magnetic susceptibility and apparent grain density, gave r^2 values of 0.75 and 0.82, respectively. The magnetic susceptibility and individual radioelement crossplots show variations reflecting the individual mineralogical make up of the measured strata e.g. parts of Mossgiel are relatively low in potassium, whereas much of Kewell East is relatively high in this radioelement. The r^2 values can be improved by using power curve fits, but the purpose of the correlations is to demonstrate the likelihood of reasonable associations and not to quantify optimum fits on limited data.

The average grainsizes range from medium grained siltstone (mg ss) to coarse grained sandstone (cg, Ss) and conglomerate. The mean grainsizes were estimated from optical microscopy, and are depicted in Figure 3. Magnetic susceptibility and gamma response generally increase with decreasing grainsize, but the pattern is not perfect. In those cases where coarser grainsizes show higher responses there is a quite substantial component of muddy matrix material in the interstices *i.e.* the responses are related to the fines and usually, but not always, are inversely indicative of overall grainsize. Similar magnetic susceptibility behaviour has been observed in the Triassic Hawkesbury Sandstone of the Sydney Basin, NSW (Emerson, 2000).

Discussion

The mineralogy of the fines is the key to understanding these results. Rubey (1933) noted that in aqueous sedimentation abrasion and sorting tend to concentrate denser minerals, including magnetite, in the finer grained portions of sandstone beds irrespective of the sandstone being predominantly coarse or fine grained.

The magnetic contributions in the fines comprise magnetite (strong), hematite (weak), and Fe paramagnetics, such as biotite, (weak). The natural gamma emitters are the radioelement K40, and the daughter products of Th232 and U238. Potassium occurs in K feldspar grains and mica flakes, which may have any grainsize short of granules, and also in illite, which is a fine. Thorium occurs in the dense detritals, zircon and apatite and adsorbed on illite and the micas; it mainly occurs in the fines. Uranium's occurrence is similar to that of thorium but it has a somewhat more independent heterogeneous distribution on account of its high mobility in the hexavalent state.

It seems that a broad correspondence would be expected between magnetic susceptibility and gamma responses, and such responses would usually increase with decreasing grain size. Discrepancies between magnetic susceptibility and gamma indications are often due to the behaviour of K minerals. Correspondences are evident in Figure 3 where the relationship between magnetic susceptibility and radioelement content is good for thorium (r^2 = 0.75), and for uranium (r^2 = 0.62), and fair for potassium (r^2 = 0.54).

Magnetic response in the clastics of the Darling Basin Devonian is a good measure of the presence of muddy material and as such is a suitable and direct physical indicator of sedimentary facies at local or regional scale *in* *these types of rocks*. In other settings, such as limestones or volcanogenic debris, other (less direct) relationships may apply.

Wireline logging of magnetic susceptibility with resolution and accuracy in deep boreholes does not seem to be feasible technically at present although shallow depth devices are available (McNeill *et al*., 1996). However, the advantage of *accurate* magnetic susceptibility measurements on *amenable* formations is that rapid coverage is possible on stored core sections and over field outcrops, and a quasi gamma log quickly generated. Where gamma log data are available, the differences, subtle or otherwise, between the magnetic susceptibility and gamma logs can be informative. In addition, magnetic susceptibility can provide much better resolution of the features of thinly bedded clastics.

Conclusions

In the Devonian clastics encountered in three widely separated Darling Basin drillholes the magnetic susceptibility method shows promise as a useful investigative tool for physical facies and correlation studies, in laboratory or field. Magnetic susceptibility measurements provide information generally compatible with natural gamma responses.

Acknowledgements

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New temperature maps of the Australian crust

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Geothermal energy represents a potentially important renewable energy resource for Australia. Regions of high crustal temperature at depths <5 km may be economic targets for hot dry rock technology. A new database of temperature measurements made from 5722 wells across Australia has been used to construct maps of the spatial distribution of temperature at 5 km depth in the Australian crust. The new database, ***AUSTHERM***, builds upon the earlier heat flow work of Cull (1982) (Figure 1) and the temperature map of Somerville *et al*., (1994) (Figure 2). The major aims of the current work are to improve both the resolution of the earlier images and the quality of the image processing used in the 1994 map.

AUSTHERM builds on the existing database of Somerville *et al*., and extending it by adding temperature data from a further 1430 petroleum wells. Entries for most other wells have also been updated and benefit from greatly improved quality control. Whilst there has been some enhancement of the spatial coverage, when compared with the earlier dataset, the bulk of the new data are found to be clustered within the same provinces that dominate the original dataset. As a result, data distribution across the continent still tends to be patchy and irregular. It is concluded that the mature state of Australian hydrocarbon exploration will likely preclude much further improvement of this distribution by future additions of new petroleum well data to ***austherm***. Alternative sources of new subsurface temperature data, such as water wells and deep mineral exploration holes are required to significantly improve the present data set.

An Arc/Info GIS coverage has been built from the ***austherm*** database. This coverage was intersected with GIS grids (constructed from Australian mean surface temperature point data provided by the Bureau of Meteorology and depth to basement line data provided by Geoscience Australia) enabling interpolation of mean surface temperature and depth-to-basement for each well location. Calculations of the crustal temperature at a depth of 5 km at each well location were then made using measured or estimated thermal gradients and depth-to-basement information. In the absence of specific data, a uniform gradient of 25ºC/km was assumed for all basement rocks. Calculated crustal temperature at 5 km depth was then used to interpolate grids of cell size equal to 0.02 degrees. Interpolation was performed via geostatistical 'Kriging' using a variety of semivariogram error-modelling approaches. Best results to date employ an exponential error model.

The crustal temperature map produced in this study reveals large spatial variations in temperature across continental Australia (Figure 3). Lowest temperatures occur where basement is exposed at the surface, such as the Yilgarn Block, Gawler Craton and Lachlan Fold Belt. High temperatures are often associated with thick sedimentary basin sequences, most notably in the Cooper-Eromanga, Macarthur and Canning Basin regions. Other smaller areas of relatively elevated crustal temperature include parts of the Sydney, Perth and Murray basins. While successful, the new crustal temperature maps continue to be influenced by artefacts caused by the strongly heterogeneous spatial distribution of subsurface temperature data across Australia. Methods to further minimise the impact of this poor distribution are currently being investigated.

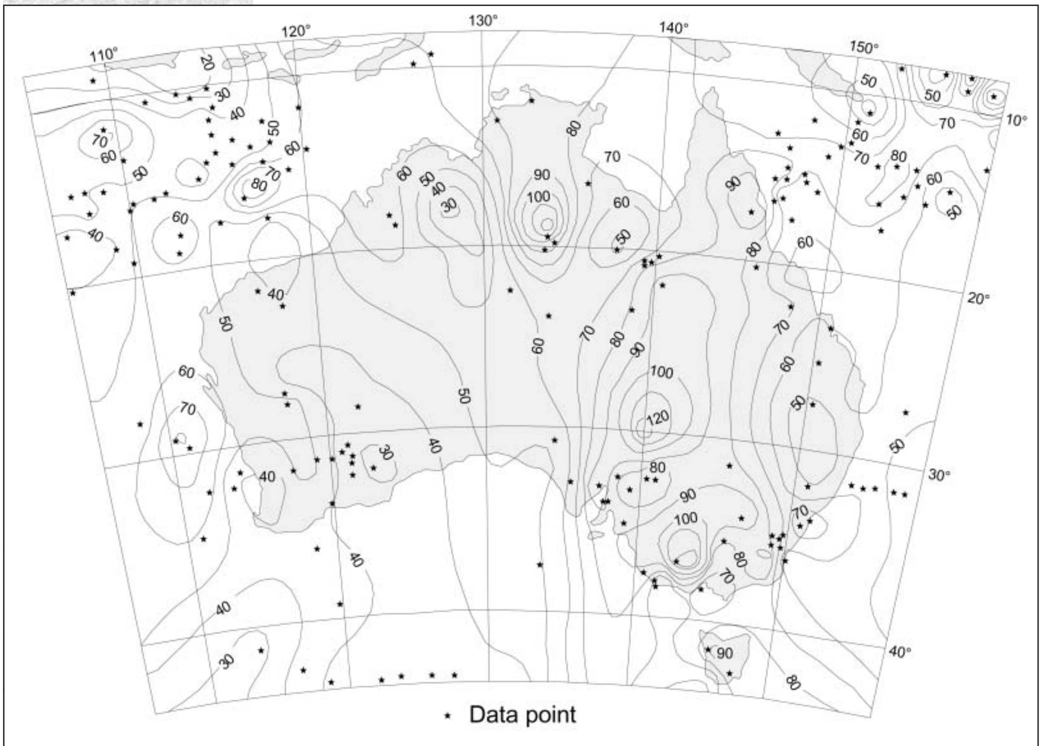

Fig. 1: Heat flow map of Australia showing available data locations after Cull (1982). Contour interval is 10 mW.m^{-2}.

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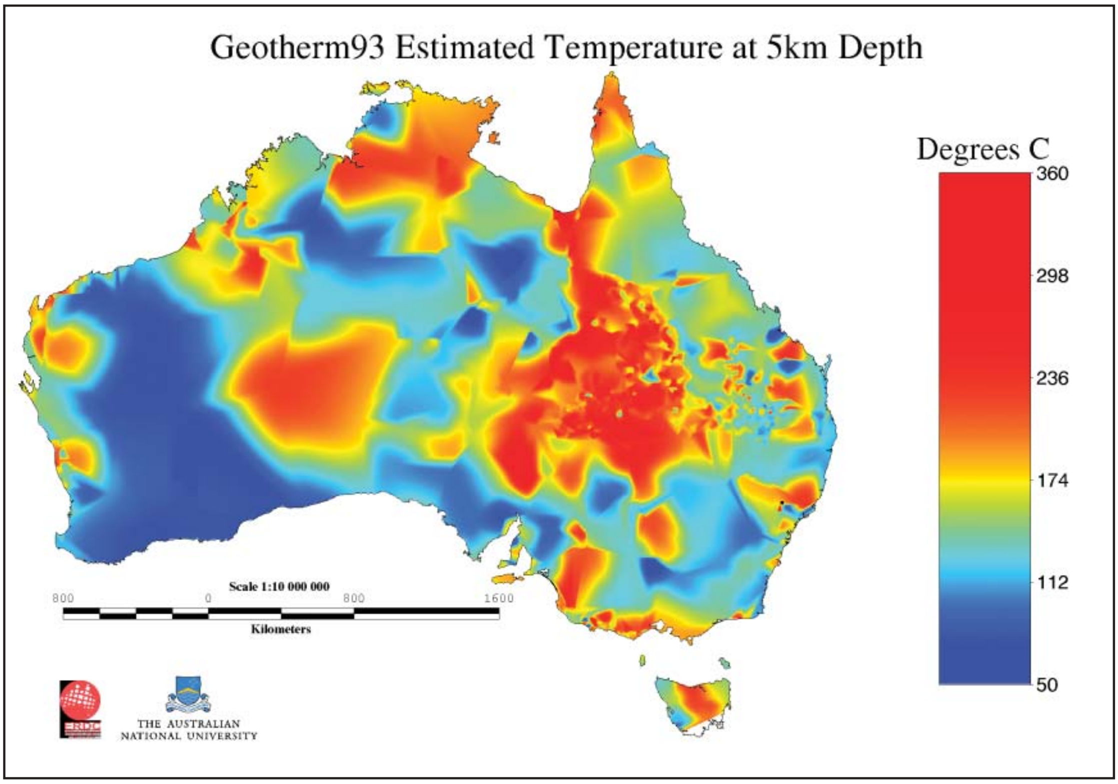

*Fig. 2: Australian crustal temperature at 5 km depth, 1993. Image generated from the **geotherm** database of Somerville et al., (1994).*

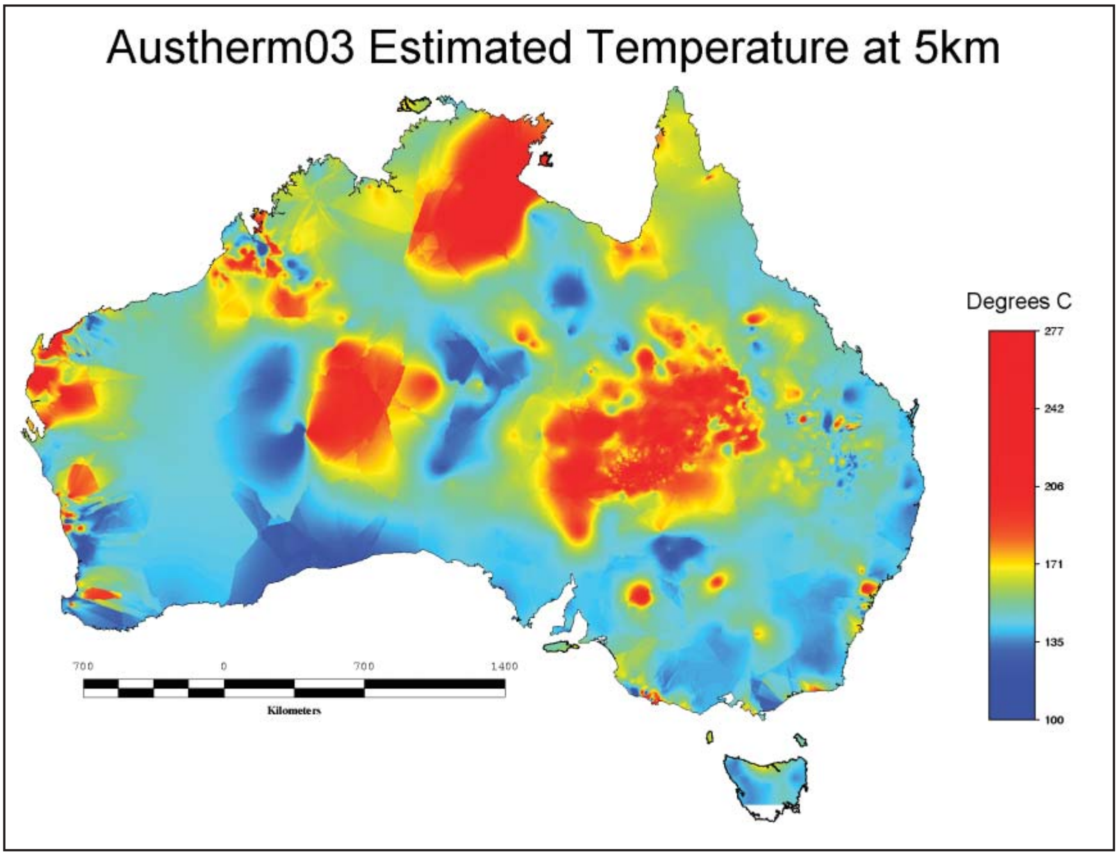

*Fig. 3: Australian crustal temperature at 5 km depth, 2003. Image generated from the new **austherm** database.*

Modelling the contemporary stress field of the Australian continent

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Abstract

We have modelled the contemporary maximum horizontal compressive stress (S_{Hmax}) regime for the Indo-Australian plate using an elastic 2D plane stress finite element model with a resolution of approximately 0.2º in both longitude and latitude. Realistic mechanical properties representing different rock types and geologic provinces for the Australian continent were included to model the stress field of a rheologically heterogeneous plate. Implementation of realistic material properties in the model results in a good fit between observed and modelled S_{Hmax} directions compared to a model with homogeneous material properties. Spatially significant rotations of S_{Hmax} directions are shown to be a consequence of perturbations of S_{Hmax} in areas of juxtaposed strong and weak rheologies. Methods developed have also been implemented in studies of the palaeo-stress regime of the Australian continent and are easily applied to other regions.

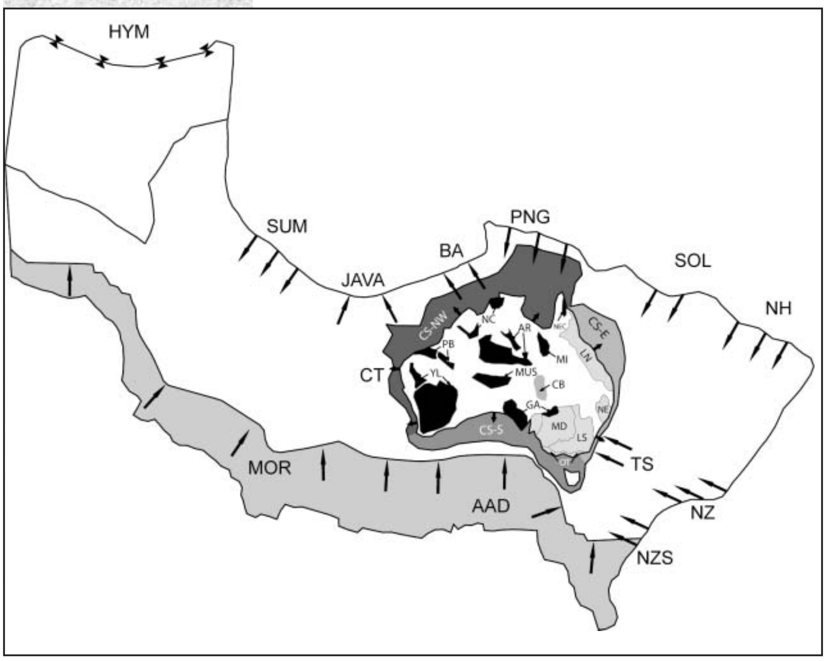

Fig. 1 Indo-Australian plate showing forces applied to contemporary model: HYM = Himalayas (fixed boundary); SUM = Sumatra Trench; JAVA = Java Trench; BA = Banda Arc; PNG = Papua New Guinea; SOL = Solomon Trench; NH = New Hebrides; CT = Continental Topographic Force; TS = Tasman Sea; NZ = New Zealand; NZS = Southern New Zealand Alps; AAD = Australia Antarctic Discordance; MOR = Mid Ocean Ridge. Boundary between light grey area along which MOR and AAD force arrows are located is the region along which the ridge push force was applied for the contemporary model. Note that force arrows are not drawn to scale. Mechanical provinces implemented in models: YL = Yilgarn Craton; PB = Pilbara Craton; AR = Arunta Block; MUS = Musgrave Block; NC = Northern Cratons; MI = Mt Isa Block; GA = Gawler Block; NEB = North East Block; CB = Central Block; MD = Murray-Darling Basin; OT = Otway Basin; LN = Northern Lachlan Fold Belt; SN = Southern Lachlan Fold Belt; NE = New England Fold Belt; CS-NW = North-West Continental Shelf; CS-E = Eastern Continental Shelf; CS-S = Southern Continental Shelf. Values for mechanical properties are listed in Table 1.

Introduction

Modelling of the maximum horizontal compressive stress (S_{Hmax}) regime of the Indo-Australian plate was carried out using the engineering standard finite element software package ABAQUS™. An elastic 2D finite element model was created containing around 24,000 plane stress elements allowing for a spatial resolution of 0.2 degrees in both latitude and longitude. Forces applied to the model (Fig. 1 and Table 1), apart from the ridge push force which can be calculated as a function of the age-distribution of oceanic lithosphere (Turcotte and Schubert 2002), were initially based on those of previous studies (Coblentz, *et al*., 1998; Reynolds, *et al*., 2002) and were the further refined by the resulting fit between modelled and measured S_{Hmax} orientations. A diminished ridge push force (Table 2) south of the Great Australian Bight was implemented to represent the Australia-Antarctic Discordance, a region of the spreading ridge that is characterised by bathymetry 800 m deeper than surrounding ridge elevation (Gurnis, *et al*., 1998). Forces applied to the models are averaged over a lithosphere of 100 km thickness.

Previous studies modelling the contemporary stress regime of the Indo-Australian Plate have used a homogeneous elastic plate (Coblentz, *et al*., 1998; Hillis, *et al*., 1999; Reynolds, *et al*., 2002). Zuber, *et al*., (1989) and Simons and van der Hilst (2002) have demonstrated the existence of provinces within the Australian continent with differing rigidity. Since S_{Hmax} orientation and magnitude are affected by mechanical properties, the adoption of a homogenous plate to model stress regimes would seem to impose inherent limitations on the method. We implement realistic mechanical properties representing different rock types and geological provinces for the Australian continent. The various material properties are based on estimated effective elastic plate thicknesses obtained from coherence analysis of gravity and topographic data (Simons, *et al*., 2000; Zuber, *et al*., 1989) as well as on shear wave analysis (Kennett, 1997; Simons, *et al*., 1999) and the known surface geology. The Australian continent was subdivided into four categories (cratons, fold belts, basins and continental shelf) based on the differing rheologies and strength of the continent as determined by Zuber, *et al*., (1989) and these are illustrated in Figure 1. Zuber, *et al*., (1989) determined areas in the west and north of the Australian continent to be relatively strong due to the older cratonic provinces, while they determined that the Eastern Highlands of the continent were relatively weak. The remainder of the Australian continent (the white areas of Fig 1) was treated as a sedimentary basin which is classified as generally stronger than the fold belts and weaker than the cratonic provinces. Results from seismic

Province	[1]Effective Elastic Plate Thickness (km)	[1]Flexural Rigidity ($x10^{25}$ Nm)	Scaling Factor	Scaled Young's Modulus ($x10^{10}$ Nm^{-1})	[2]Refined Young's Modulus ($x10^{10}$ Nm^{-1})	Refined Rigidity ($x10^{25}$ Nm)
Basins	64	0.25	0.12	0.714	0.714	-
Yilgarn Block	132	2	0.95	5.7	5.7	-
Pilbara Block	132	2	0.95	5.7	5.7	-
Northern Cratons	134	2.1	1.00	6	6	-
Arunta Block	88	0.61	0.29	1.74	1.74	-
Musgrave Block	88	0.61	0.29	1.74	1.74	-
Gawler Block	92	0.69	0.33	1.98	1.98	-
Mt. Isa Block	134	2.1	1.00	6	6	-
North Lachlan Fold Belt	26	0.016	0.0076	0.046	0.046	-
South Lachlan Fold Belt	20	0.0077	0.0037	0.022	0.01	0.0035
North East Block	-	2	0.9524	5.7	5.7	-
Murray-Darling Basin	29	0.022	0.0105	0.063	0.063	-
New Eng. F. B.	16	0.0036	0.0017	0.01	0.01	-
Otway Basin	-	-	-	-	0.063	0.022
Oceanic crust	-	-	-	-	7	2.45
NW Continental Shelf	-	-	-	-	0.31	0.109
Southern Continental Shelf	-	-	-	-	0.095	0.033
Eastern Continental Shelf	-	-	-	-	0.031	0.0109
Central Block	-	-	-	-	0.3	0.105

Table 1. Values defined for the material properties used in the model. [1]Values for estimated effective elastic plate thickness and flexural rigidity from Zuber et al. (1989). [2]Refined values from stress modelling. Scaling factor determined by the ratio of the provinces value of flexural rigity with the highest value for flexural rigity determined by Zuber et al. (1989).

wave analysis of the Australian continent (Kennett 1997; Simons, *et al*. 1999) support the findings of Zuber, *et al*., (1989) and further indicate the existence of a relatively weak zone located in central eastern Australia (Fig. 1). The relative strengths of the provinces were implemented by altering the Young's moduli of the materials. Relative values for the Young's moduli of the different materials (Table 1) were calculated based on a ratio to the strongest rigidity value as determined by Zuber, *et al*., (1989). See (Dyksterhuis, *et al*. in review) for further information regarding modelling methods used.

The strength and rigidity of the Australian continental shelf remains relatively unconstrained. We divide the continental margin into three regions with differing ages of last thermal reheating (Fig 1). The north-west continental shelf has the oldest age of thermal reactivation, at about 130-155 Ma (Müller, *et al*., 2000). The southern continental margin was last reheated in the late Cretaceous (from ~ 95 Ma in the Great Australian Bight to 60 Ma south of Tasmania) while the eastern continental margin was last reheated during Tasman Sea rifting and breakup in the Late Cretaceous (90 Ma in the South Tasman Sea to ~60 Ma in the Coral Sea) (Müller, *et al*., 2000). The equivalent elastic thickness of the Australian continental margins were implemented by varying the Young's moduli between 3.1 x 10^8 Nm^{-2} and 7.14 x 109 Nm^{-2} in an iterative fashion and constraining the resulting fit with measured stress orientations. We found that orientations of S_{Hmax} directions over the continental shelf and Australian continental interior were dependant on the elastic strength of the continental shelf and determined strengths for all materials are listed in Table 2. Estimating the relative strength of the continental shelves using stress orientations represents a novel approach for constraining the relative strength of continental shelf segments.

Homogeneous Model

In order to assess the relative fit of modelled S_{Hmax} orientations for different models a residual misfit between the average measured S_{Hmax} orientation (Reynolds, *et al*., 2002) and an average modelled S_{Hmax} orientation was calculated (Table 3). Modelled S_{Hmax} orientations using a homogeneous model (Fig. 2) are similar to those obtained

Table 2. Forces applied to model. Positive forces are directed towards the interior of the plate. Note: Force magnitude of 1 x 10^{12} Nm^{-1} is equivalent to a stress of 10 MPa across a plate of thickness 100 km.

Location	Force x 10^{12} Nm^{-1}
Australia Antarctic Discordance	1.17
Banda Arc	– 0.60
Continental Topography	– 0.50
Java	– 0.60
Mid Ocean Ridge	1.75
New Hebrides	1.20
New Zealand	2.50
Southern New Zealand Alps	3.00
Papua New Guinea	3.40
Soloman	1.40
Sumatra	2.00
Tasman Sea	1.08

Average Stress Direction Regions[1]	Amadeus	North Bonaparte	South Bonaparte	Bowen	Canning	Canarvon	Cooper	Gippsland	Otway	Perth	Total Residual Misfit
Homogeneous	76.95	10.4	5.4	148.6	19	1.4	37.9	1.2	18.2	16.4	335.45
Heterogeneous	33.6	4.5	4	105	10.7	4.7	53.8	0.9	5.8	4.7	227.7

Table 3. Residual misfit between average predicted and average measured stress orientations for model with homogeneous and heterogeneous material properties. 1 As defined by (Coblentz, et al., 1998; Reynolds, et al., 2002).

in previous studies (Coblentz, *et al*. 1998; Reynolds, *et al*. 2002). The overall stress pattern is controlled by push from the MOR along the southern margin of the Indian-Australian Plate and collision at the northern boundary at the Himalayas and Papua New Guinea, as concluded by previous studies (Hillis, *et al*. 1997). Modelled S_{Hmax} orientations, however, vary in a smooth fashion over the Australian continent and result in a less than adequate fit between modelled and observed S_{Hmax} orientations since observed S_{Hmax} directions show quite dramatic rotations in orientation at boundaries between rheological provinces. For example the rapid rotation of observed S_{Hmax} orientation between the Amadeus and Cooper basins is not well reproduced by the homogeneous model, with any rapid spatial variability in S_{Hmax} directions restricted by the homogeneous material properties. A relatively high value of total residual misfit was obtained with the homogeneous model, implying that using homogeneous material properties may represent an over simplification.

Heterogeneous Model

Results for the modelled contemporary stress orientations using a heterogeneous plate are shown in Figure 3. Stress directions over the west Australian continent correlate well with observed S_{Hmax} orientations. On the north-west Australian shelf modelled S_{Hmax} directions have a similar NE trend as observed data (Fig. 3) with values of residual misfit (Table 3) showing there to be roughly a 5° difference between the measured and modelled stress orientation in this area. S_{Hmax} trends in the south of the Australian continent are not adequately explained solely as a result of the rotation of the S_{Hmax} trend due to the collisional boundaries at PNG and the Himalayas. Data measured over the southwest and southeast of the Australian continent all display a general E-W compressional trend (Coblentz, *et al*., 1995). This seems counter-intuitive given the fact that a MOR system is located south of the area providing a large force in a northerly direction. Indeed the ridge push force is the dominant plate driving force, and so it can be expected that this would be represented in the S_{Hmax} orientation data with N-S trending compression. Hillis, *et al*., (1997) and Reynolds, *et al*., (2002) attribute the E-W compression to the rotation of the stress field between the Himalayas and PNG. Results of this study indicate that the S_{Hmax} direction does have a general N-S trend over the southern Australian continental margin, and that the observed E-W compression over the southern Australian continent is due to perturbations of the S_{Hmax} direction around areas with relative rheological strength differences. Spatially rapid stress rotations such as those between the Amadeus and Cooper basins are caused principally by the heterogeneity of the model and the juxtaposition of strong and weak material.

Stress measurements taken predominantly in the Gippsland and Otway basins indicate a NW-SE trend in the S_{Hmax} direction in the south eastern margin of Australia. Results of this study model the NW-SE trend over the Gippsland and Otway basins well (Fig. 3 and Table 3). Modelled stress directions over the Murray-Darling Basin region and South Lachlan Fold Belt also show the same orientation as the measured stress directions, trending slightly more northward. Measured stress orientations from the Bowen Basin over the northeast of Australia show a N-NE trend. S_{Hmax} orientations in the modelled results have very low amplitudes, even indicating a slight extensional stress regime in the Drummond and Bowen Basin regions. Low modelled stress amplitudes may indicate that local sources of stress play a dominant role in determining orientation of S_{Hmax} directions in this region (Zoback, 1992). Fit with the modelled stress orientations in the region of the Sydney Basin is poor,

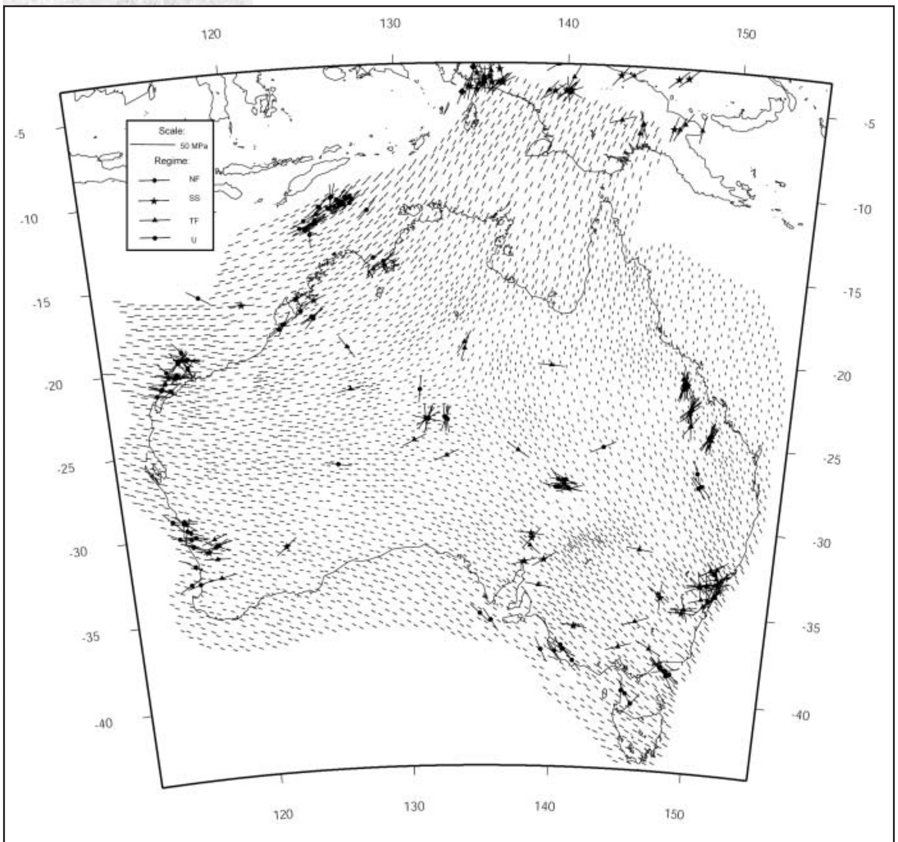

Fig. 2. Modelled contemporary maximum horizontal compressive stress (S_{Hmax}) orientations for a plate with homogeneous material properties. Filled black lines indicate compressional stress while grey lines indicate tensional stress. Lines marked with symbols show the measured stress orientations of A-C quality taken from the Australian Stress Map database. NF = normal faulting; SS = some strike slip component; TF = reverse faulting; U = undetermined.

however, stress data in this area are not regarded as being of high quality (Hillis and Reynolds 2000), and so the relatively poor fit of modelled stress directions is not regarded as significant.

Conclusion

By implementing realistic material properties for the Australian continent and continental shelf, the important affects heterogeneous material properties have on the contemporary maximum horizontal compressive stress (S_{Hmax}) have been demonstrated. Large perturbations in both the orientation and magnitude of S_{Hmax} are seen to occur in areas of juxtaposed strong and weak materials. Orientations of modelled S_{Hmax} agree closely with observed S_{Hmax} directions, indicating that using a model with homogeneous material properties may be an over simplification. The methods developed have also been employed in the modeling of palaeo-stress regimes of the Indo-Australian plate for time periods in the geologic past (see (Dyksterhuis, *et al*., 2004)), and as such represent a valuable tool for creating predictive frameworks for fault reactivation, hydrocarbon migration and breaching of hydrocarbon seals through time whilst also providing insight into the contemporaneous stress regime of the Australian continent which is pertinent to more efficient hydrocarbon production (Hillis, *et al*., 1997).

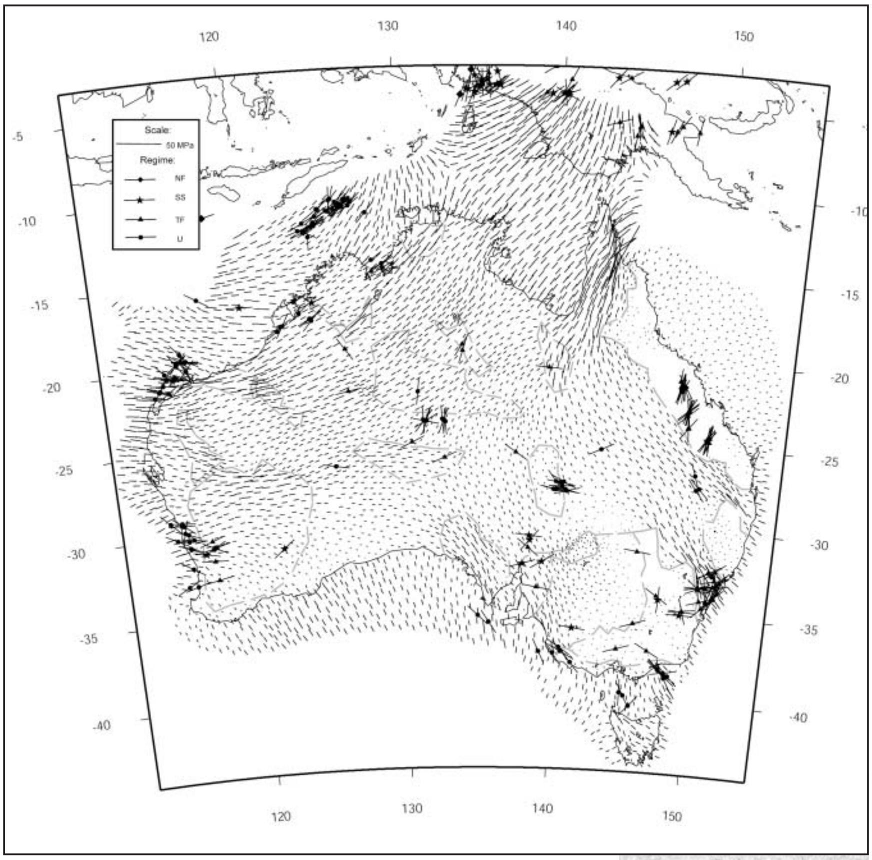

Fig. 3. Modelled contemporary maximum horizontal compressive stress (S_{Hmax}) orientations with realistic material properties for the Australian continental and continental shelf. Filled black lines indicate compressional stress while grey lines indicate tensional stress. Outlines of material provinces shown by dashed grey lines.

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Regional constrained 3D inversion of potential field data from the Olympic Cu-Au province, South Australia

Introduction

The almost complete absence of basement outcrop or surface expression of mineralisation is the prime impediment to mineral exploration in the Gawler Craton of South Australia, and large areas elsewhere in Australia (Fig. 1). To explore in these covered terranes, we need high quality regional information, plus tools and techniques that allow us to better utilise the limited direct geological information from buried rocks. Analysis of potential-field data is one of the most common and cost-effective ways of inferring hidden geology. There are high quality aeromagnetic data available over most of the actively explored areas of Australia, and it is hoped that more closely-spaced ground gravity measurements, together with improvements in airborne gravity and airborne gravity gradiometer methods, will in the future raise the standard of gravity coverage to that of the magnetics.

Hitherto, quantitative interpretation of potential-field data has principally involved forward modelling of profiles or sections by skilled interpreters. The value of the outcome relies heavily on the skill, knowledge, objectivity and consistency of the interpreter. Profile (2D) forward modelling is an excellent way to test ideas and hypotheses but it becomes difficult to connect the results of separate cross sections to build a rigorous and consistent 3D model, even when the sections are relatively close together, and particularly where there is little along-strike continuity.

The application of inversion techniques to derive a 3D property-distribution from a potential-field dataset (Li and Oldenburg, 1996; Li and Oldenburg, 1998a) has been limited by factors such as the availability of computer processing power as well as software to manage and visualise 3D geological features and physical property distributions. The continuing improvement in computer hardware performance and an expanding range of 3D software tools allows more sophisticated use of potential field data, and better integration of these data with other geoscience datasets. The use of unconstrained inversions by industry in prospect-scale exploration is becoming routine.

The multidisciplinary Gawler Mineral Promotion Project at Geoscience Australia is using the inversion programs MAG3D and GRAV3D, developed by the University of British Columbia – Geophysical Inversion Facility, to undertake regional-scale, constrained magnetic and gravity inversions to investigate the distribution of lithologies, structures, and alteration under sedimentary basin cover.

The Olympic Dam Area

Our study is focussed on the Olympic Cu-Au province (Skirrow *et al*., 2002), and is centred on a volume of crust that includes the giant Olympic Dam iron oxide copper-uranium-gold deposit in the eastern Gawler Craton, 520 km north of Adelaide. This deposit has proven reserves of 123 million tonnes of copper, uranium and gold ore, and a measured resource of 520 million tonnes of ore (WMC Resources Annual Report - Financial, 2002). Although the deposit lies under more than 300 m of sedimentary cover, the magnetite and hematite alteration associated with mineralisation gives rise to very clear potential-field signatures (Rutter and Esdale, 1985). The cover can exceed 1500 m in thickness elsewhere in the study area, but the potential-field signatures from iron oxide alteration are still generally strong.

The regional geology comprises Archaean gneisses, metamorphosed sedimentary and volcanic rocks of the Palaeoproterozoic Hutchison and Wallaroo Groups, and Palaeoproterozoic meta-granitoids of the Donington Suite. The mineralisation is contemporary with the early Mesoproterozoic granitoids and gabbros of the Hiltaba Suite and the co-magmatic Gawler Range Volcanics.

Methods

The 'local volume' of crust that we have most interest in measures 150 km x 150 km with a depth of 10 km. To avoid edge effects, a larger data extent of 174 km x 174 km is used, together with a padded inversion model volume of 198 km x 198 km x 18 km. This was discretised into nearly 1.5 million cells of 1 km x 1 km x 0.5 km. Approximately 50 computer hours were required to run each inversion once the local volume was split into nine overlapping tiles.

The contributions from sources outside the local volume were removed by nesting the local volume within a coarser regional inversion that covered a much larger 516 km x 536 km x 64 km volume, a procedure described by Li and Oldenburg (1998b). To obtain the residual signal for the local inversion, the physical properties for cells in the regional volume that coincide with the local volume were set to zero. A forward model was then run using the remainder of the regional inversion model to predict the regional response at the locations of the data points to be used in the local inversion. Finally, the regional response was subtracted from the observed data at these locations. Because of the transcrustal depth used in such a large inversion, the reduction in magnetic susceptibility below the Curie depth was enforced by using a reference model and weighting factors that limited non-zero susceptibilities to the upper 20-25 km of the model.

A series of 'unconstrained' and 'constrained' inversions of the residual data were carried out. The term 'unconstrained'

Fig. 1. View north from Woomera towards the Olympic Dam mine site (beyond horizon).

is somewhat of a misnomer, as the same mathematical constraints that minimise absolute departures and shape changes with respect to a reference physical property model are employed in both instances. The difference is that the unconstrained inversions do not employ any specific *a priori* geological information in the form of a non-zero reference physical property model. A reference model based on known, or inferred, geology was used with the (geologically-) constrained inversions. Under these conditions, the inversion process can be viewed as a test of the consistency between the observed potential field data and the geometry and physical property values used to create the reference model. The inversion objective function limits the differences between the final inversion model and the supplied reference model, subject to the requirement of fitting the observed data to the supplied level of uncertainty in these data.

The constrained inversions in this study used a reference model derived from a 2D top-of-basement geology interpretation of the central Olympic Cu-Au province by Direen and Lyons (2002). The major unit boundaries were taken from this interpretation and extruded vertically to depths that were based on the present geological understanding within the project team (Fig. 2). A regular 3D mesh was then superimposed on the geological bodies. Average density and magnetic susceptibility values were assigned to each of the cells within each distinct geological unit, based on published literature values.

Results and Discussion

The purpose of this study was to demonstrate the use of regional-scale constrained inversions for understanding geology under cover sequences, and for identifying prospective regions for future exploration. Figure 3 shows a comparison of density values for a horizontal slice at 1000 m depth through the reference and constrained inversion models and a similar comparison of magnetic susceptibility values. There is broad agreement between the reference and inversion models. The images of differences highlight where changes to the geological boundaries and/or the physical property values are required to achieve consistency between the reference model and the observed data.

Fe oxide Cu-Au mineralisation, exemplified by the Olympic Dam deposit, is characterised by haematite and magnetite alteration. Hanneson (2003) describes a simple method by which density and magnetic susceptibility estimates can be used to infer the distribution and intensity of these alteration types. Using the physical property relationships given in Figure 4 and the density and magnetic susceptibility inversion models, percentages of the end-members in a simple ternary system comprising barren host rock, magnetite and haematite/sulphides can be derived for each volume element in the 3D mesh. This assumes that the primary controls on the physical properties are these three end-members, and that significant alteration will dominate over variations in physical properties attributable to differences in host lithology. We also make the assumption that the magnetite component will represent all susceptible minerals as their magnetite equivalents. Likewise the haematite/sulphide component includes contributions from other dense non-magnetic minerals. The inversion of magnetic data using MAG3D assumes that the anomalous field is solely due to induced susceptibility. The presence of remanence introduces complex errors into the magnetic susceptibility estimates which propagate through to the calculated proportions of the ternary system.

Figure 5 shows the distribution of anomalous alteration derived from an unconstrained inversion, with blue surfaces enclosing volumes with > 1% magnetite alteration and brown surfaces enclosing volumes with > 1% haematite/sulphide alteration. These anomalous percentages may appear small, but they reflect averaging within a model built with elements that have a volume of 0.5 km^3. The spatial averaging is further influenced by the smoothness constraints employed during the inversion. Regardless, this technique has allowed us to produce the

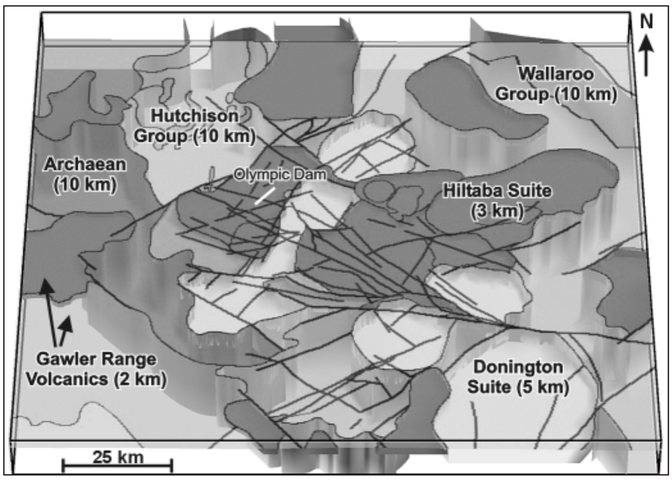

Fig. 2. Perspective view, from the south, showing the 3D reference model of basement geology used in the constrained inversions (Direen and Lyons, 2002). Numbers in parentheses show the thickness assigned to each unit.

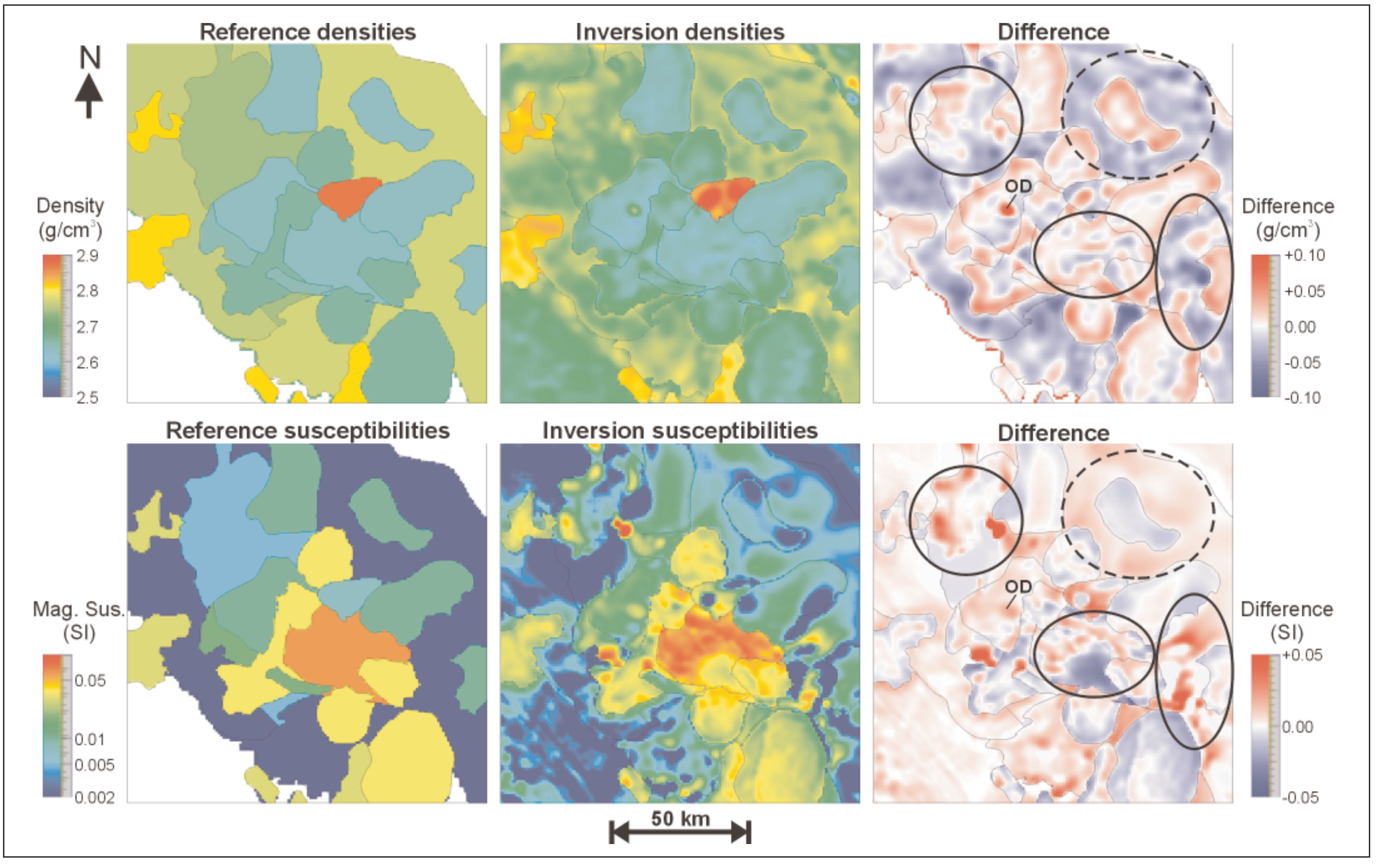

Fig. 3. Depth slices at 1000 m comparing densities and susceptibilities in the reference model and the constrained inversion. In the difference images, blue colours indicate that the reference property was too high, red colours indicate that the reference property was too low, OD shows the position of Olympic Dam, the dashed circle shows units that have consistently higher or lower properties, whereas the solid circles show areas of high variability, and therefore more complex geology.

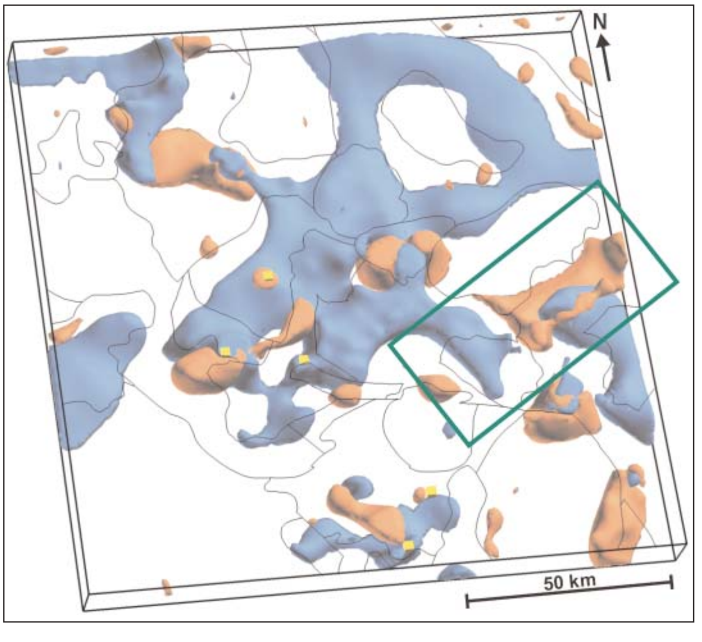

Fig. 5. Perspective view of a 3D alteration map of the inversion volume. Brown surfaces enclose all cells with > 1 wt. % haematite/sulphide alteration (and may include areas of other dense minerals or remanent magnetisation); blue surfaces enclose cells with > 1 wt. % magnetite alteration (which may include other magnetically susceptible minerals as their magnetite equivalents). Black lines indicate unit boundaries of the basement geology interpretation (Direen and Lyons, 2002); yellow cubes indicate the location of known copper-gold mineral occurrences (with top-most being Olympic Dam). Green box shows the location of Fig. 6.

first regional 3D map of alteration in the Olympic Dam area, which is currently being validated against observed alteration in drill holes. Despite its simplicity, it shows that there is anomalous alteration that can be observed *at a*

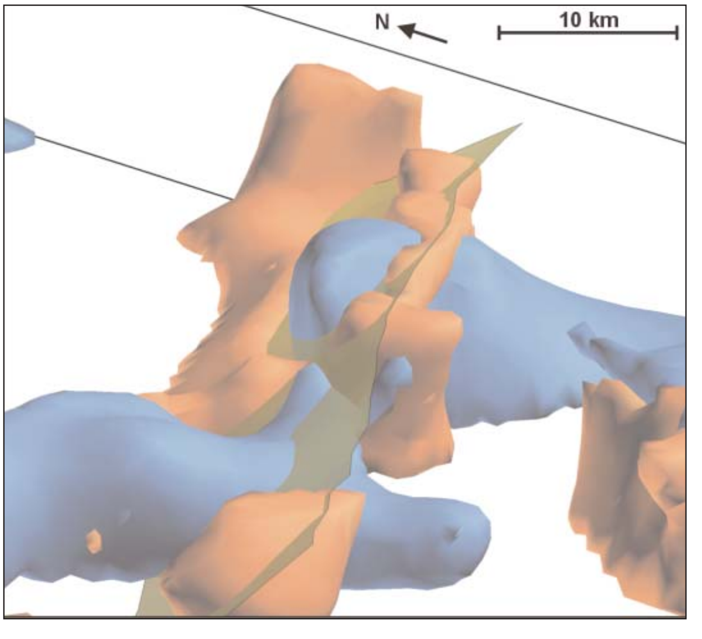

Fig. 6. The yellow surface is the interpreted trend of a structure, previously unknown, that appears to have controlled the distribution of alteration.

regional-scale around each of the known mineral occurrences (shown as yellow cubes). In addition, there are a number of features that have a geometry that is suggestive of structural control (Fig. 6). Such observations are important for better understanding the conduits that are a critical part of the regional mineral system.

Concluding Remarks

Although the use of regional-scale, geologically-constrained potential field inversions is still in its early days, the examples in this study show that the method is viable and produces useful results. Further work will allow us to evaluate the consistency of a broader range of geological scenarios with the observed potential field data, and to refine techniques for extracting information that is of value to studies of mineral potential.

Acknowledgements

PIRSA Mineral Resources Group provided ground gravity and airborne magnetic data, which were combined with data extracted from Geoscience Australia's national databases for use in the inversions.

This paper is published with the permission of the CEO of Geoscience Australia.

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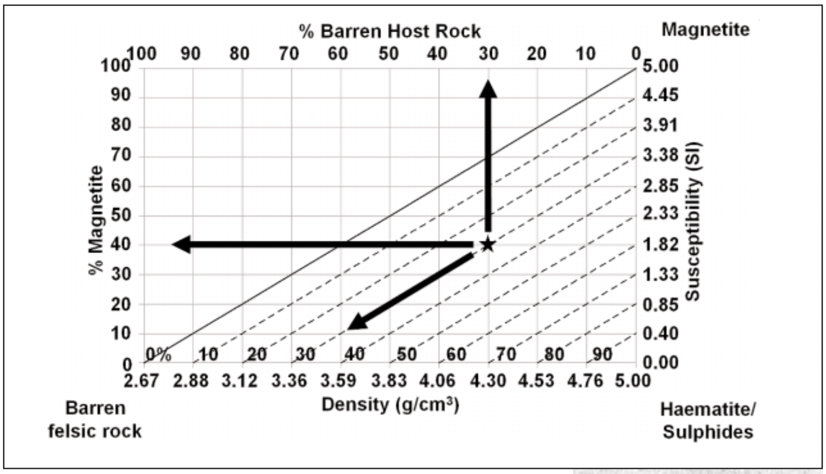


Fig. 4. Plot of susceptibility versus density showing how, for any given density-susceptibility pair, one can calculate approximate percentages of end-member alteration styles in a system dominated by magnetite and haematite/sulphide alteration (Hanneson, 2003).

Skirrow, R. G., Bastrakov, E., Davidson, G., Raymond, R. L., and Heithersay, P., 2002, The geological framework, distribution and controls of Fe-oxide Cu-Au mineralisation in the Gawler Craton, South Australia: Part II: Alteration and mineralisation; in Porter, T.M., (editor), Hydrothermal iron oxide copper-gold & related deposits: A global perspective, volume 2, PGC Publishing, Adelaide, 33–47.

Geoscience Australia

Geophysical data releases from Geoscience Australia

1. Australian National Gravity Database - March 2004 Edition

Geoscience Australia has released the 2004 edition of the Australian National Gravity Database (ANGD). This year's release contains some 192 000 more gravity readings than the 2003 Edition and the combined onshore and offshore point located data readings are now in excess of 1,200 000 stations. Included with the point located data is the 2001 Edition of the Gravity Grid of the Australian Region.

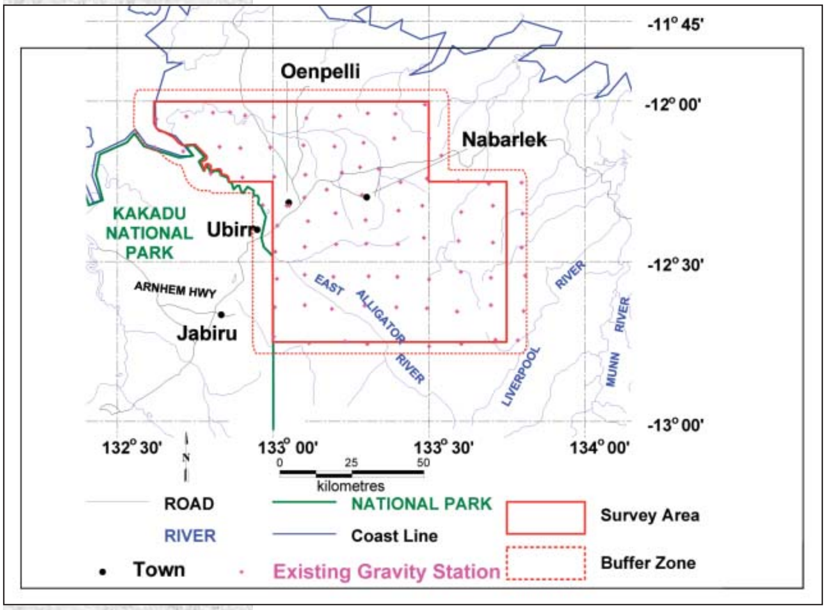


Fig. 1. Location of the West Arnhem Land airborne geophysical survey.

Data cover the area extending from 8° S to 48° S and 108° E to 162° E. All data are provided in GDA94 coordinates.

Both the database and grid may be downloaded free of charge from the GA website at: http://www.ga.gov.au/rural/projects/20011023_32.jsp, or by using the GADDS at http://www.ga.gov.au/gadds/. A CD-ROM containing the ANGD and grid may be purchased at a cost of $99.00 (including GST), plus postage and packing from GA, Email: sales@ga.gov.au

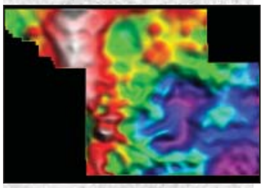


Fig. 2. Airborne survey using Bouguer data produced from the 107 second Kalman filter. The cell size for the grid is 400 m.

2. West Arnhem Land, NT, airborne gravity point located data and grids

In the February 2004 Preview (p. 20) an image of the preliminary results of the West Arnhem Land airborne gravity survey was shown. GA and the NTGS have now released the processed data from this survey. It comprised 4500 line-km of airborne gravity data. The survey was flown at a constant barometric flying height of 600 m along east-west flight lines at 2000 km spacing, with north-south tie lines at 20 km spacing. The specifications called for an rms error of <15 µm/s2 for the 107 s filtered data at the tie line intersections. The raw data were sampled at 300 Hz but final processed data are at 2 Hz.

These data were acquired as part of a joint project between GA, the NTGS, Cameco Australia Pty Ltd and Rio Tinto Exploration Pty Ltd. The survey was flown by Fugro Airborne Surveys Pty Ltd using Canadian Micro Gravity's GT1-A airborne gravimeter. The data-release includes the terrain-corrected gravity values presented as Complete Bouguer Anomaly values.

Figure 1 shows the location of the survey and the pre-existing gravity stations, Figure 2 shows the Bouguer data derived from the airborne survey and Figure 3 shows a Bouguer image derived from the pre-existing land based data set.

For more details see http://www.minerals.nt.gov.au/ntgs/conferences/Ages2004/AGES_info04.htm.

The data may be downloaded free of charge from the GA website at http://www.ga.gov.au/download/minerals.html, or from GADDS at http://www.ga.gov.au/gadds.

West Arnhem Land survey data and images can also be downloaded free of charge from the NTGS website at: http://www.minerals.nt.gov.au/ntgs/geophysics/regional_grav.html.

Alternatively, the West Arnhem Land airborne gravity data set is released on one CD-ROM, which also contains the March 2004 release of the entire Australian National Gravity Database (see above).

3. Burakin Region airborne geophysics release - WA

GA has also released over 147 000 line-km of airborne geophysical data over the Burakin area of Western Australia covering parts of the Ninghan, Moora, Bencubbin, Perth and Kellerberrin 1:250 000 Map Sheet areas.

This release comprises magnetic, gamma-ray and elevation located data and grids from a survey flown for GA in June 2003 and from three private company surveys flown between December 1996 and February 1997. The company data have been levelled with the Burakin survey data to create a combined dataset giving a continuous coverage.

All data have been gridded using variable density gridding with a 40 m fine cell and an 80 m coarse cell size, depending on the line spacing (200 or 400 m). The survey areas are shown in the diagram below (Figure 4).

All surveys were flown 60 m above ground level and the magnetic data were sampled every 0.1 seconds (~7 m) and the gamma-ray spectrometric data and GPS positioning data were sampled every second (~70 m). Images of the magnetic and radiometrics from this release are shown on the front cover of this edition of Preview.

The data sets are available using the GADDS at www.ga.gov.au/gadds. For more information about these or any other geophysical datasets, including acquisition specifications, please visit the GA website at www.ga.gov.au or contact: Mario Bacchin via Email: mario.bacchin@ga.gov.au.

New data acquired in WA

Geoscience Australia has contracted out an airborne magnetic, gamma-ray and elevation survey in the Cue and Kirkalocka area of Western Australia. The survey should start in late March 2004.

Approximately 55 437 line-km of airborne magnetic, gamma-ray and elevation data are being acquired along flight lines flown at 400 m apart at 60 m above ground level in an east-west direction.

The new datasets will be released in the second half of 2004.

SpectrumData wins three year Geoscience Australia contract

SpectrumData has been awarded a three year multi-million dollar contract by Geoscience Australia.

The contract, the largest of its kind ever awarded in Australia, is to remaster GA's vast collection of petroleum exploration data onto high density 3590 cartridges.

Over the course of the three year program, some 400Tb of data will be processed to achieve an 85% reduction in the warehouse space required to house these valuable data sets. In addition, all data will be reformatted into industry standard demultiplexed formats increasing the accessibility of the data for future exploration initiatives. The funding for this work was allocated in the 2003/04 Commonwealth Budget.

The Federal Minister for Energy and Resources, Ian MacFarlane referred to the data as "some of the most precious data imaginable for companies considering mining exploration of any sort in this country".

Due to the age of many of the data sets, it is expected that a significant proportion of the tapes will be suffering from damage or deterioration. SpectrumData hopes to achieve a better than 98% recovery rate.

SpectrumData, formally part of Encom Technology, is the largest Australian owned data transcription and duplication company in the country. For more information please contact: Guy Holmes on Tel: 08 9470 6844.

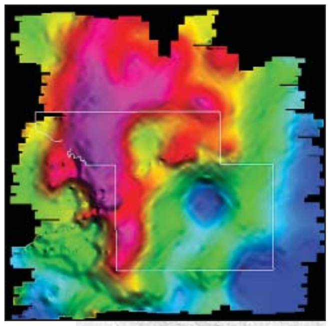


Fig. 3. Image with a cell size of 400 m produced by the variable density technique whereby the gridding process begins with a coarse cell size (say 2400 m) and ends with a smaller cell size (400 m).

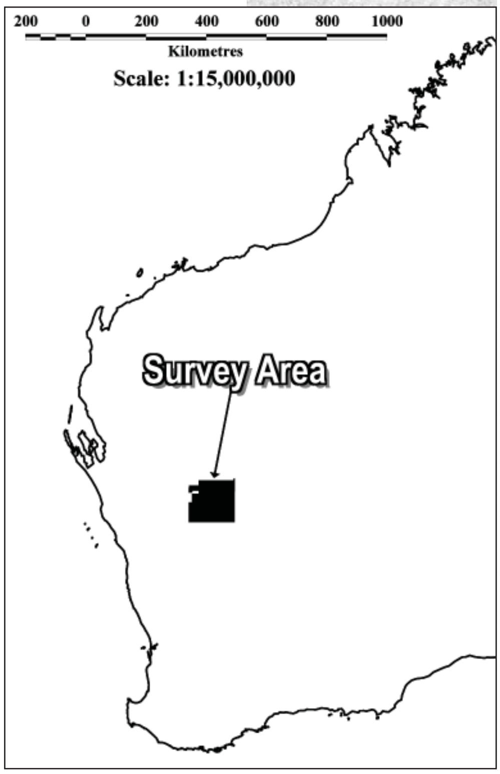


Fig. 5. Location of the Cue and Kirkalocka airborne survey.

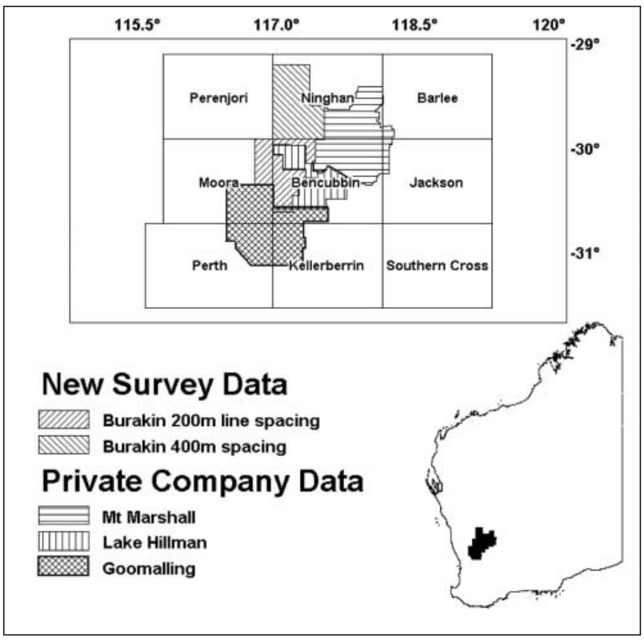


Fig. 4. Location of the surveys in the Burakin data release.

Geological Survey of WA

Airborne geophysical coverage in WA to double over four years

On 10 February, the Western Australian Premier, Geoff Gallop, outlined a plan to invest an additional $12million over the next four years to double the area of the State covered by high-tech aerial geophysics.

The Premier said the move, which he hoped would be matched dollar-for-dollar by the Commonwealth, would reverse a worrying decline in WA's market share of world exploration.

The priority areas for exploration are:

- Murchison-Gascoyne and the eastern Wheatbelt, which are highly prospective for nickel and gold;
- the Esperance through to Warburton area, which is poorly understood and largely unexplored but which has potential for large Broken Hill-style base metal deposits;
- the Musgrave-Arunta area adjacent to the state's eastern border; and
- the nickel, base metals and diamond bearing areas of the Kimberley.

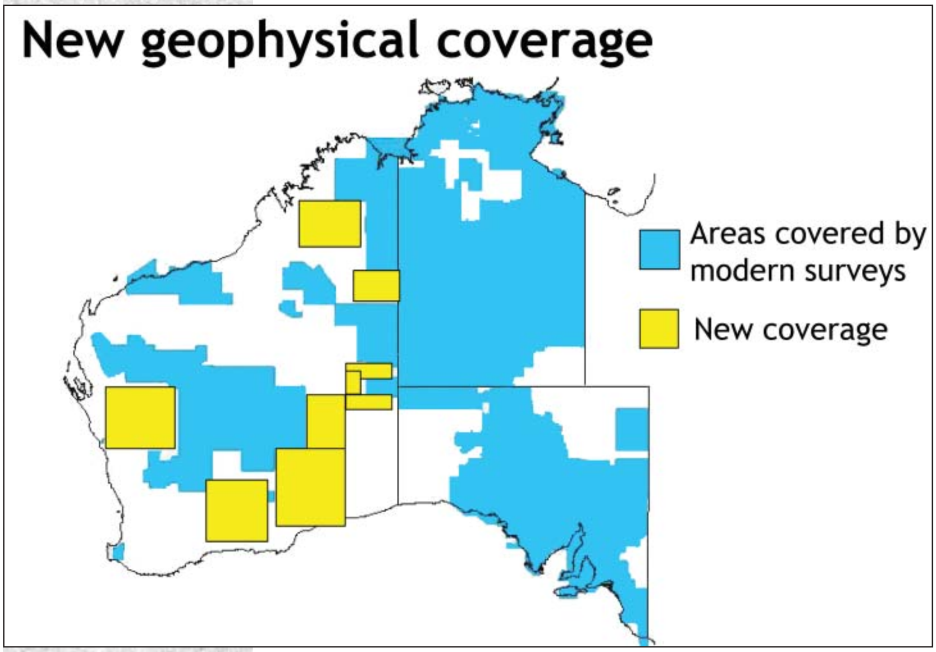
In addition to the new geoscience information, Dr Gallop said the government would provide an additional $2.1million over three years for a range of other mining and exploration initiatives.

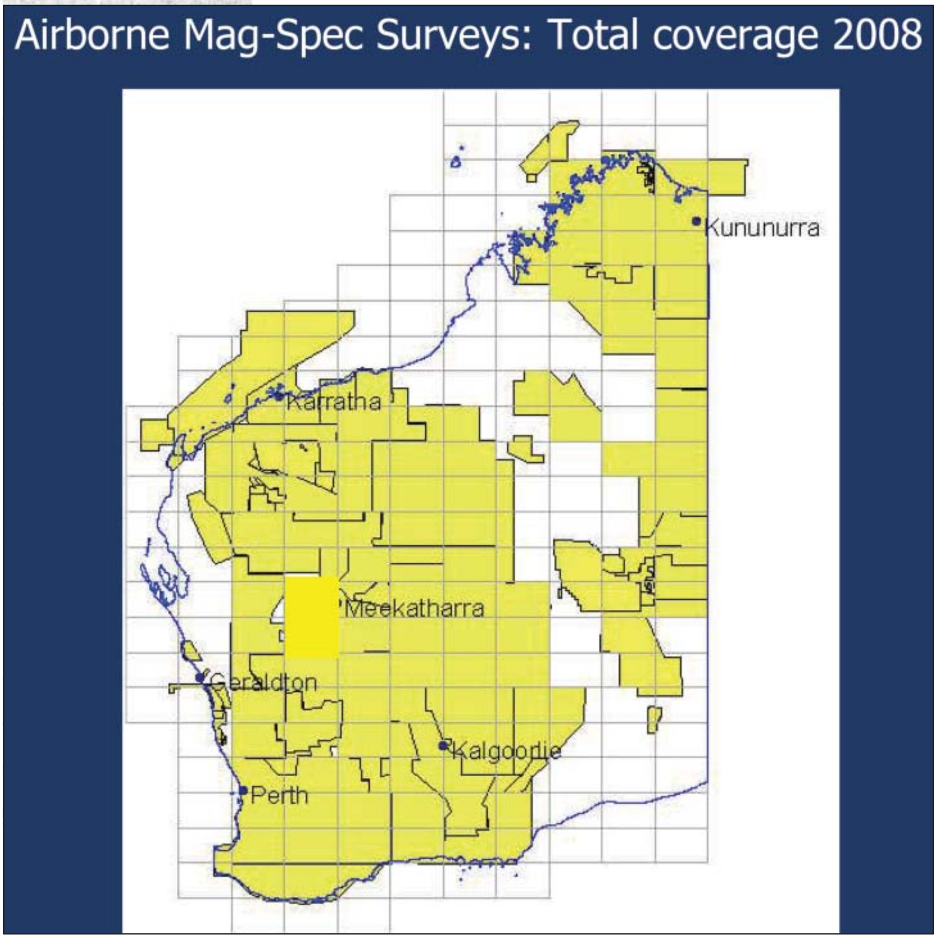
This includes releasing mineral exploration data contained in 13,000 reports collected during past exploration activities and which have been gathering dust in the government's back room - in some cases for 20 years. The reports represent $2 billion worth of archived exploration information.

The government will also amend the *Mining Act 1978* this year to ensure that in future, mineral exploration data is released after five years so the whole industry can share the knowledge.

In addition, funding will support the management of the transfer of Mining Lease applications to Exploration Licenses, another aspect of the proposed amendments to the *Mining Act 1978*.

The two figures below show the current situation, with the new data that has been acquired recently and the planned coverage in 2008. Notice how the coverage in the Northern Territory is superior to that over both South Australia and Western Australia.





Geoscience Victoria

More on the restructure[1]

The Geological Survey of Victoria and Petroleum Development Branch were merged on 16 February 2004. The announcement by Richard Aldous Executive Director, Minerals and Petroleum Division stated:

"The changes are simple and will involve no job losses. The objective is to capture and integrate our business processes around key functions, and to build the capability in policy, business development and technology. The key changes are as follows:

1. The geo-science and information functions of the Geological Survey of Victoria and Petroleum Development Branch will merge. The role of this newly formed branch is to attract explorers and exploration dollars to Victoria. It will continue to provide regional, state-of-the-art, relevant, high quality geoscience information essential for project generation and servicing the exploration sectors.

This new structure will allow for and encourage the:

- sharing of geo-science knowledge and capability;
- capture of synergies in processes associated with marketing and customer service, as well as other business processes;
- maintenance of a focus on the discrete needs of minerals and petroleum customers;
- capture of synergies associated with the collection, manipulation, analysis and interpretation of considerable quantities of geoscience data; and
- the pursuit and use of next generation science and technology to assist our mission.

The new branch will be called GeoScience Victoria and Kathy Hill (former Federal President of the ASEG) will be the new Director.

The brand name, 'Geological Survey of Victoria' will be retained.

2. The facilitation functions will join and become part of a new branch called Business Development and Technology (BDT). This branch will not only continue to facilitate investor's development projects, but will be responsible for the emerging technology strategy, including facilitating technology development and transfer in the resources sector. The role of BDT is to reduce obstacles for investors and to encourage new technology and its application to Victoria's earth resources development.

This new structure will allow:

- the integration and optimisation of processes for facilitation, approvals, EES process and cross government facilitation; and
- stronger technology capabilities to manage Victoria's interest in earth resources related technology, and use this for business development and better outcomes in the resource sector.

John Lambert will head the Technology Development function, manage and coordinate Minerals and Petroleum R&D interests, and interface with industry, other government departments and research providers.

VIMP launch

A wide range of geoscientific products, including geology and regolith maps, geophysical interpretations, GIS CDs, web mapping application updates and digital open file exploration data, will be showcased at the 16th Victorian Initiative for Minerals and Petroleum (VIMP) data release and seminar on 25 May 2004.

The VIMP program has been a major success over the last eight years creating Australia's most comprehensive geoscientific data package over the entire state. The program has funded statewide airborne magnetic and other surveys and a vast program of geological mapping right across the state that helped stimulate a major expansion of the minerals and petroleum exploration effort in Victoria.

The results of new geological mapping in the Glenelg area of western Victoria and the Buffalo 1:100,000 mapsheet area of north east Victoria will be provided with accompanying reports.

New insights into the geology, geophysics, economic geology and landform evolution are provided in each of these areas.

To further target exploration work, a regolith-landform map and report for the Ararat - Stawell area will also be released. The major regolith material has been defined and placed in a landscape context, with additional work on regolith geochemistry over the Mt Ararat copper deposit and the Stawell Big Hill gold deposit.

The release of the interpretation of geophysical data over the St Arnaud 1:250,000 mapsheet area continues the series of basement geology interpretation maps and reports in areas covered by a veneer of sediment, to assist in exploration for gold and base metals.

Mineral exploration stagnates but petroleum increases to three year high

Minerals

Figures released in March 2004 by the Australian Bureau of Statistics showed that the trend estimate for mineral exploration expenditure was relatively flat throughout 2003, after rising in the previous four quarters. The trend estimate for the December 2003 quarter ($184 M) is now 2.9% higher than in the December quarter 2002. Figure 1 shows plots of the data from December 1995 through to December 2003.

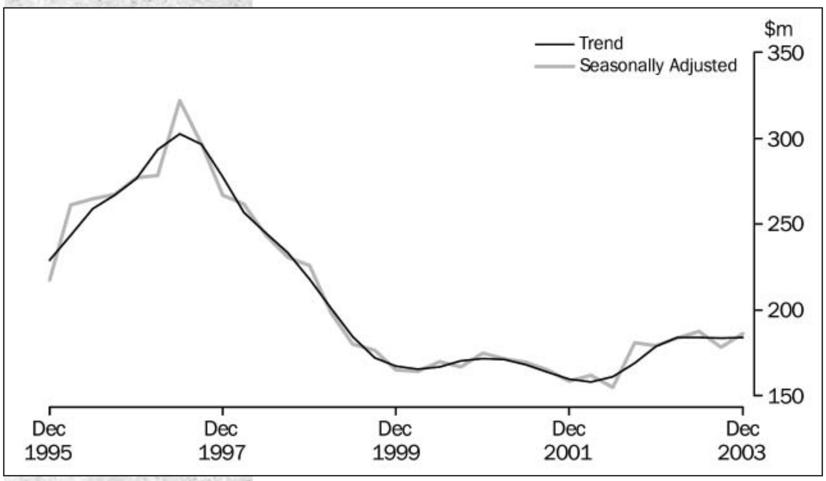


Fig. 1. Trend and seasonally adjusted quarterly mineral exploration expenditure from December 1995 to December 2003 (provided by the Australian Bureau of Statistics).

The trend for most states and territories was also flat, with increases in Western Australia ($103 M -$111 M) almost cancelling out falls in the Northern Territory (from $16 M to $10 M).

In actual dollars invested WA continues to dominate. Of the total of $199.5 M spent in the December quarter, $122 M was spent in WA. Queensland ranked second with $31.2 M followed by NSW ($14.8 M), Victoria ($10.6 M) and the NT ($10.3 M).

The trend estimate for metres drilled was also very stable with a very small decrease of 0.4% to 1336 km after four consecutive quarters of growth. However, the current estimate is 13.1% higher than the December quarter estimate for the previous year.

In terms of commodities, out of a total of $199.5 M, gold was the most sought after ($93.1M) followed by coal ($24.1 M) and nickel/cobalt ($22.8).

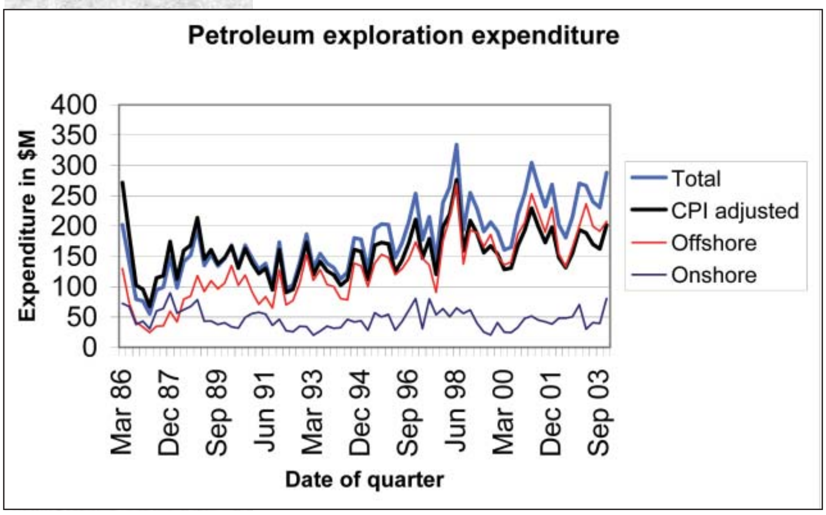


Fig. 2. Quarterly petroleum exploration expenditure from March 1986 through December 2003 for onshore and offshore areas.

Petroleum

In the December quarter 2003, expenditure on petroleum exploration rose by $57.4 M (24.9%) to $288.1 M, the highest level since March 2001. Expenditure was $17.7 M (6.6%) higher than in the December quarter 2002. There was a significant increase in exploration on areas other than production leases (up $68.1 M or 37.0%), while exploration on production leases fell by $10.7 M (or 23.0%).

Onshore exploration expenditure recorded a substantial increase of $41.3 M (105.1%), mainly as a result of onshore drilling. Offshore exploration increased slightly by $16.1 M (8.4%), with a rise in non-drilling activity offsetting a fall in drilling.

Western Australia with $188.2 M out of a national total of $288.1 M again dominated the petroleum exploration scene. The next best state was Queensland with $36.5 M, way behind.

Figure 2 shows the exploration investment from March 1986 through December 2003. Notice that since the beginning of 1998 the expenditure has been flat, give or take the large scatter due to the high cost of offshore drilling and seismic surveys.

According to Metals Economics Group's (MEG's) recent edition of Corporate Exploration Strategies, worldwide allocations for commercial nonferrous metals exploration are up by about 26% from 2002, representing the first increase in worldwide spending since 1997's exploration peak.

Worldwide nonferrous exploration spending steadily increased through the early 1990s to a crest of $5.2 billion in 1997, before falling for five straight years to a ten-year low of $1.9 billion in 2002-an overall decline of more than 63%. The table below shows the changes from 1993 through 2003.

Figure 3 shows the worldwide exploration expenditure by region. Canada is the dominant force on a national basis, with Australia coming in second place. However, Africa has surpassed Australia for the first time.

The bulk of the overall increase in junior spending this year is allocated to Canada, as many Canadian juniors have

Global expenditure on non-ferrous metal exploration starts to rebound

taken advantage of the combination of an improvement in mining equity investment and Canada's super flow-through share program to boost domestic exploration. It is anticipated that Canadian domestic exploration spending will continue at a high level over the next two years.

This is really a wake-up call the government here to take some real action in the May budget to encourage more mineral exploration.

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

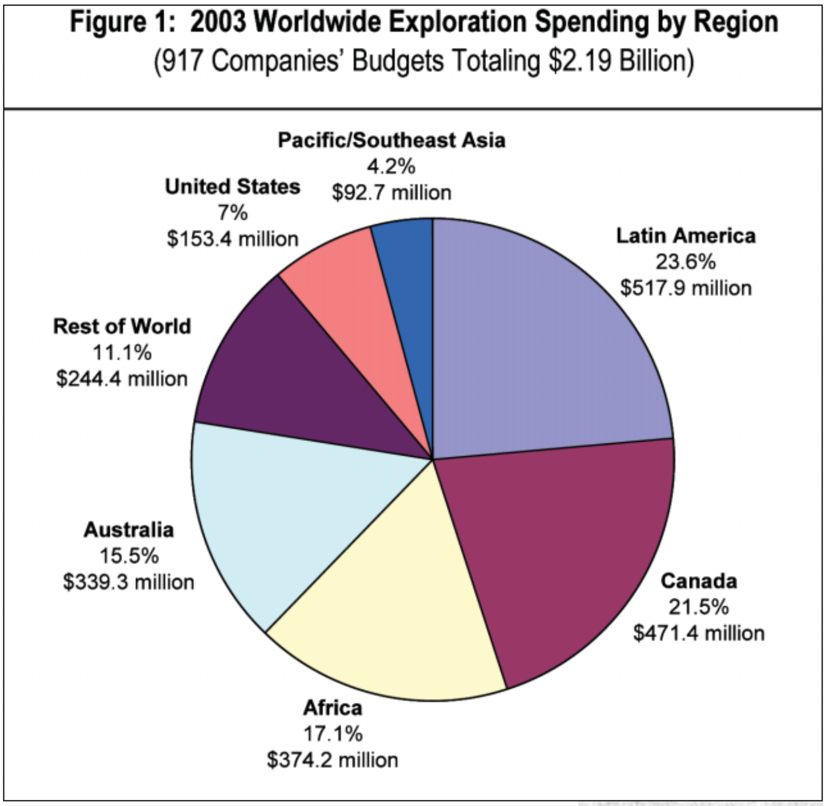


Fig. 3. Pie chart showing the worldwide exploration expenditure by region in 2003.

Why attend technical conferences?

Technical conferences can provide you with exposure to a wide range of resource technologies and case histories that are relevant to your job. Whereas the expanded abstracts represent a useful summary of the speaker's knowledge of the subject, attending the actual presentation gives you access to the speaker's experience of, and enthusiasm for, the subject matter. Logic gaps are more apparent and sometimes a lot of confidential information that doesn't make its way into print will be available as spoken asides or the answers to questions.

Conference delegates can benefit by attending sessions that are peripheral to their field of study. In this manner, they can gain insight into associated technologies that have application to their own studies. Exploration results from the other side of the world may be immediately applicable to local situations. Parallel technical sessions also increase the prospects of finding interesting subject matter most of the time.

Furthermore, by attending a talk or two in a field you are not too familiar with you can exercise the mind and hopefully find elements of relevance that could be employed back in the office.

In addition to the technical sessions, the exhibition area provides an excellent means of experiencing a large number of technologies and services to the industry. Attending delegates can talk to associates and contractors in an informal environment and comparisons can be made from the displays and demonstrations by competing exhibitors.

Useful information from conferences can be shared with colleagues back in the office and any results pertinent to the company's operations can be emphasised. By attending the conference you are gaining important knowledge and are therefore working profitably for the company.

Attending a conference is not only about self-improvement and hard work. After the presentations end at 5 pm, there is time to network with old friends and future associates.

Phillip Cooney
March 2004

Environmental Magnetism: Principles and Applications of Enviromagnetics

By Michael E. Evans and Friedrich Heller

Volume 86 in the INTERNATIONAL GEOPHYSICS SERIES, a series of monographs and textbooks edited by Renata Dmowska, James R. Holton and H. Thomas Rossby

*Academic Press (an imprint of Elsevier Science), 2003, 299 pages, hardback, A$210.65,
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Size: 162 x 235 mm*

*Reviewed by Peter Milligan
Peter.Milligan@ga.gov.au*

This book is concerned with the occurrences and uses of magnetic minerals in the natural and cultural environment. Most substances in the earth exhibit magnetism to some degree, and iron associated with magnetic minerals is one of the most common substances. Magnetism developed in suitable materials can provide a natural tracer of former environmental conditions and processes, and also the timing of such processes.

The aim of the authors is "to provide sufficient groundwork to allow advanced undergraduates, graduate students, and interested professionals (all of diverse backgrounds) to grasp the essential aspects of magnetism, mineralogy, and the many processes by which the observed magnetic signals are encoded in the various natural archives". Considering the scope of the topic, the authors do well, with a large section devoted to the theory, and many practical examples. For such studies knowledge is required of the magnetic substances involved, of their relevant magnetic properties and of the measurement and analysis techniques used, and these are well catered for.

The book contains 12 chapters, an appendix, glossary, references and index, and has a foreword by Subir K. Banerjee of the Institute for Rock Magnetism, University of Minnesota.

It starts, after the Introduction, with three chapters containing the basics of magnetism relevant to environmental studies: Basic Magnetism in Chapter 2, Enviromagnetic Minerals in Chapter 3 and Measurement and Techniques in Chapter 4. Chapter 5, Processes and Pathways, outlines how magnetic minerals get into soils, aeolian deposits and water-laid sediments, either by complex physical, chemical and biological mechanisms or by various other means of transportation. In Chapter 6, the concept of time, and attempts to assign a chronology to sequences of events, is discussed. This includes details of time variations of the geomagnetic field, and how they may be used for dating purposes. Chapter 7, Magnetoclimatology and Past Global Change explores the relationship between magnetic properties and climate/past climates/climate change particularly using examples from sedimentary deposits preserved in a variety of settings. The remaining chapters, using a variety of examples, concentrate on Mass Transport (Chapter 8), Magnetism in the Biosphere (Chapter 9), Magnetic Monitoring of Pollution (Chapter 10), Archeological and Early Hominid Environments (Chapter 11) and, finally, a short Chapter 12 on Our Planetary Magnetic Environment.

There is a brief Appendix outlining magnetic units in the SI and CGS systems, followed by a comprehensive glossary and references.

A presentation technique used in the book is to reserve detailed technical explanations to separate boxes, so they don't hinder the main flow of discussion, and the reader can refer to them separately if inclined.

This work could be used as a textbook for beginning graduate students with a background in physics, as well as for specialists in biology, archaeology, or atmospheric pollution, or for others who are curious about the strengths and weaknesses of environmental magnetism as a tool of choice. The high price may prevent widespread use, and relegate its role to being a reference work in libraries.

Nevertheless, it is a very high-quality hardcopy edition, which you would expect with a price tag of over $200. There are illustrations on almost every page, although colour plates are restricted to four pages in the centre of the book, where they duplicate the same illustrations in black and white at appropriate locations in the text.

Michael E. Evans is at the University of Alberta, Edmonton, Canada, and Friedrich Heller is at the Swiss Federal Institute of Technology, Zurich, Switzerland.

Copies of this book can be purchased direct from Elsevier Science Customer Service (phone: 1800 263 951; fax: (02) 9517 2249; email: service@elsevier.com.au; web site http://www.academicpress.com).