Preview

Australian Society of Exploration Geophysicists

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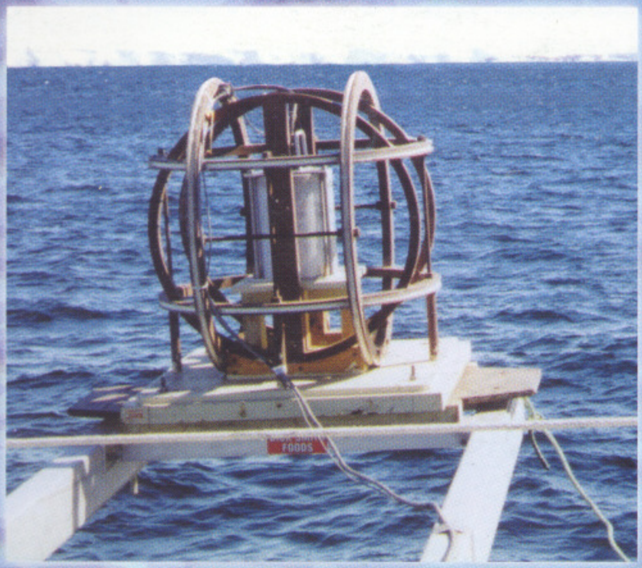

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by Charles Barton

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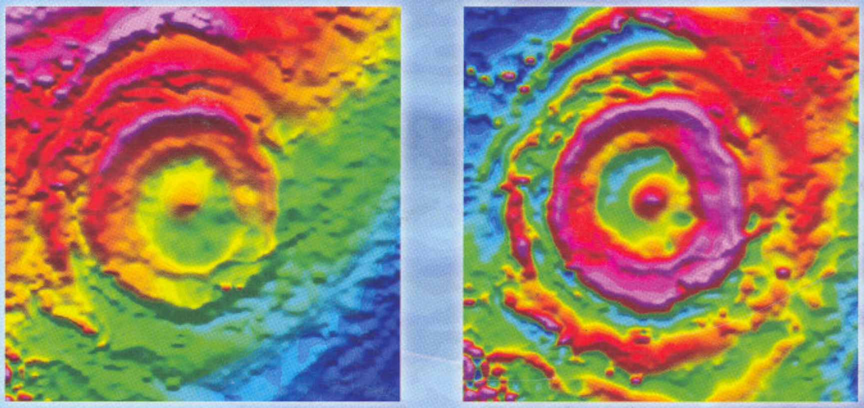

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Editor's Desk

Well a lot has happened since we all met in Brisbane, and the world is now a very different place. No World Trade Centre in New York, no ANSETT, no Pasminco, Normandy may be swallowed up and more mergers on the way.

It can be difficult to focus on things geophysical, but come what may, we are still going to need new ore deposits, more petroleum resources and better management of our environment. In other words, the ASEG is still going to be very relevant for the foreseeable future.

In this issue we review the Brisbane Conference, look at the National Salinity Program, Gamma Rays, the Northern Territory, Impact Craters and the South Magnetic Pole. In other words, a real feast of different applications for geophysics. So much so, that we have had to hold over the Branch News and Webwaves until December.

Eristicus is on holiday but, in his absence, I might mention a couple of matters that crossed my desk in the last month.

Major National Research Facilities Program announced

The first was the announcement by the Minister for Industry, Science and Resources, Senator Nick Minchin on 21st August of the allocation of $155 million under the Commonwealth Government's Major National Research Facilities (MNRF) Program for fifteen new research centres. The MNRF Program was announced as part of the Commonwealth Government's $3 billion Backing Australia's Ability statement, as a five-year commitment to strengthen innovation.

Unfortunately only one of the 15 proposals is in the geoscience sector. Nevertheless, congratulations to Peter Mora from the University of Queensland for his successful proposal to establish The Australian Computational Earth Systems Simulator (ACESS) which will consist of:

"Integrated software systems for multi-scale, multi-physics simulations and visualisation of earth systems combined with thematic parallel supercomputer hardware required for three-dimensional earth simulations. ACESS will be located at the University of Queensland, with nodes in Melbourne and Perth.

ACESS will provide an advanced computational virtual earth laboratory serving the Australian earth science and industrial communities. The facility will support earth systems and science and technology innovations, hazard management and environmental management through the 21st century. [It] will provide a national focal point for scientific and industrial earth systems simulations to form, together with climatic and oceanic research, a holistic earth simulation capability.

ACESS will provide scientific breakthroughs, new predictive minerals exploration capabilities, and industrial innovations." The funding from the Commonwealth will amount to $4.8 million.

For further information contact Peter Mora
Tel: 07 3365 2128

The Value of Petroeum R&D

The second, is a report from the Australian Petroleum CRC which contains an analysis by Mark Matthews on 'The Value of Petroleum R&D in Australia' The report indicates a very high rate of return on investment in R&D to the tune of $27 for every CRC dollar invested. The analysis concludes that the value (NPV) of global technological advances to the Australian upstream petroleum industry over the period 2000-2010 will be ~$9 billion; and the value of technological advance that addresses specifically Australian problems will be ~$3 billion. In other words we should be spending more on R&D in Australia. Copies of the Report can be obtained from the APCRC in Canberra (Tel: 02 6200 3366).

AUSLIG to Join AGSO-Geoscience Australia, and Digital Data to be Free

AUSLIG, Australia's National Mapping Agency, will be joining AGSO-Geoscience Australia as part of a reorganisation in the Department of Science, Industry and Resources. Although not yet physically located in the same building, the changes will bring together the two main government institutions dealing with publicly available spatial data sets. This should lead to a better deliverables of information for explorers, and land managers.

At the same time the merger was announced Senator Minchin also announced:

The formation of a single organisation to represent business interests in the Spatial Information Industry- the Australian Spatial Information Business Association; and
Provision of free access to on-line government-held fundamental spatial data, in line with the recommendations of the Commonwealth Interdepartmental Committee on Spatial Data Access and Pricing.

It looks like AGSO's geophysical data will now be available on line and at no cost.

Changes in the Preview Editors

Preview is well served by four associate editors, who not only contribute articles, but also are active in soliciting new material and providing editorial advice from time to time.

We now have a new Minerals Associate Editor, Peter Fullagar. I would like to welcome him to his new position and to thank Steve Mudge for the contributions he has provided in that role over many years.

We are always on the lookout for interesting new material so if anyone has any suggestions, please don't hesitate in contacting either one of the associate editors or myself.

Happy reading

David Denham

This is a guest Editorial by Katherine McKenna, who has recently joined the Federal Executive as ASEG Vice-President.

ASEG - Past, Present and Future

The Brisbane ASEG Conference should be seen as one of the highlights of the year within the geophysical world. The Conference was extremely well attended, the standard of the papers presented was high and the level of participation by exhibitors was encouraging in the present economic environment.

The Conference was also truly international with numerous members attending from overseas. An agreement was signed between ASEG and SEGJ, whereby SEGJ will become an Associated Society of the ASEG and representation from the SEG and EAGE.

It was an honour to meet Mr Satoru Ohya, President of the SEGJ. It was interesting to learn that the role of geophysics in Japan was so focused on environmental and engineering issues rather than exploration and mining.

The reasons for the success of the Conference definitely lies with the effort of Jenny Bauer, Nick Sheard and the organising committee and all should be extremely proud of the Conference and the results.

Membership

The ASEG Conference had many members attending and also attracts an increase in new membership. We hope that over the following months these new members see the benefit of remaining a member of the ASEG.

Changes in Exploration

A topic of conversation that was raised endlessly at the Conference was the merging of companies, not only mining companies but also within the service industry. In the last number of years we have seen such merges as BHP-Billiton, Rio and North, the formation of Fugro Airborne Surveys and the government intervention with the Shell Woodside proposal. Further rumours still exist and one imagines that the story has not ended. This current situation offers a challenge to the role of geophysicists and the ASEG and we should look at the role ASEG can play. An example of this was the Career Management Seminar that was held at the Conference. This was well attended and from initial reports strongly accepted.

The Soapbox

As this is my first time in writing the President's Piece I feel I should be able to stand on the soapbox for at least one subject. 2001 is the year of the volunteer and it should be recognised that there are a number of people within your own State Branches, within the Federal Committee, Sub-committees and the conference organising committees that all give their time free of charge, as volunteers. This, as those involved know, means working at night after working a full day or during family time or on weekends; times that could be spent doing other relaxing fulfilling things. The question should be asked well, why do they do it? It must be the belief in the ASEG, the commitment to the development of geophysics, the enjoyment of working with your peers and a commitment in seeing that the ASEG continues to provide a service to its members. To be honest these are actually my own thoughts and you really should take time to thank these people and ask possibly at your next branch function why do they put the effort in. It is the volunteers that enable the ASEG to continue and it will be volunteers that will see the ASEG continue in the future. The ASEG, as a society will only be as good as the effort we put into it, only as interesting and innovative as we make it and only as successful as the members that participate in it allow it to be. I urge you to, if you have the time, to play an active role in the ASEG, be it attending your local branch activities, presenting new ideas at a local meeting, writing an article for Preview, or volunteering to help at a local branch level or as a committee member.

Katherine McKenna
First Vice-President

Katherine graduated from Macquarie University in 1988 with a BSc. She worked the following 2 years as a geophysicist for Lachlan Resources following magnetic anomalies across NSW and New Zealand. In 1990 Katherine worked for Austirex International (World Geoscience) as a geophysicist working in airborne magnetic and radiometric processing and interpretation. She covered areas throughout Australia and overseas in mineral and oil exploration. After 7 years, she took on consulting work, interpreting airborne magnetic data under the banner of Toronga Resources and then as Anomaly Solutions working in areas such as Oman and Fiji.

In 1999 Katherine joined Geoterrex-Dighem as manager of Interpretation and Processing and is currently holding the same role with Fugro Airborne Surveys.

Katherine is a member of the ASEG and SEG, and has been actively involved with the ASEG for a number of years. She has served on the NSW and WA Branch Committees, the Organising Committee for the 1997 ASEG Conference in Sydney, and is presently First Vice President of the Federal ASEG.

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Contents

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Material published in Preview aims to contain new topical advances in geophysical techniques, easy-to-read reviews of interest to our members, opinions of members, and matters of general interest to our membership.

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

Deadlines

Preview is published bi-monthly, February, April, June, August, October and December. The deadline for submission of all material to the Editor is the 15th of the month prior to issue date. Therefore, the deadline for editorial material for the December 2001 edition is 15th November 2001.

Advertisers

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

Advertising copy deadline is the 22nd of the month prior to issue date. Therefore, the advertising copy deadline for the December 2001 edition is the 22nd November 2001.

New Members

Triegue Allen	Curtin	WA
Alan Anderson	BHP-Billiton	Vic
Ian Eric Andreasen	MIM	Qld
George David Collier	Santos	Qld
Eslbm Ahmed Elawadi	Kyushu Univ	Japan
Lars Folke Engelmark	Western-Geco	Malaysia
Megan Evans	Total Depth	WA
Muhammad Farooq		NSW
Neil Fraser	Gravitec	NSW
David Gibbons	U of Tas	Tas
V Grauch	USGS	USA
Ross Gwyther	CSIRO	Qld
Alastair Haldane	NCPGG	SA
Zsolt Hamerli	Santos	Qld
Bryce Robert Hamilton	QUT	Qld
Stephen Hayes	QUT	Qld
Gary Hodgkingson	De Beers	Canada
Jens Hovgaard	Hovgaard	Canada
Daniel Paul Howe	QUT	Qld
Anthony James Jervis	NCPGG	SA
Anre Jorster	De Beers	South Africa
Victor Labson	USGS	USA
John Patrick McMonagle	Velseis	Qld
Asmita Mansi Mahanta	BHP Minerals	Vic
Mahmoud Majedi	Santos	SA
Richard Marshall	IPS	NSW
Jacqueline Mascini	QUT	Qld
Adam Miethke	QUT	Qld
Paul Moorfield	Santos	SA
Wes Nichols	Callide Coalfields	Qld
Luke David Nothdurft	QUT	Qld
Michael O'Connell	Fugro	Canada
Angela O'Rourke	QUT	Qld
John Parrish	Periseis	USA
Hugh Patterson	Precision Expl	NSW
Jeffrey Phillips	USGS	USA
Paul Rampant	Natural Res & Env	Vic
Craig Roberts	Peak Gold	NSW
Ian Scott	WMC	Vic
Gregg Spencer	Santos	Qld
Peter Mitchell Stone	BHP Billiton	Vic
Peter John Todd	Dept Nat Res & Mines	Qld
Chris Wallace	De Beers	Canada
Paul Wootton	RW Associates	NSW
Jacek Zbik	NCPGG	SA

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Email: guy@encom.com.au

Calendar of Events

2001

November 25-28
Eastern Australasian Basins Symposium 2001 - New Guinea, East Australia, New Zealand
Co-ordinated by the Victoria/Tasmania Branch of Petroleum Exploration Society of Australia
Theme: A refocussed energy perspective for the future
Melbourne Hilton on the Park, Melbourne
Contact: Miriam Way, EAB Symposium, AusIMM
PO Box 660, Carlton South Vic 3053
Tel: (03) 9662 3166
Fax: (03) 9662 3662
Email: miriamw@ausimm.com.au

November 26-27
New Gen Gold 2001: New Generation Gold Mines Case Histories of Discovery Conference
Burswood Convention Centre, Perth WA
Organised by AMF and Keith Yayes & Associates Pty Ltd
Contact: Donna Biddick at the AMF
Tel: (08) 8379 0444
Email: NewGenGold@amf.com.au
Website:www.NewGenGold.com.

December 10-14
AGU 2001 Fall Meeting, San Francisco, Calif., U.S.A.
Sponsor: American Geophysical Union (AGU)
Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA;
Tel: +1 202 462 6900
Fax: +1 202 328 0566
Email: meetings@agu.org
Website: www.agu.org/meetings/

2002

February 10 - 14
Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP 2002), Las Vegas, Nevada
Sponsor: Environmental and Engineering Geophysical Society
Theme: Geophysics: The Next Generation
Contact: Becky Roland, EEGS, 720 S. Colorado Blvd., 960-S, Denver, CO, 80246.
Email:eegs@neha.org
Website:www.eegs.org

April 14-16
Global Exploration 2002
Denver, Colorado, USA
Organised by the Society of economic Geologists
Website: www.SEG2002.org

April 15-18
International Geophysical Conference and Exposition, Yogyakarta, Indonesia
Theme: Geophysics for Human Kind
Sponsors: The Indonesian Association of Geophysicists (HAGI), and the Society of Exploration Geophysicists (SEG)
Abstract Deadline: mid-August, 2001
Contact: Dr Wally Waluyo
Tel: 62 21 350 2150, ext.1434
Fax. 62 21 350 8032/351 0992
Email: wallywaluyo@pertamina.co.id

April 22-26
European Geophysical Society (EGS) XXVII General Assembly, Nice, France
Sponsors: EGS, American Geophysical Union (AGU)
Contact: EGS Office, Max-Planck-Str 13, 37191 Katlenburg-Lindau, Germany
Tel: +49 5556 1440
Fax: +49 5556 4709
Email: egs@copernicus.org
Website: www.copernicus.org/EGS/

May 12-17
International Association of Hydrogeologists, Australian National Chapter
International Groundwater Conference, Darwin, Northern Territory, Australia
Theme: Balancing the Groundwater Budget
Contact: Gary Humphreys
Email: Gary.Humphreys@nt.gov.au

May 27-30
64th EAGE Conference & Technical & Exhibition, Florence, Italy
Website: http://www.eage.nl

May 28 - June 1
2002 AGU Spring Meeting, Washington, DC, USA
Sponsor: AGU
Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA
Tel: +1 202 462 6900; Fax: +1 202 328 0566
Email: meetinginfo@agu.org
Web Site: www.agu.org/meetings

June 30- 5 July
16th Australian Geological Convention
Theme: Geoscience 2002: Expanding Horizons
Adelaide Convention Centre, Adelaide SA
Contact: info@16thagc.gsa.org.au
Website: www.16agc.gsa.org.au

July 9-12
Western Pacific Geophysics Meeting, Wellington, New Zealand
Sponsor: American Geophysical Union (AGU)
Contact: AGU Meetings Department, 2000 Florida Avenue NW, Washington DC 20009 USA
Tel: +1 202 462 6900
Fax: +1 202 328 0566
Email: meetinginfo@agu.org
Website: www.agu.org/meetings

September 22-25
Applied Structural Geology for Mineral Exploration and Mining Symposium, Sponsor: Australian Institute of Geoscientists
Venue: WMC Conference Centre, WASM, Kalgoorlie, WA
Contacts: Julian Vearncombe at vearncom@iinet.net.au or Jocelyn Thomson at aigwa@iinet.net.au

September 22-27
SEG International Exposition & 72nd Annual Meeting, Las Vegas, Nevada, US.
Website: www.seg.org

ASEG's 15th Conference an Outstanding Success

Overview

ASEG Conferences are very important for our Society. They present a unique opportunity for our members, from the resource industries, research institutes, government agencies, service providers and many others interested in things geophysical, to interact over a wide range of issues. The Brisbane Conference was no exception, and in spite of challenging times in the main industry sectors we had 546 registrants (of which 104 came from overseas), 68 exhibitors occupying 103 trade booths, as well as 129 papers and 35 posters. Very impressive for a society with less than 1500 members.

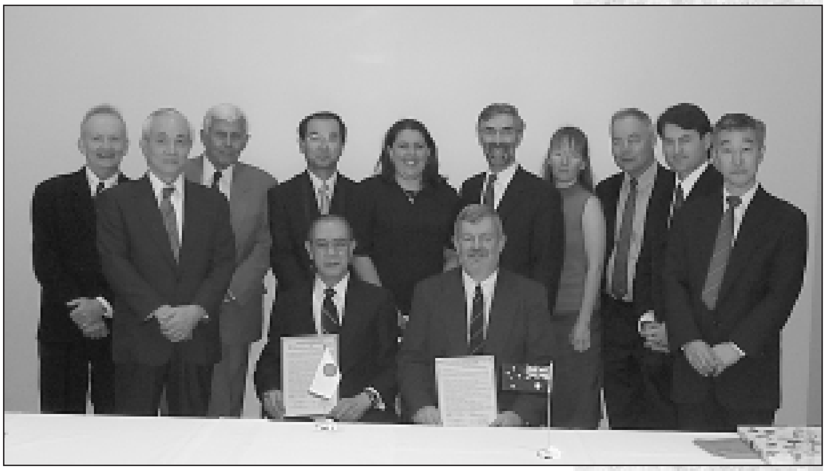
The Brisbane Convention Centre proved to be a very effective venue and Jenny Bauer and Nick Sheard's team are to be congratulated on a fine performance. The picture on the upper right shows some of the team captured in an informal pose at the Conference.

In an increasingly global industry it was good to have over 100 registrants from overseas. It was also fitting for the ASEG to strengthen its overseas interaction by signing an Agreement to increase our cooperation with the Society of Exploration Geophysicists of Japan. The picture on the right shows both teams at the signing ceremony.

What follows are a few snapshots of the Conference. We have material from the Opening Ceremony, the Dinner and the Awards presented as well as a collage of photographs assembled by Henk van Paridon.

I hope the words and pictures that follow bring back pleasant memories of the ASEG in Brisbane.

Some of the Conference Committee, from left to right: Darren Rutley, Andrea Rutley, Ian Young, Karel Driml, Steve Hearn, Randall Taylor, Jenny Bauer (Co-Chair), Koya Suto, Troy Peters, Natasha Hendrick, Voya Kissitch, Fiona Duncan, Nick Sheard (Co-Chair), Noll Moriarty, Henk van Paridon and Andrew Mutton. Not present for the photo were: Grant Asser, Michelle Axford, Gary Fallon, Nigel Fisher, Sydney Hall, Lindsay Horn, Richie Huber, Dan Mack, Michelle McMillan, Frank Nicholson, Kathlene Oliver, Terry Ritchie and Wendy Watkins.



SEGJ/ASEG Signing Ceremony: left to right: Dave Robson, Yoshinori Ishii (SEGJ former president), John McDonald, Yuzuru Ashida (SEGJ vice-President; standing) Satoru Ohya (SEGJ President, seated), Katherine McKenna, Tim Pippett (ASEG President, seated), Brian Spies (ASEG past-President) Suzanne Haydon, Mike Smith, Mark Russell and Koya Suto.

ASEG Awards at Brisbane 2001

Lindsay Ingall Memorial Award for *the Promotion of Geophysics within the wider community*

Greg Street

This new award is for the promotion of geophysics within the wider community to commemorate Lindsay Ingall, who passed away in 1999. Lindsay was one of the founders of the ASEG, and served our society and other geoscience organisations in many capacities. He had great communication skills, which contributed to his capacity to relate technically and effectively with other professionals, regardless of their own understanding of the principles of geophysics. This awards honours Lindsay for his capacity to comfortably cross geoscience boundaries and for his enduring commitment to assisting geoscientists and others in Australia.

Greg Street has played a significant role in expanding the application of geophysics into the environmental field. From encouraging fellow scientists to pursuing environmental causes and identify solutions, to educating parliamentarians, Greg's active role in the fight against salinisation and other environmental hazards has resulted in numerous public appearances and contributions to all forms of media. Not simply a spokesman for a cause, Greg has teamed with many influential geophysicists and environmental scientists to publish several papers on the application of geophysical techniques for environmental applications. He has supported and advised many students from all scientific backgrounds on the application and limitations of different geophysical techniques.

Greg began his career in 1974 with a BSc (Hons) in Geology from the University of New England. He worked as a geophysicist for Scintrex from 1976-1984, during which time he also completed an MSc at Imperial College, London.

Greg has worked with the Geological Survey of Western Australia, specialising in environmental and groundwater

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Snapshots from Brisbane 2001

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geophysical applications, before spending time with the Mackie Martin Group where he was responsible for the environmental, hyrodrogeological, engineering and mineral geophysical operations. For the following nine years, Greg worked for World Geoscience Corporation where he continued to apply geophysical methods to environmental and groundwater problems. During this time, Greg began to actively pursue the media and national figureheads to convince them of the success of the integrated approach to understanding, managing and solving dryland salinity problems. He is presently working with Sinclair Knight Metz as a geophysicist in the environmental field.

Typical of Greg's promotion of geophysics to the wider community was his coordination of the Salinity and Land Management Conference held in Bendigo this year. This Conference allowed landholders to actively discuss the problems and challenges they were confronting with the problem solvers, environmental scientists and geophysicists. Greg has also found the time to spend over nine years on various ASEG Committees including being the President of the ASEG and Chairman of an ASEG Conference. He is part-time lecturer, a supervisor of PhD students and has written in excess of thirty papers on environmental geophysical applications.

Greg Street has significantly helped educate the environmental and farming sector of our community about geophysically based solutions that were previously unknown to them. His work has had both national and international recognition, with publications and working solutions taking place both here and abroad. Whether behind the scenes, encouraging felloe scientists, developing new techniques, coordinating educational conventions or in front of the cameras or microphone, he is dedicated to bridging the gap between the farming community (those with the problem) and the geophysical society (those with the answers) and is a worthy recipient of the Lindsay Ingall Memorial Award

ASEG Service Medal for *extraordinary and outstanding service to the ASEG over many years*

Mike Smith

Mike Smith graduated with a BSc (Hons) and MSc from Sydney University in the early seventies.

He initially worked for the Bureau of Mineral Resources before spending 14 years with Exxon Minerals. In his time with Exxon he was variously based in Perth, Sydney, New York and Madrid, with responsibility for the design, implementation and interpretation of geophysical surveys in many different countries.

In 1985 he joined Austpac Resources NL as Exploration Manager and was responsible for exploration programs in PNG, Solomon Islands, Vanuatu, Fiji, New Zealand, Japan, Philippines and Bolivia.

Since 1996, Mike has been with Geo Instruments in Sydney as Manager for marketing and sales of helicopter-borne electromagnetic, magnetic and radiometric surveys.

Mike has a long history of voluntary involvement with geoscience societies. Apart from the ASEG, he has served three terms as President of the Australian Institute of Geoscientists, two terms as Vice-president, and is currently a Councillor.

Mike joined the ASEG in 1975 and first served in an executive capacity in 1976 as a FedEx Committee member. He became First Vice-President in 1977, Treasurer in 1978, and again served as a Committee Member in 1979.

After a break while he lived overseas, Mike jumped back in and became President of the ASEG in 1999. He is currently still on the Federal Executive Committee.

Mike has also always been actively involved in the ASEG Conferences whenever possible and has served on several Conference Committees.

Mike has been a truly 'active' member of the ASEG for over 25 years. Throughout his membership he has made a concerted effort to give something back to the profession and the Society.

Honorary Membership *for Distinguished Contributions to the Profession of Exploration Geophysics*

David Denham

David Denham has had a distinguished career in all facets of the geophysics profession, but has also gone beyond the work environment with various contributions to the professional societies and the support organisations that encompass our profession.

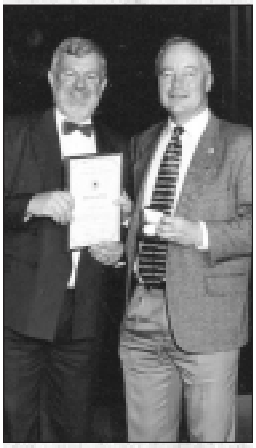
David's professional experience extends to most areas of geophysics. After obtaining his PhD in developing electrical resistivity techniques at Leeds University he joined British Petroleum as a research seismologist before moving to Australia in 1964 to work with the BMR.

After a period assisting with the administration of the Petroleum Search Subsidy Act, he moved to Papua New Guinea in 1965 to take charge of the geophysical observatory in Port Moresby. While there he set up a network of seismographs to monitor earthquakes in the region and used the results to estimate earthquake risk and study the tectonics of the region.

He returned to Australia in 1970 to work on earthquake risk and studies of the Australian crust from seismic sources. In the mid-1970s he compiled the first regional stress map of Australia, and set-up the Australian Seismological Centre in BMR in 1984. He was awarded an Order of Australia in 1985 for services to seismology.

He subsequently became Chief of the Divisions of Geophysical Observatories and Mapping, and Geohazards Land and Water before heading the Minerals Division until his retirement in 1999.

In addition to being a leading practitioner in geophysics, David has also made significant contributions to professional societies and geoscience support organisations. He was Chairman of the Governing Council



ASEG President, Timothy Pippet presenting Greg Street (top) with the Lindsay Ingall Memorial Award and Mike Smith (above) with the ASEG Service Medal.

ASEG President, Timothy Pippet presenting David Denham with Honorary Membership.

of the International Seismological Centre from 1994-1996 and President of the Geological Society of Australia from 1996-1998. For several years he wrote the 'Science in Government' column in the ANZAAS magazine Search.

He has been an active member of the ASEG for over 20 years, and in mid-1999 he took over as Editor of Preview, a role that he continues to the present. His contributions to Preview in particular, and to the ASEG publications in general, have been substantial.

More recently David is serving as President of the Australian Geoscience Council, through which office he has been very active in promoting the cause of the geoscience professions at the highest levels of government and business. He is also a Vice-President of FASTS.

The Society and the profession have benefited greatly from David's professional contributions and representations on behalf of the geoscience profession for many years, and it is fitting to recognize this with the award of Honorary Membership of the ASEG.

Grahame Sands Award *for Innovation in Applied Geophysics*

The Falcon Team of BHP-Billiton

Edwin van Leeuwen (Leader and Manager), Clive Affleck Mike Asten, Maurice Craig, Graeme Creer, Peter Diorio, Mark Dransfield, Nick Fitton, Giles Hofmeyer Gary Hooper, Jim Lee, Xiong Li, Ken McCracken, Tim Monks (deceased), Graeme O'Keefe, Marion Rose, Peter Stone, Bob Turner and Ken Witherly.

This award is based on an endowment made by members of the ASEG in memory of Grahame Sands, who was tragically killed at the prime of his life and career in an aircraft crash in 1986, whilst developing and testing new navigational equipment for geophysical survey aircraft.

Falcon is the name given to an airborne gravity gradiometry system developed by the team at BHP Research. Airborne gravity gradiometry has been the dream of many researchers in exploration geophysics for many years, with up to a dozen research efforts worldwide attempting to develop the technology over the past thirty years. The Australian team at BHP Research succeeded where all others had failed.

The Falcon system identifies small variations in the Earth's gravity field at wavelengths down to 200 m, with a low noise level that allows fast and cost-effective regional exploration for mineral and petroleum resources.

The project posed formidable technical problems. Gravity sensors are equally sensitive to the accelerations of an aircraft and to gravity. The GPS revolution improved the performance of airborne gravity systems to about 10 $\mu m/s^2$ sensitivity over 2 km wavelengths but it was clear that this technology would never deliver the performance required for exploration needs, particularly in the minerals industry. To be useful in minerals exploration, the airborne sensor must resolve a gravity signal over a million times smaller than the accelerations of the aircraft, and at the same frequencies that correspond to the peak in the aircraft

Some of the Falcon team; they are from the left: Graeme O'Keefe, Mark Dransfield, Xiong Li, Bob Turner, Edwin van Leeuwen, Jim Lee, Ken McCracken, Marion Rose, Maurice Craig, Mike Asten, and Peter Stone.

Absent were: Clive Affleck, Graham Creer, Peter Diorio, Nick Fitton, Giles Hofmeyer, Gary Hooper, Tim Monks (deceased), and Ken Witherley.

acceleration spectrum. Knowledgeable professors of physics quoted Albert Einstein, and said it was impossible.

The Falcon Team recognised that concepts and technologies developed for the US submarine fleet in the 1970s had the potential to provide what the mineral explorer needed, but a one hundred fold improvement over the submarine technology was required. The primary requirements were sensitivity, robustness and low operating costs. The smallest possible aircraft would be used, the system would be operated by the co-pilot, and the gravity images from a day's operation needed to be available for examination before the next day's flying. This meant an entirely new instrument based on the concepts and techniques partially proven by the US Navy.

BHP assembled a small group of high calibre people from its corporate technology laboratories and also outsourced to world-class laboratories and consultants. These included the universities of Newcastle (NSW), Braunschweig, Toronto, Calgary and Flinders, and Sanders Geophysical (the chosen aircraft contractor). Some unusual sources of technology were examined in detail, perhaps the most unusual being the Russian company that manufactured the inertial navigation systems for the Soviet ballistic missile program.

BHP's hardware contractor, Lockheed Martin, designed, manufactured and optimized the hardware with continuous and detailed involvement to Team Falcon.

The development of the applied mathematics, statistics, signal and image processing and software to convert the very noisy data from the gravity sensor into geophysical maps was conducted by the BHP research team itself. The magnitude of this achievement is hard to grasp (even by the participants).

The construction started in early 1996 and the system first flew in December 1997. The subsequent flight test and optimisation program ultimately took another 19 months.

A laser scanner was developed to map the topography to a high degree of accuracy, and to compute the gravity signal that needs to be subtracted from that seen by the gravity sensor.

A second level of noise reduction, yielding in the vicinity of a factor of a hundred in noise suppression, was developed as part of the image-making algorithms. The presence of this noise is due to the uncompensated short term mechanical variations in the characteristics of the sensor that are of the order of 1 part in 10**8. As such, the compensations are continuously time varying and must be entirely automatic in operation.

The system is flown in a Cessna Grand Caravan. Several other symbiotic geophysical technologies are flown on the aircraft with the gravity system; these include a stinger-mounted caesium vapour magnetometer, a Laser scanner system which, in combination with excellent differential GPS navigation, provides very detailed and accurate terrain mapping, and a scintillation spectrometer.

The aircraft acquires up to 1000-1500 km of data per day, typically at a line separation of 200 m and producing about 10 gigabytes of data. To allow the geophysical maps to be finished overnight, the signal and image processing computing system is part of the ground support system that travels with each aircraft, and is designed for operation by a data technician without specialist geophysical or numerical knowledge.

The instrument has achieved a performance that is a factor of three better than the initial design specification. The rejection of aircraft turbulence is much greater than expected, with the result that the system can successfully map the Earth's gravity field to the required accuracy in all flying conditions, restricted only by conditions of crew safety. This has a dramatic effect n productivity and keeping costs down. The resulting gravity data are comparable to ground gravity collected on a 200 m grid after upward continuation to the flying height, typically about 100 m above the ground surface.

Since October 1999, the Falcon systems have been in constant operation in Australia, South Africa and North America.

The Falcon Team's remarkable achievement is now acknowledged by the ASEG, through the presentation of the 2001 Grahame Sands Award.

ASEG Service Certificates for outstanding service to the ASEG

Alan Appleton

Alan Appleton is a geophysicist with the Department of Primary Industries and Resources, SA.

He started service with the ASEG in 1975 and has been continuously on the South Australian ASEG Committee for 26 years, which must be some kind of record. He has probably attended more ASEG technical meetings than anyone else in the State.

Alan has been a highly conscientious committee member over these many years and has always provided excellent input to all aspects of the Society. He also served on the Conference Committees for the Adelaide Conferences in 1988 and 1995.

This ASEG award recognises Alan for his continuous support of the ASEG at the grass roots level.

Graham Butt

Graham Butt started his geophysical career with Geoterrex in the early seventies and through his many years with the company, rose to become the Australian manager. He left Geoterrex in the mid-nineties and is currently Manager of Business Development with Encom Technology in Sydney.

Graham joined the ASEG in 1974 and has served in various capacities over the years on State, Federal and Conference committees.

He became ASEG Treasurer in April 1999, without prior association with the financial operations of the Society, or the benefit of working on the Executive or with the previous Treasurer. Accordingly he took on a substantial challenge, with the Society operating an annual turnover of around $900 000, including the financial arrangements of the State Branches.

In addition to coming to grips with these issues, Graham was truly tested by three other significant issues during his two terms as Treasurer:

- The Federal Government's Goods and Services Tax,
- The development of the contract with the new publisher for Preview, Exploration Geophysics and the Membership Directory, and
- Developing a working relationship with a new Secretariat.

Graham's approach to the requirements of the treasurer's duties was one of diligence and long hours, both at night and on weekends. He was clearly the hardest working committee member during this period, and he continued this sustained effort in the following year, until the demands of the voluntary function began to impact on his increased professional work commitments.

Graham tenaciously followed up any missing or misunderstood material, and was tireless in his pursuit of invoices and payments. He pursued the Secretariat, accountants and the auditors for detail, clarity and accuracy.

Kim Frankcombe

Kim Frankcombe gained his BSc (Hons) from the University of Tasmania in 1978.

He started his career with Stockdale Prospecting as a diamond geologist. He then spent three years with Mobil Energy Minerals Australia as a geophysicist specialising in uranium exploration.

Feeling a need for independence, he formed his own consultancy in 1983 and spent the next five years carrying out a very wide range of geophysical activities including placer gold exploration, opal exploration, ground water and engineering surveys.

Continued On Page 12

Alan Appleton

Kim Frankcombe.

The Need To Find More Metal

Vince Gauci
Managing Director of MIM

This is an edited version of Vince Gauci's keynote address presented at the Conference.

Exploration is the lifeblood of the Industry and geophysics will play an even more important role in the future, so I see this as an important conference and I appreciate the opportunity to address you today. Exploration is regarded as a key element in the continuing development of our business at MIM. The way we go forward is the only question that we have at MIM, because we know we have to be successful in our quest to discover new orebodies if, as a Company, we are to stay relevant.

I want to start by considering where the Industry is today. It is always difficult to get a historical fix on the present day. The present always seems to be at a key point in history, a time of great change, and a period of seminal events. Today is no different. It is a time of great change.

Is the world sustainable?

The biggest secular issue of the day is the sustainability of our activities on this planet. Will the world support us indefinitely if we keep on living as we do? Will the world continue to support us even if we change the way we use its resources?

These are the questions that have motivated the global leadership to convene the World Summit on Sustainable Development next year. It will occur at a point of time, of course - September 2002 in Johannesburg - but it is in fact a step in the progression of mankind towards achieving sustainable development during the 21st century.

The road to sustainable development began at the conference on the human environment in Stockholm almost 30 years ago. By the late eighties, the World Commission on Environment and Development had come up with a definition of sustainable development, which was:

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

It is a definition, which we in MIM continue to accept today.

In 1992, the Earth Summit in Rio linked environmental and economic responsibility, and set out universal principles to guide international action. Ten years later, in Johannesburg, nations will be asked to report progress and to consider what more needs to be done to achieve sustainable development.

All of us here today play a part in the quest for sustainable development because minerals are fundamental to human life. Some three years ago, the world's largest mining companies created a Global Mining Initiative and the associated Mining, Minerals and Sustainable Development project. Their purpose is to determine how the mining, minerals and metals industries can best contribute to sustainable development.

Paradigm was awarded Best Booth.

Continued From Page 11

Between 1988 and 1992, Kim was the Manager of Ground Geophysics and Airborne EM for World Geoscience Corporation. This involved ground surveys around the world and managing teams of scientists and engineers developing the QUESTEM airborne EM system.

Kim then spent five years with the Normandy Group with responsibility for exploration geophysics in WA.

In 1998 Kim joined the Southern Geoscience Consultants Group in Perth and since that time has consulted to numerous clients on widely varying geophysical projects within Australia, the US and Asia.

Kim joined the ASEG in 1978. He has served on several state committees and has been President of both the South Australian and Western Australian Branches. He was Co-chairman of the Perth ASEG Conferences in both 1994 and 2000 and has been Chairman of the ASEG Conference Advisory Committee since 1997. There is not much that Kim does not know about running conferences.

This award recognises Kim's long support of the ASEG and, in particular for his continuing help in running successful conferences.

Awards for Contributions at ASEG 2001

Laric Hawkins Award for the most innovative use of geophysical techniques from a paper presented at the ASEG 2001 Convention

'*Estimating residual statics using pre-stack migration*' by John Bancroft and Xinxiang Li; presented by John Bancroft.

Best Booth in the ASEG 2001 Exhibition

Paradigm Geophysical

Best Technical Presentations

- '*FALCON test results from the Bathurst mining*' by Mark Dransfield, Asbjorn Christensen, Peter Diorio, Marion Rose and Peter Stone. Presented by Mark Dransfield.
- '*Long offset towed streamer recording - a cheaper alternative to multi-component OBC for exploration?*' by R Gareth Williams, Graham Roberts and Keith Hawkins. Presented by Gareth Williams.

It is important that mining is integrated into the sustainable development of the world and not marginalised and in conflict with the mainstream of life. Sustainable development must include a sustainable mining industry.

How do we deal with falling commodity prices?

While the mining industry takes part in the securing of a sustainable future, there is another great change occurring in our industry - a great change in the commercial structure of the industry. By and large, mining companies have not done well in the traditional base metals and coal businesses. Their share of the total returns has been very poor for many years, despite technical and operational improvements that have increased productivity and reduced costs, particularly in recent years.

Mining companies in the past were encouraged to keep going by the prospect of occasional spikes in the prices for our commodities. The reality is that, the "spikes" are now smaller in amplitude and less frequent, and as a result we have experienced decade upon decade of rarely uninterrupted poor returns.

Supply surpluses have been a major factor in keeping prices low, and when there were not actual surpluses, prices have been kept low by the sure knowledge that producers will create a surplus at any sign of price improvement. These circumstances have given rise to chronically inadequate returns on investment and to shareholders. Of course, investors cannot afford to tolerate this situation. Ultimately, they have withdrawn much of their capital and placed it elsewhere, as the reduced size of mining in the Australian share index now shows.

The mining industry is now responding with a period of company consolidation in which fewer and bigger mining companies are being created. This development should lead to more discipline in the supply of minerals and metals. The long-term outcome should be better, with more consistent returns to mining companies and their shareholders.

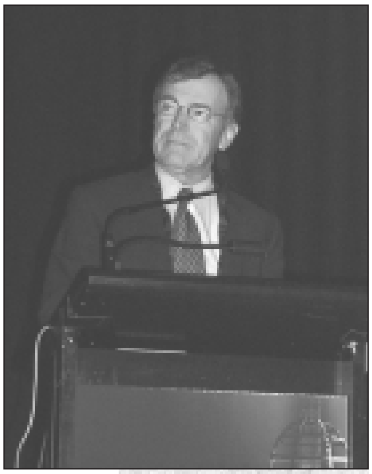
In an industry with chronically low prices and either surpluses or expected surpluses, mining companies looking to grow or replace their reserves have found in recent times that it is cheaper and easier to buy undervalued assets than to develop new projects. Such assets come complete with licences to operate, and that is a distinct advantage to a mining company today when new projects face the requirements of a very complex raft of approvals. These circumstances of low prices, poor returns and undervalued assets encourage company consolidation and discourage the development of new projects. This in turn discourages exploration.

What is the future for mineral exploration?

Having risen for 30 years, mineral exploration has declined sharply in recent years and so have the number of significant discoveries, particularly in the non-gold sector. Exploration expenditure worldwide rose during the 1990's to a peak of US$4.5 billion in 1997, but then fell sharply to US$2.3 billion in 2000, barely half the 1997 peak. The factors contributing to the decline include:

- falling prices for minerals and metals,
- the withdrawal of exploration companies from some high risk countries,
- problems of access to land in traditionally strong mining countries such as Australia, Canada and the US,
- reduced access to capital for junior explorers,
- the relative lack of success in finding new orebodies despite the high level of spending and,
- the consolidation of the mining industry.

Leigh Clifford, CEO of Rio Tinto, said recently that consolidation promises to lead to a more stable and rational industry.



Vince Gauci addressing the Conference

He went on to say: "Consolidation is already encouraging a more 'hard nosed' attitude to new developments in place of the perennial optimism that has traditionally seen investment in new capacity follow hard on the heels of higher demand. Fewer, larger operators can afford to think longer-term and develop projects in a way that may help reduce the peaks and the troughs of the mineral commodity cycle."

Leigh noted that the immediate consequences for the industry are likely to be continued reductions in exploration expenditure, and a more staggered development of new projects as companies consider the impact of new mines on their existing business.

This so-called hard-nosed approach is probably good for the mining industry (for those companies that survive) with the prospect of better supply-side discipline. Undoubtedly it will have an impact upon exploration, but will that impact be positive?

While global exploration activity has contracted in recent years, in Australia mineral exploration expenditure in 1999/2000 was at its lowest level for almost 25 years, although there has been a slight upward trend in the latest quarterly figures. As for discoveries, there has not been a major discovery in Australia for 10 years. The major mining projects in Queensland over the last few years were developments of discoveries made more than 10 years ago, and in some cases more than 30 years ago.

Where does this leave mineral exploration in the future?

I believe exploration can look forward to the future with confidence because the world will continue to need minerals and metals. However, like the rest of the industry, exploration will have to adjust to a leaner, more efficient and effective model.

Improvements in mining and processing technology, and operating practices, have reduced production costs to meet the challenge of reducing prices, and these improvements have in fact been a contributing cause of the decline in prices. These same dynamics and challenges apply to exploration. Mineral explorers will need to find deposits that can take their place among the smaller number of viable projects that the consolidated mining companies will be developing.

You should be - and many of you are - improving technologies and improving operating practices to increase your chances of making discoveries, discoveries that are of sufficiently high quality to compete for the development dollar from the emerging hard-nosed mining companies.

Land access and Research

In Australia, we still have a long way to go to overcome the obstacles to land access and the administrative nightmare that we have created in this country around native title. I should emphasise that native title is not the issue. The mining industry supports native title. The issue is the failure of legislators to provide an effective process for dealing with native title and the consequent impediment to land access for exploration and mine development.

Queensland has been particularly affected. Its share of Australian mineral exploration expenditure has fallen from 20% to 12% since 1996, and there is no doubt that this is directly linked to land access having been particularly difficult in Queensland.

If native title is to deliver benefits for indigenous people in respect of mining, then the mining industry and indigenous communities have to work together on a better solution than the legislators have given us so far. The industry and indigenous people are starting to do this. There is a positive role for Government to play in this process and the Queensland Government has demonstrated its willingness to participate.

Technically, there is the overriding problem of finding mineral deposits under substantial cover. Geophysics, properly integrated with other remote targeting geological and geochemical techniques, is required to meet this challenge. My own company is attempting to tackle this with the development and application of MIMDAS, our deep penetrating electrical technique, as a new 3D mapping and target delineation tool. Such techniques are increasingly required if we are to reduce the drilling risk and maximise the chance of discovery while maintaining cost effective exploration.

While we must compete in a commercial environment, we benefit from collaborative efforts with universities and the CSIRO and in AMIRA-sponsored projects. In recent years, the Australian Government has created Cooperative Research Centres to extend this kind of collaborative work but has recently failed to continue a CRC dedicated to exploration geophysics. This is a mistake because of the growing importance of geophysics to finding the next generation of mines in Australia.

I titled my address "The need to find more metal". With the benefit of a little reflection, I should have made two changes. Coal has become so important to MIM, and coal is entrenching its position as Australia's most important mineral product, that my title should have read "The need to find more resources". For MIM, our managers and workforce have turned around the performance of our coalmines to such an extent that coal is now a major pillar on which the company's future success will be built.

Secondly, I should have turned the title, "The need to find more metal", into a question rather than a statement. The question is: Will metals, or mineral resources, have a central part to play in the future of the world, and do we need to find more of them? In the world striving to achieve sustainable development, a world of consolidated mining companies, of greater supply discipline, and of greater competition for the funding of new mining projects, the answer is - most definitely yes.

ASEG 16th Geophysical Conference and Exhibition: Growth Through Innovation

16-19 February 2003, Adelaide Convention Centre

After a wonderful event in Brisbane, the Society's meeting focus moves onto Adelaide for the 16th Geophysical Conference and Exhibition. This will take place from 16-19 February 2003, at the redeveloped Adelaide Convention Centre.

The theme of the Adelaide Conference is 'Growth Through Innovation'. Reserves growth, company growth, professional growth and personal growth - all require to be underpinned by innovation. From von Wrede's use of variation in the magnetic field to locate magnetic ores to high-resolution aeromagnetic surveys; from seismic refraction profiles over Gulf Coast salt domes to time-lapse three-dimensional seismic surveys over offshore fields - innovation in exploration geophysics has delivered all facets of growth. We invite you to Adelaide for the ASEG 16th Geophysical Conference and Exhibition to continue the proud geophysical record of 'Growth Through Innovation'.

The Adelaide Convention Centre has been redeveloped and will be a highlight of the meeting. New exhibition areas are even closer to conference session rooms and a major glassed atrium area (with views over the River Torrens and Adelaide Oval) is adjacent to the exhibition halls. Richard Hillis and Mike Hatch have assembled a strong team to organise the Adelaide meeting and contacts are provided below. The conference organisers are SAPRO Conference Management. Rob Bulfield is the SAPRO contact (08 8227 0252; rob@sapro.com.au). If you have any enquiries about the ASEG 16th Geophysical Conference and Exhibition in Adelaide, please contact Rob, Richard, Mike or any of the conference organising committee listed below.

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Honorary Treasurers Annual Report

The audited Financial Statements for the year ended December 31st 2000 for the Australian Society of Exploration Geophysicists are presented.

The Financial Statements provided herein refer to the consolidated funds held and managed by the Society as a whole, including its State Branches.

The Society receives funds from membership subscriptions, corporate sponsorship, publications sales, subscriptions to publications, publications advertising, surpluses from conventions, meetings, and income from accumulated investments. The 2000 accounts include the 14th International Conference and Exhibition in Perth, WA.

These funds are used to promote, throughout Australia, the science and profession of geophysics. This was achieved during 2000 by funding the publication of four issues of Exploration Geophysics in three volumes during the year, the publication of Preview six times in the year, by paying capitation fees for the administration of State Branch organisations, by providing funding for the national administration of the Society, by funding continuing education programs and by the provision of loans and grants for conventions, for meetings and for the ASEG Research Foundation.

The Balance Sheet indicates the retained profits increased during the year from $364,972.91 at December 31st 1999 to $378,730.90 at December 31st 2000.

The Profit and Loss Account shows that the Income of the Society was $504,693.26 ($255,506.66 in 1999) and the Expenditure was $490,935.27 ($258,746.25 in 1999).

Income and expenses are accounted for on an accrual basis between yearly accounting periods. A change was made to accrual policy in 2000 in that the income and expenses of the December/January Preview publication (Issue #89) have not been accrued for in 2000. In future these amounts will be included in the following, not the current, year.

The main differences between the 1999 and 2000 accounts relate to 2000 being a conference year. The conference accounts have been separately audited and although the total conference income and expenditure are not included in the 2000 figures, the conference surplus and the amount paid by the conference towards publications costs are included in the 2000 accounts.

The largest contribution to operating income is from publications at $177,346, followed by conference revenue amounting to $137,452 and by membership income of $102,628. State Branch income, other than from capitation fees, was $60,536.

Publications were the largest expense of the Society, amounting to $278,042, with secretariat and accounting expenses amounting to $73,129 and the Society's contribution to the Research Foundation at the reduced level of $25,000. State Branch expenditure was $74,657.

Membership income in 2000 was generated from 1073 individual, two Corporate Plus and 30 Corporate members.

G. Butt
Past Honorary Treasurer
13 September 2001

Balance Sheet as at December 31st 2000 – all amounts in dollars

	2000	1999
CURRENT ASSETS		
Cash	381,916.68	347,380.36
Receivables	18,058.05	42,083.38
Inventories	0.00	600.00
Other (pre-payments & short term deposits)	22,185.17	20,000.00
TOTAL CURRENT ASSETS	422,159.90	410,063.74
NON-CURRENT ASSETS		
Property, plant and equipment	4,648.00	6,041.00
TOTAL NON-CURRENT ASSETS	4,648.00	6,041.00
TOTAL ASSETS	426,807.90	416,104.74
CURRENT LIABILITIES		
Accounts Payable	46,080.00	49,134.83
TOTAL CURRENT LIABILITIES	46,080.00	49,134.83
TOTAL LIABILITIES	46,080.00	49,134.83
NET ASSETS	380,727.90	366,969.91
EQUITY		
Issued Capital	1,997.00	1,997.00
Retained Profits	378,730.90	364,972.91
TOTAL EQUITY	380,727.90	366,969.91

Consolidated Profit and Loss Account for the year ended 31 December 2000

	2000	1999
TOTAL INCOME	504,693.26	255,506.66
TOTAL EXPENDITURE	490,935.27	258,746.25
OPERATING SURPLUS (DEFICIT) before income tax	13,757.99	(3,239.59)
Income Tax (credit) attributable to operating surplus (deficit)	0.00	0.00
OPERATING SURPLUS (DEFICIT) after income tax	13,757.90	(3,239.59)
Retained profits at the beginning of the financial year	364,972.91	368,212.50
Total available for appropriation	378,730.90	364,972.91
RETAINED PROFITS AT THE END OF THE PERIOD	378,730.90	364,972.91

ASEG Research Foundation Hitting Its Straps

Phil Harman
Howard Golden,
Barry Bourne and
Mike Dentith,
ASEG Research Foundation Committee

The ASEG Research Foundation turns eleven years old this year, and is proud to announce that it is going from strength to strength. In these days of shrinking opportunities for employment in the traditional mining and petroleum arenas, the ASEG Research Foundation continues to assist committed geophysics students with funding for studies in all facets of Applied Geophysics at the BSc (Honours), MSc, and PhD (or equivalent) levels.

Ironically, the Foundation commenced its function in September 1989, to address the decline in student enrolments in geophysics. Eleven years on, this issue is more relevant than ever. The Foundation continues to rise to the challenge, attracting high-calibre students into exploration geophysics, thus ensuring a future supply of talented, highly skilled geophysicists for industry.

Grants provided by the ASEG Research Foundation are paid directly to the relevant Australian University Departments to cover field or laboratory expenses associated with an approved project. Grants are not provided as student scholarships in order to preserve the tax deductibility status of donations.

ASEG members from mining and petroleum as well as from academia serve on an honorary basis on the ASEG Research Foundation Committee. All administrative costs are borne by the committee members and no Foundation funds are used for operating expenses. Phil Harman of BHP Billiton assumed the role of President of the Foundation in August.

Funding for the Foundation comes exclusively from a percentage of corporate ASEG membership fees along with tax-deductible individual contributions. While the Foundation, of course, never truly has enough resources; the following list of accomplishments highlights how successful the Foundation has been in advancing the cause of ensuring a continuing supply of highly trained competent geophysicists emerging from Australian universities.

Years of existence	11
Collaborating Universities	13
Honours students assisted	69
MSc students assisted	18
PhD students assisted	21
Total dollars disbursed	$732 000

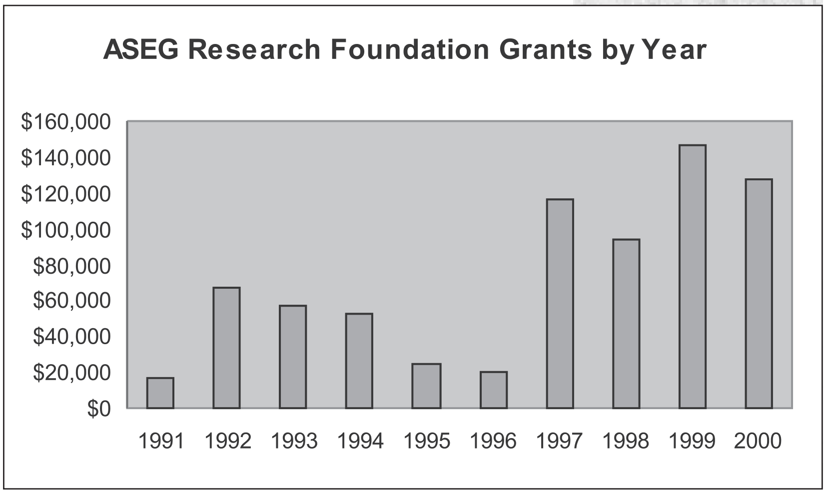
The Foundation is convinced that the decrease in enrolment in tertiary geophysics programs may reflect some realities of the related industries, but must in the long term be reversed. There will be continuing requirements for highly skilled geophysicists in the minerals and petroleum industries, as well as the emerging fields of environmental, hydrological, anthropologic and forensic geophysics. The ASEG Research Foundation remains committed to the geophysics industry and to students of geophysics, and intends to continue to assist the best students in their tertiary education programs.

A truly successful Research Foundation will only ultimately be effective with the continued financial support of the membership of the society and with sufficient funds to become self-sustaining. The aim of your Foundation Board over the forthcoming year will be to try to build up the financial reserves while continuing our vital support of worthwhile projects.

One particular way that all of us can help is to make a direct contribution at the time of ASEG membership renewal. Make sure that you include an amount in the space provided on the renewal form that you will be receiving shortly. Remember that it is an approved deduction for income tax purposes. And applications for ASEG RF grants are always welcomed from staff of all Australian Universities.

Geophysics remains one of the most challenging and exciting professions in spite of the current downturn in the exploration business. The future of our profession depends on a steady flow of enthusiastic new young people. The ASEG Research Foundation is one way in which we can all help to achieve this at whatever level we choose.

More information is available from the web site at http://www.aseg.org.au/RF_intro.htm



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Calibration and Use of Portable Gamma-ray Spectrometers
Part 1 - Calibration

Summary

Portable (hand held) gamma-ray spectrometers and scintillometers have been in widespread use in geological applications for several decades, but in order to provide accurate and reliable information, they need to be calibrated adequately and used correctly. This article (Part 1) outlines the theory and practice of calibrating portable gamma-ray spectrometers, and covers the need for calibration, collection and reduction of calibration data, some important assumptions made and the availability of calibration facilities in Australia.

Part 2 (which will appear in the next issue of Preview) develops guidelines for proper field practices based both on the physical principles of the method and on the assumptions made during calibration.

What is calibration?

The term "calibration" is used in two senses in portable gamma-ray spectrometry.

Sense 1. Equipment manuals typically use "calibration" to refer to the process of adjusting instrument gain so that the energies of detected gamma rays are measured accurately and recorded in the correct spectrometer channels.

Procedures vary with different instruments, but typically this involves monitoring the gamma rays from a source producing a photopeak of known energy and adjusting the gain to ensure that the gamma rays forming this peak are correctly registered. The source is generally chosen so that its photopeak falls outside (usually below) the energy range used for geological applications, although some instruments use the 2.615 MeV photo peak from ^{208}Tl in the ^{232}Th decay series.

The energy calibration adjustment procedure may be manual or automatic, and the source may be permanently incorporated in the instrument, or may need to be retrieved from its storage location and presented to the detector.

The adjustment is necessary because small but significant changes in the characteristics of the measuring circuitry inevitably occur over time and as a result of changes in external temperature. The adjustment is particularly important in situations where the ambient temperature is changing rapidly. It is similarly necessary to allow sufficient time for equipment warm-up before making the adjustment.

Energy calibration is an important part of the operation of any portable gamma-ray spectrometer, and should be done in accordance with the manufacturer's recommendations (procedure and frequency) to ensure that the results are consistent and reliable. This is likely to mean reading the manual!

Sense 2. As used from here onwards, "calibration" is the procedure that establishes the proportionality between measured counts and ground concentrations of potassium (K), uranium (U) and thorium (Th) in field geological applications. Calibration in this sense is what enables us to use the spectrometer to make quantitative determinations of the K, U and Th compositions of surface rocks and soils.

Why should we calibrate?

In general, the presence of either U or Th produces responses in all three spectrometer channels. Thus, a response in the U or Th channel may indicate the presence of U, or Th, or both. Also, a response in the K channel may indicate the presence of K, U or Th. Calibration takes account of these interactions and allows us to estimate the amounts of K, U and Th in the geological source causing the observed responses.

Under the same field conditions, two nominally identical spectrometers are likely to give systematically different countrates in corresponding channels. The differences result from factors such as minor variability in construction, component tolerances and gain adjustment. Instruments from different manufacturers may give significantly different responses in corresponding channels. This makes it difficult to compare or combine results taken with more than one instrument.
Calibration allows conversion of the observed countrates to the amounts of K, U and Th in the geological source, and these will be directly comparable even when measured with different instruments.

The calibration procedure uses calibration pads doped with known amounts of K, U and Th to estimate the constants of proportionality between countrates and element concentrations. First, however, it is necessary to measure and correct for background radiation.

What is background?

Radiation originating from the Earth's surface is the "signal" in gamma-ray spectrometry. Other sources of radiation produce a "background" which is part of the noise and needs to be removed from observed readings. The three main sources of background radiation are instrument noise, cosmic radiation and atmospheric radon. Instrument noise is partly due to trace amounts of K, U and Th in the detector and partly due to electronic circuit noise. This component of background is generally small and is relatively constant.

Cosmic radiation striking the atmosphere generates secondary radiation and gives rise to a "cosmic" gamma-ray flux, part of which has energies within the measuring range of gamma-ray spectrometers.

Gaseous atmospheric radon (^{222}Rn) and its daughter products are the main source of background radiation.

Radon is produced in rocks and soils from the decay of uranium-238 (^{238}U) and diffuses into the lower atmosphere. The unstable daughter products of the decay of radon, particularly ^{214}Bi and ^{214}Pb, are adsorbed by airborne aerosols and dust particles and emit gamma rays when they decay. This background varies with time and location and depends on how local weather conditions affect atmospheric mixing and precipitation of aerosols, as well as on the amount of radon diffusing from local source rocks and soils.

The background for each channel is estimated by taking measurements in an area where the gamma-ray flux from the ground is minimal. For some applications, where quantitative measurements with high accuracy and precision are required, the area must be selected carefully. This may involve taking measurements in a boat over a wide river or lake, (water depths greater than 1m absorb more than 97% of the radiation from the lake/river bed). The boat must be far enough from the shore that there is no significant gamma-ray contribution from the land.

For less exacting applications, a local background may be used, but all quantitative measurements will be relative to the K, U and Th concentrations at the background station. It will generally be convenient to select a low-countrate area close to the local base of operations for use as the background station. Granitic and gneissic terrains may have high associated countrates and should be avoided as background stations. Basic igneous rocks and most sediments are generally associated with low countrates, although there are exceptions.

At least in the early stages of any survey, background measurements should be taken at least daily to establish whether or not the background variations during the day and from day to day are significant with respect to the precision and accuracy required for the survey.

It is popular field practice to describe anomalism as a multiple of "background". This has little meaning except in a very general and vague relative sense, and it is better in the geological context to convert countrates to an equivalent grade.

Having established the background, the next stage of the calibration procedure is to take measurements over specially constructed calibration sources with known concentrations of K, U and Th. To develop an insight into how thick these sources need to be (and to help in assessing some field situations) the concept of "half-thickness" is helpful.

What is the "Half-thickness" ?

Gamma rays are scattered and absorbed by material between their source and the detector. The relative effectiveness of different materials in absorbing a beam of gamma rays may be expressed in terms of the half-thickness. This is the thickness of material required to attenuate the beam by 50%. Although half-thicknesses are normally quoted for narrow (collimated) mono-energetic beams, they still provide a practical guide for judging how detector response may be affected by different field situations.

Thus, 10 cm of water will reduce a beam of 1 MeV gamma radiation to 50% of its original intensity, 20 cm will reduce the beam to 25% of the original intensity, 30 cm to 12.5% and so on. One metre of water (ten times the half-thickness for 1 MeV gamma rays) will reduce the beam to 2^{-10} or about one-thousandth of its original intensity.

It will also be apparent from Table 1 that there is little point in making a calibration pad thicker than about 80 cm (ten times the half-thickness for 3 MeV gamma rays), as the concrete pad itself will absorb 99.9% of the radiation from emitters deeper than 80 cm.

Material	Half thickness for 1 MeV gamma rays	Half thickness for 3 MeV gamma rays
Lead	0.9 cm	1.4 cm
Rock	5 cm	8 cm
Concrete	5 cm	8 cm
Water	10 cm	18 cm
Air (sea level)	89 m	158 m

Table1. Approximate half thickness values for some materials that may be encountered in gamma-ray spectrometry.

How is the spectrometer response related to source composition?

The spectrometer response can be represented as a set of equations in which the response is a linear function of source compositions and a set of sensitivity coefficients. These coefficients are the proportionality constants relating the countrate in any channel to unit concentrations of K, U and Th. These unit concentrations are conveniently chosen as 1% K, 1 ppm U and 1 ppm Th for most geological situations

	counts/s per 1% K	counts/s per 1 ppm U	counts/s per 1 ppm Th
K window	3.36	0.250	0.062
U window	0	0.325	0.075
Th window	0	0.011	0.128

Table 2. Typical window sensitivities for a portable gamma-ray spectrometer with 76mm diameter × 76 mm deep cylindrical sodium iodide detector (IAEA, 1989). Matrix S of Equations (1), (2), (3) and (4).

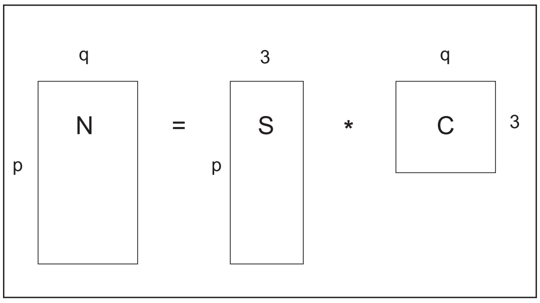


Fig. 1. Schematic view of dimensions of matrices describing spectrometer response. N is the matrix of countrate observations using a p channel spectrometer with calibration constants S over q sources of compositions C.

For any channel i, the background-corrected observed countrate, n_i, is in the general case made up of three parts, which are the countrates caused by contributions from the K, U and Th components:

$$n_i = s_{ik} c_k + s_{iu} c_u + s_{it} c_t$$

Where s_{ik} is the proportionality constant which determines the countrate contributed to channel i by unit concentration of K, s_{iu} is the proportionality constant which determines the countrate contributed by unit concentration of U and s_{it} is the proportionality constant which determines the countrate contributed by unit concentration of Th.

Similar equations can be constructed for each of the other spectrometer channels. In matrix notation the set of equations can be written as:

$$\mathbf{N} = \mathbf{S}\ \mathbf{C} \qquad (1)$$

Where **N** is a matrix in which the number of rows is equal to p, the number of spectrometer channels, and the number of columns is equal to q, the number of sources used. **C** is the matrix of source composition. It has three rows - K %, U ppm, Th ppm and q columns. **S** is the p×3 matrix of calibration constants that relate source composition to observed counts in each of the p spectrometer channels. These dimensions are shown pictorially in Figure 1.

If the s's are unknown, there are 3p unknowns (matrix **S** has dimensions p by 3) and so at least 3p observations are required for a solution to exist. As p observations are made on each source, it follows that observations over three sources are required to estimate the matrix **S**. Further, these sources must be of significantly different compositions to ensure that the equations are linearly independent (i.e. it is not sufficient to take multiple readings on one source, nor to use sources constructed by simply diluting the same source material with an inert component).

For more than three sources the equations are over-determined (more observations than unknowns), and matrix **S** may then be calculated as the least-squares solution, which can be shown to be:

$$\mathbf{S} = \mathbf{N}\ \mathbf{C}^T (\mathbf{C}\ \mathbf{C}^T)^{-1} \qquad (2)$$

For three sources, the solution is exact and Equation (2) simplifies to:

$$\mathbf{S} = \mathbf{N}\ \mathbf{C}^{-1}$$

These equations may be solved as long as q≥3, irrespective of the number of channels in the spectrometer i.e. at least three sources of different compositions are required to calibrate a spectrometer in terms of the three major radioelements.

When the calibration matrix **S** (also called the sensitivity matrix) is known, the matrix Equation (1) applies and allows calculation of the column vector **C** (the set of source compositions) from the column vector **N** (the background-corrected observed countrates in each of the spectrometer channels):

$$\mathbf{C} = (\mathbf{S}^T \mathbf{S})^{-1}\ \mathbf{S}^T\mathbf{N}$$
(3)

For a three-channel spectrometer, **S** is a square matrix and Equation (3) simplifies to:

$$\mathbf{C} = \mathbf{S}^{-1}\ \mathbf{N} \qquad (4)$$

The "stripping ratios" sometimes used in airborne gamma-ray spectrometry are not normally applied to ground measurements (although they could be). It is more usual to convert observations directly to ground concentrations, as indicated above, than to calculate stripped values as a separate step.

Where do we find calibration pads?

There are five sets of transportable cuboidal calibration pads (1 m × 1 m × 0.3 m thick) and one fixed cylindrical set (2 m diameter × 0.5 m thick) in Australia.

The fixed pads were constructed by CSIRO (Dickson and Lovborg 1984) and are located at Darlinghurst in NSW. Geo Instruments (now Fugro) offers a service for calibrating portable instruments using this set of pads.

The portable pads can be used to calibrate both portable and airborne instruments. One set was manufactured in Canada (Grasty et al., 1991) and is owned by Fugro (Perth). The other four sets were manufactured by CSIRO and are owned by Fugro (Sydney), PIRSA Minerals and Energy Resources (Adelaide), AGSO (Canberra) and Kevron (Perth). Kevron (now Fugro) allows others to use its pads at Jandakot airport, Perth, for an appropriate (non-financial) consideration.

The AGSO pads are available for use by companies and individuals. Portable spectrometers (and helicopter systems) can be calibrated at AGSO (Symonston, Canberra), and the pads can also be transported to Canberra airport to calibrate fixed-wing airborne systems.

How do we collect and reduce the calibration data?

Check and adjust the spectrometer gain as recommended by the manufacturer for the particular instrument being used ("calibration" in sense 1, as described earlier).

Take readings on each of the calibration pads and the background pad in turn (Figure 2), and record the reading time, pad identifier and the counts in each of the spectrometer channels. Reading times need to be sufficiently long to reduce the fractional errors in the observed counts to acceptable levels. A ten minute sampling time enables calibration of a spectrometer with a 76mm diameter x 76mm deep cylindrical sodium iodide detector to a relative precision of 1 %, on calibration pads which have IAEA recommended concentrations of K, U and Th.

Unless radioelement concentrations in the pads are extremely high, it is unlikely to be necessary to make a dead time correction. Some modern spectrometers can make an automatic dead time correction.

After normalising counts to the same reading time (for example by converting all readings to counts per second), the observed counts over each pad are corrected for background by subtracting the readings over the background pad.

Equation 2 above gives the essential mathematics for reducing the background-corrected data, and if there are only three pads, the simplified form of Equation 2 can be used. Note that the pad concentrations of K, U and Th (matrix **C**) should be the concentrations relative to the background pad, not the absolute concentrations of the radioelements in the pads.

The program PADWIN is in general use in Australia for reduction of calibration data, but all of the calculations can be done in Microsoft's Excel spreadsheet software, and I can provide a simple example by email on request.

What assumptions do we make in calibrating spectrometers?

It is a tacit assumption that unit amounts of K, U or Th in any of the sources will always produce the same countrate in any given channel. This implies that the source-detector geometry is constant for all sources used - all sources are of the same dimensions and the detector is placed in the same relative position on each pad.

In fact, we are assuming that the pads are large enough to represent a uniform infinite half-space to the detector (so-called 2π geometry because the half-space subtends a solid angle of 2π steradians at the detector). In practice, the pads are commonly about two metres in diameter and up to about a metre in thickness. This is a good approximation to 2π geometry for a detector placed at the centre of the pad (Figure 3).

Some calibration facilities may provide correction factors or modified concentrations, which compensate for the pads' finite dimensions. Grasty et al. (1991), for example, provided correction factors for cuboidal transportable pads of dimensions $1 \times 1 \times 0.3$ m (Table 3).

We assume that the pads have been constructed so that the radioactive material is homogeneously dispersed throughout the pad and there are no hot spots. The requirement to place the detector directly on the pad aggravates the effect of even minor pad inhomogeneities on the observed countrate (Figure 3). Some facilities provide a stand, which raises the detector to fixed heights above the pad, as a means of averaging out these effects. Correction factors are provided for effective pad concentrations at each height.

We also assume that the calibration sources are in radioactive equilibrium. This might not be the case if, for example, radioactive material has been finely comminuted and gaseous decay products such as radon or thoron have escaped, or if soluble daughter products have been leached out during mixing of the concrete matrix. The custodian of the calibration pads should have information about this.

Can we calibrate scintillometers?

As with spectrometers, scintillometers need to be calibrated so that the results from surveys with different instruments can be compared directly. Ten counts/s on one instrument may not have the same significance as ten counts/s on another.

Fig. 2. (Below) Readings are taken on each of the calibration pads and the background pad in turn.

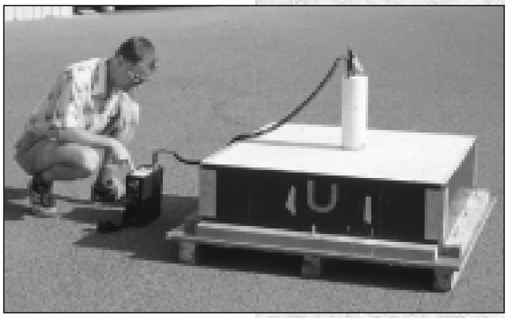
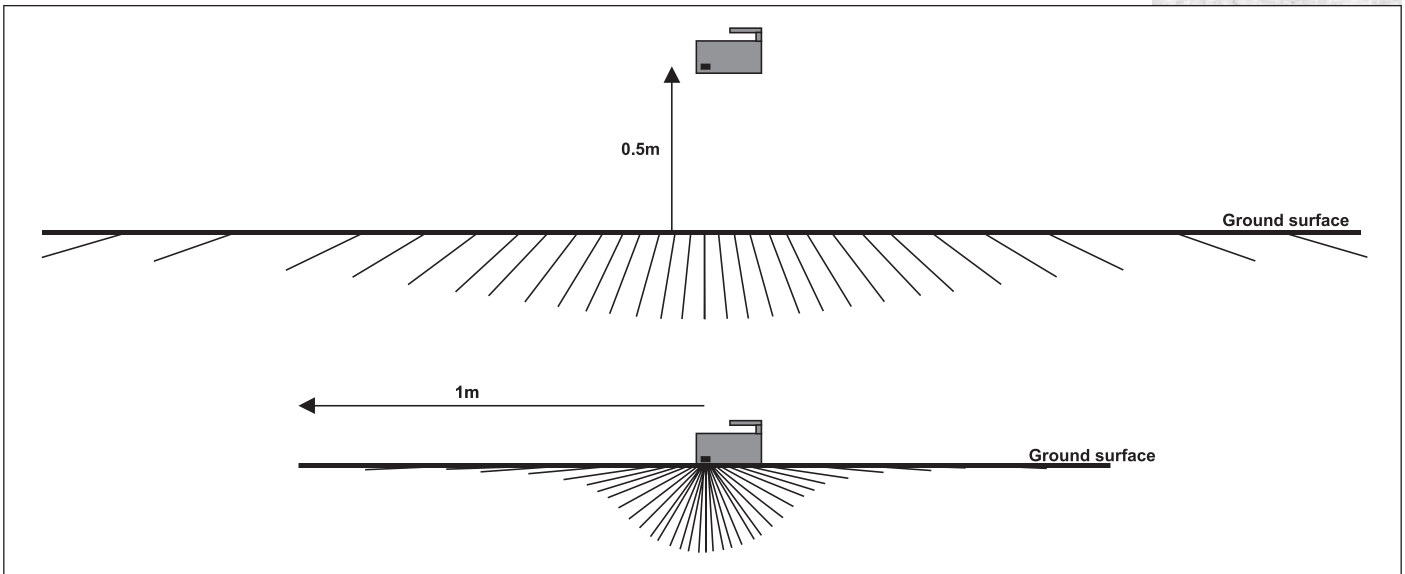


Fig. 3. (Bottom) Change in volume sampled by a spectrometer with change in height above ground (diagrammatic). The shaded portion shows the volume of rock within which a gamma ray travels less than 25cm to reach the ground surface en route to the detector. Almost 90% of the radiation received at the detector is likely to come from within this volume.



Transportable calibration pad (dimensions 1× 1 × 0.3 m)	Energy (MeV)	Correction factor (detector height = 0.06 m)
K pad (density=2.23 t/m^3)	1.46	1.156
U pad (density=2.24 t/m^3)	1.76	1.165
Th pad (density=2.28 t/m^3)	2.62	1.188

Table 3. Factors for correcting finite size of calibration pads to a flat infinite half space (2π geometry).

However, as a scintillometer has only a single channel, it is not possible to determine whether the recorded radiation came from K, U or Th or a mixture of these. This has led to the convention of expressing the recorded countrate as if it had all been produced by one radioelement, usually U, in geological applications. An observed scintillometer countrate is then expressed as parts per million equivalent uranium (ppm eU). More recently, in line with the increasing use of gamma-ray detectors in environmental monitoring, instruments may be calibrated in terms of dose rate. This is the rate at which unit mass of a given substance absorbs energy. The dose rate is expressed in Gray per second (Gy/s) where 1 Gy is the dose which imparts 1 J of energy to 1 kg of the material. Some older scintillometers may display microröntgens per hour (μR/h), which is an exposure rate based on the ionising effect of the radiation rather than on the energy absorption of the exposed material.

Scintillometers can be calibrated using the same pads as for spectrometers, and pad custodians will be able to supply U equivalent values. These U equivalent values are then simply plotted against the (background-corrected) scintillometer countrates. A best-fit straight line should pass through the origin if background has been correctly determined, and this is used to estimate the equivalent radioelement concentrations for field measurements (Richards, 1982). For very high countrates a dead time correction may be required.

Acknowledgements

Bruce Dickson of CSIRO, Roger Henderson of Geo Instruments and Gary Paterson of Kevron are gratefully acknowledged for providing useful information about the Australian calibration facilities with which they have been involved. I would like to thank Stephen Billings for reviewing the manuscript, and Brian Minty of AGSO for suggesting this article, for supplying figure 2 and for much valuable discussion and background information.

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AGSO-Geoscience Australia

Latest release of airborne geophysical and gravity data

***Western Australia*: Londonderry-Drysdale**. Pixel image maps of the Drysdale and southern half of the Londonderry 1:250 000 Sheet areas have been released> Both areas are in the Kimberley region, which is known to contain kimberlite pipes and traces of diamonds.

Survey flight lines were flown north-south at 80 m above ground level and spaced 400 m apart. Magnetic data were sampled approximately every 7 m and gamma-ray spectrometric data every 70 m.

Product prices are as follows: Colour TMI map $161.85, greyscale $134.90, colour TMI and greyscale $269.80, gamma-ray $161.85, and digital image data $323.75 per map.

***Queensland*: Cairns-Georgetown.** Pixel image maps of airborne magnetic and gamma-ray spectrometric data from the Cairns to Georgetown geological regions of north Queensland have been released. The maps cover three areas, namely:

- Most of the Mossman 1:250 000 Sheet area and the southern part of the Cooktown 1:250 000 Sheet area;
- Most of the Atherton 1:250 000 Sheet area; and
- The eastern two-thirds of the Gilberton 1:250 000 Sheet area.

The Queensland Department of Natural Resources and Mines acquired data for these maps between July and November 1999 on east-west flight lines spaced 400 or 200 m apart. Terrain clearance was 80 m with a sample interval of approximately 7 m for the magnetic data and 70 m for the gamma-ray data.

Product prices are as the same as for the WA data described above.

***South Australia*: South Olympic, Lake Harris & Mulgathing regions**. Point located and gridded gravity data have been released for three regions in the Gawler Craton. The data were acquired by PIRSA over the period April to May 2001 and comprise 3533 new gravity stations. The complete survey data-set and grids will be made available to bona fide interested parties at no charge.

For further information:
Contact: Peter Percival on
Tel: 02 6249 9478
Email: peter.percival@agso.gov.au.

Northern Territory Geological Survey

New data on NTGS Web Server

Preliminary located magnetic, radiometric and elevation images from surveys currently being flown on behalf of NTGS are now available for viewing on the NTGS Airborne Geophysical Image Web Server (NTGS AGIWS) at: http://www.dme.nt.gov.au/ntgs/geophysics/air_map/survey_specs/new_surveyspecs/new_surv_map.html.

This service represents a first for the industry, and has been implemented so that explorers have the opportunity to work with current airborne imagery during the field season, rather than typically having to wait until the end of the field season to receive data.

The site is updated every 2 weeks or so to ensure all the new imagery is available shortly after acquisition.

The NTGS web site (http://www.dme.nt.gov.au/ntgs/geoscience_info/pub_products.html#Remote) also has available its Landsat 7 data, which has just been released. The NTGS Landsat 7 repository will in the near future be supplemented significantly by data from NT Department of Lands Planning & Environment.

Minerals Industry Study for Central Region of Northern Territory

The Federal Minister for Industry, Science and Resources, Senator Nick Minchin, and NT Minister for Resource Development, Daryl Manzie, have announced a major minerals study of the Northern Territory's Tanami, Tennant Creek and Arunta regions.

The Central Region of the Northern Territory has been selected for examination under the Regional Minerals Program (RMP) due to its significant gold, base metals and industrial mineral potential and relative lack of infrastructure.

The aim of the six-month study, which started in August, is to promote exploration, increase opportunities for mineral and minerals processing projects, improve infrastructure and create employment opportunities in the area. It will consider exploration and mineral potential, supply and service needs, infrastructure requirements and environmental aspects.

"This vast region has an impressive historical mineral production and potential for a resurgence, particularly in gold, if the world class Callie deposit is an indication," Senator Minchin said.

The geological link between the Tanami and Tennant Creek has recently been the focus of a major geoscientific program by the Northern Territory Geological Survey. Recent successful exploration projects suggest a high expectation of further mineral discovery over the next few years.

"The proposed Alice Springs-Darwin railway will provide a great boost to the mining industry. Combined with a possible new gas pipeline through the region, development of Tennant Creek as a regional service centre and improved links to mines, the Central NT has every reason to be optimistic about the future", Senator Minchin continued.
The Commonwealth is providing $110 000 towards the study which is also being funded by the NT Government and mining industry.

"This is the first time the Northern Territory has participated in the Regional Minerals Program This study brings together industry and Federal, Territory and local government representatives for common goals, increasing cooperation and improving coordination."

Mineral Resources Tasmania

New aeromagnetic and radiometric surveys

The Final Regional Development Plan from the Western Tasmanian Regional Minerals Program (WTRMP) recognised that "stimulation of exploration expenditure (in western and north-western Tasmania) requires an increase in the standard of data available to exploration companies" and recommended measures to improve the standard. As a consequence Mineral Resources Tasmania (MRT) is undertaking a program of data acquisition and consolidation to produce the high quality datasets needed by explorers. Much of the area has rugged topography and is densely vegetated; constraints which place increased emphasis on the need for high quality remotely sensed data.

During the first half of 2001 approximately 116 000 line-km of helicopter and fixed wing magnetic and radiometric data were acquired over King Island and western and north-western Tasmania as part of the WTRMP. The surveys were flown at 200 m line-spacing and 80 m nominal terrain clearance and replace the 500 m spaced fixed wing surveys flown in the early to mid-1980s. Radiometric data were collected over much of western Tasmania for the first time. MRT has combined this new data with approximately 40 000 line-km of pre-existing modern fixed wing data to produce the first consistent magnetic and radiometric dataset over the entire western Tasmanian mineral province, which hosts six world class ore deposits (see Figure 1).

Fig. 1. Radiometric Ternary Plot of Western Tasmania, K=red, Th=green, U=blue. The data appear to be unaffected by vegetation.

The digital data from these surveys will be released in early October 2001 and hardcopy products will be on display at Mining 2001 in November. For further information on these surveys contact Bob Richardson (phone 61 (0) 3 6233 8324 or email rrichard_pc@mrt.tas.gov.au).

Acquisition of about 11 000 line-km of frequency domain helicopter EM data over the Mt Read Volcanic Belt and in areas with shallow granite and potential host rocks for replacement-style base- and precious-metal deposits will re-commence in October 2001. The data will be released in the second half of 2002. Other activities being undertaken as part of the WTRMP include studies of the hydrocarbon potential of the offshore areas, test lines of SAR and MASTER data, production of new geological maps of the Mt Read Volcanic Belt and scanning of geological reports relating to the WTRMP area.

Victoria

More funding to promote minerals and petroleum exploration

Candy Broad, the Minister for Energy and Resources, has confirmed a funding increase, announced in the recent Victorian State budget, of $7.5 million over four years on promotion of exploration and improved regulation. Of this, $4 million will be provided to extend the Victorian Initiative fro Minerals and Petroleum (VIMP). VIMP funds will be used to upgrade Victoria's regional geological database and preserve and value-add to existing industry-acquired data. Although comparatively modest, the additional funds should provide a welcome boost to the geosciences in Victoria.

Western Australia: Department of Mineral and Petroleum Resources

Major reorganisation in State Government

On 1 July 2001, the Department of Minerals and Energy and the Department of Resources Development were merged to form the new Department of Mineral and Petroleum Resources.

The structural changes required to bring the various aspects of the former departments together in a coherent whole have had limited impact on the structure of the Geological Survey of Western Australia (GSWA). However, tighter funding has resulted in reduced allocations for geophysical data acquisition in the GSWA; currently, no new geophysical survey programs are planned for 2001/02.

In past years the GSWA has been successful in being able to increase the availability of public domain data by the judicious merging of new data acquisition with multiclient data purchases, often with the support of AGSO-Geoscience Australia. There is an optimistic expectation that it may be possible to continue this approach in 2001/02 despite the budgetary constraints.

The reduced funding for geophysics has seen a minor change in the management of geophysics in the GSWA. Potential field expert, Sergey Shevchenko, has been transferred from the Petroleum and Basin Studies Group to the Regional Mapping Group. The Geophysics component of the Regional Mapping Group has been combined with Remote Sensing under the management of Andrew Sanders. David Howard has been transferred to oversee the Statutory Exploration Reporting Groups but will continue to be available for geophysical advice and consultation.

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The Search for the South Magnetic Pole

Summary

A shipboard survey to locate the South Magnetic Pole (SMP) was carried out in December 2000 using a privately-owned vessel, the *Sir Hubert Wilkins*. The mean of the observed positions of the magnetic pole under quiet conditions was 64.67° S, 138.12° E, which is only 11 km from the position of the dip pole predicted by the International Geomagnetic Reference Field (IGRF). The closest directly-measured approach to either of the Earth's magnetic poles was achieved at 13:45 hr UT on 22 December 2000, when a distance to the pole of 1.6 km was recorded. The present set of ship-board observations, together with earlier attempts using the same technique in 1986 are the culmination of a long history of attempts to reach the South Magnetic Pole: James Clark Ross in 1841, David, Mawson, and Mackay in 1909, Bage, Webb and Hurley in 1912, and Pierre Mayaud in 1954. The South Magnetic Pole has drifted some 1300 km from the position calculated by Ross in 1841, at an average speed of 8.2 km/yr. The pole is presently drifting in a northwesterly direction at 4 km/yr, which is about ten times slower than the drift rate of the North Magnetic Pole.

Introduction

The Earth's north and south magnetic poles are the principal points on the Earth's surface where the horizontal field is zero and magnetic inclination is ±90°. The magnetic poles are directly observable, and should not be confused with the north and south geomagnetic poles, which lie at the intersection of the Earth's geocentric dipole axis with the Earth's surface and are determined from the first three spherical harmonic Gauss coefficients.

Both of the Earth's magnetic poles have been the object of a succession of polar expeditions, and both were reached before their geographical counterparts:

North Magnetic Pole	31 May 1831	James Clark Ross
North Geographic Pole	6 Apr 1909	Robert Peary
South Magnetic Pole	16 Jan 1909	Edgeworth David, Douglas Mawson & Alistair Mackay
South Geographic Pole	14 Dec 1911	Roald Amundsen

The Canadian Geological Survey (particularly Larry Newitt) has made regular surveys to locate the north magnetic pole, but only a few attempts to reach the South Magnetic Pole have been made prior to the measurements reported in this paper:

Observer	***Date***	***Closest distance (km)***	***South Magnetic Pole****	
			Lat (S)	***Lon (E)***
James Clark Ross	1841	~250	75° 05'	154° 08'
Douglas Mawson	1909	130	72° 25'	155° 16'
Eric Webb	1912	62	71° 10'	150° 45'
Pierre Mayaud	1952	116	68° 42'	143° 00'

***** *Pole positions from Dawson and Newitt (1982) and Webb and Chree (1925)*

The magnetic poles drift gradually at speeds of a few kilometres per year in response to fluid motions in the Earth's outer core. Superimposed on this secular drift is a rapid daily motion caused by time-varying external magnetic fields produced by electric currents in the ionosphere and magnetosphere. The paths traced out daily by the magnetic poles are typically elliptical and have diameters ranging from less than 10 km on magnetically quiet days to many hundreds of kilometres when the Earth's magnetic field is disturbed by emissions from the Sun. Even larger excursions may occur during a severe magnetic storm. At polar latitudes the magnetic field is usually undisturbed for only a few days per month, so it is practically impossible to reach an instantaneous position of a magnetic pole.

The magnetic poles and their movement attract public interest and both poles are becoming an increasingly popular destination for adventure tourists. The positions of the magnetic poles are marked on navigation charts, they provide a convenient test for the accuracy of global field models in polar regions, and they are used for studying auroral phenomena (the auroral ovals centre about the magnetic poles). Finally, the diurnal motions of the poles provide information about external magnetic fields, and their secular drift rates give estimates of fluid velocities in the outer core.

The South Magnetic Pole drifted off the Antarctic continent near the French base at Dumont D'Urville in about 1960, and is now a few hundred kilometres out to sea, well removed from local (coastal) anomalies. A shipboard technique was developed so that the position of the pole could be determined and tracked at sea.

Technique

The observational technique involves accurate determination of the horizontal component of the field using a gimbal-mounted three-axis fluxgate. The field sensor is placed at the centre of a system of orthogonal Helmholtz coils (Figure 1) to provided first-order cancellation of the magnetic field of the ship. Accurate cancellation is achieved by spinning the ship and integrating the two horizontal channel output signals resolved along geographical axes. (Resolving along ship's axes gives the field of the ship.) After each determination of the horizontal field vector, the distance and bearing to the pole from the ship is calculated using horizontal field gradients derived from the IGRF.

The method was tested in January 1986 with Rod Hutchinson of the Bureau of Mineral Resources (now AGSO) as the observer, and again in December 1986 with Ian Allison and Pat Quilty of the Australian Antarctic Division as observers (Barton et al., 1987; Barton, 1988). These tests demonstrated the viability of the observational method, but on neither occasion was a comprehensive set of reliable measurements obtained. Pack ice prevented a close approach to the pole in December 1986.

The December 2000 survey was carried out aboard the *Sir Hubert Wilkins* , courtesy of Don McIntyre of Ocean

Frontiers with major sponsor Dick Smith Foods. The *Sir Hubert Wilkins* was particularly well suited to the task, being small (600 t) with an aluminium helicopter deck above the stern that allowed the magnetometer sensor assembly to be mounted on non-magnetic beams well away from the immediate magnetic gradients of the ship. The reproducibility of the measurements suggests that the ship-board technique is capable of locating the magnetic pole to within a few kilometres.

Results

A progression of measurements was carried out between 06:34 UT December 21 and 14:05 UT on December 22, 2000. The magnetic field was disturbed at the beginning of the observations with the pole displaced far from its predicted (IGRF) position of 65° 36′ S, 138° 18′ E and moving at about 17 km/hr. During the course of the observations, the pole moved towards the predicted position and finally settling to a small-amplitude elliptical trajectory near the IGRF dip pole (Figure 2). The mean of the observed positions of the pole during the final quiet interval was 64.67° S, 138.01° E (twelve tightly clustered observations centred around 10:11 UT, 22 December 2000).

The closest spot measurement was taken at a distance of 1.6 km from the magnetic pole, recorded at 13:45 hr on 22 December 2000, when the pole was calculated to be at 64.67° S, 138.01° E. We believe this to be the closest direct observation ever made to either of the magnetic poles. The previous closest observation was made at the North Magnetic Pole by L. Newitt and C. Barton at 21:35 UT on 4 May 1994, when an inclination of 89° 59.2′ (corresponding to about 3 km for the dipole field gradient of 0.27 min/km) was recorded using a declination-inclination fluxgate theodolite (Newitt and Barton, 1996).

Conclusion

The present set of ship-board observations, together with earlier attempts using the same technique in 1986 (Barton et al., 1988) are the culmination of long history of attempts to reach the South Magnetic Pole: James Clark Ross in 1841, David, Mawson, and Mackay in 1909, Bage, Webb and Hurley in 1912, and Pierre Mayaud in 1954. The present mean observed position of the South Magnetic Pole is 64.67° S, 138.01° E. A more detailed analysis using observatory data to estimate an undisturbed position of the pole has not yet been completed. Nevertheless, the proximity of the mean observed position to the IGRF dip pole (11 km) is confirmation that the latter is accurate. The magnetic pole is presently is 240 km offshore from the French base at Dumont D'Urville, 2827 km from the Geographic Pole, and 1906 km from the South Geomagnetic Pole. Since Ross's observations in 1841, the pole has drifted NNW some 1300 km at an average speed of 8.2 km/yr. It is now drifting northwest at 4 km/yr, which is ten times faster than the present drift rate of the North Magnetic Pole.

Acknowledgements

Ship support was provided by Don McIntyre of Ocean Frontiers Pty Ltd (www.oceanfrontiers.com.au) with main sponsor Dick Smith Foods; the Australian Geological Survey Organisation provided equipment. I thank Andrew Lewis for building the digital data acquisition system, Bruce Sibson and Raymond De Graaf for preparing the survey equipment, and Captain Craig Rogers and the crew of the *Sir Hubert Wilkins*.

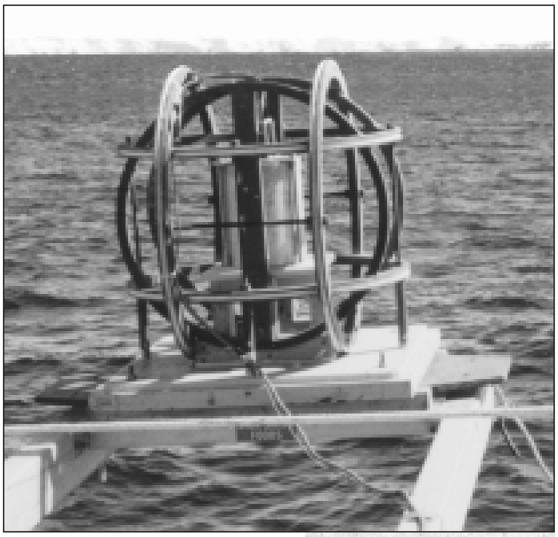

Fig. 1. Magnetometer sensor assembly, comprising a central canister containing a gimbal-mounted 3-axis fluxgate, which is surrounded by a set of three orthogonal pairs of Helmholtz coils. Currents through the coils are used to provide first-order cancellation of the magnetic field of the ship.

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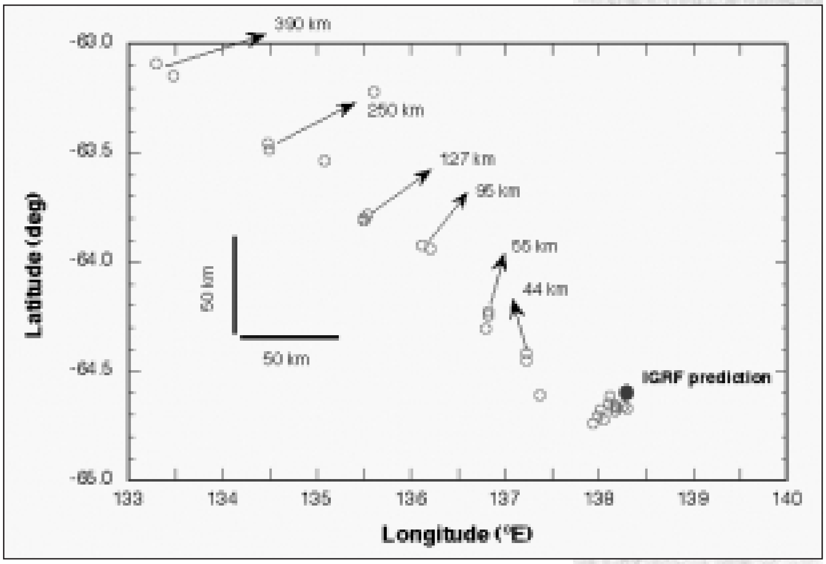

Fig. 2. Observed locations of the South Magnetic Pole. The arrows point in the direction of the ship when the observation was made; distances to the ship are given. IGRF denotes the position of the dip pole given by IGRF 2000 at epoch 2001.0.

The Geophysical Characteristics of The Granites-Tanami Goldfields: a Regional Perspective

This paper is published in Preview because, for technical reasons, it was not contained in the Brisbane Conference CD

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Key words: *airborne magnetic surveys, gravity surveys, interpretation, Tanami Region, Proterozoic, gold, Northern Territory*

Summary

Goldfields in the Tanami Region are associated with elevated gravity responses due to high density host rocks such as basalt, dolerite and BIF. The Tanami, Dead Bullock Soak and The Granites goldfields occur in stratigraphic units that exhibit high magnetic responses. Mineralisation at Tanami is associated with zones of demagnetisation along major faults. At Dead Bullock Soak and The Granites mineralisation is associated with magnetic highs produced by pyrrhotite in alteration assemblages.

Qualitative interpretation of semi-regional (400-500 m spaced) and, where available, detailed (line spacing of 200 m or less) airborne magnetics, and gravity data represents the best method for identifying potential gold prospects in the Tanami Region. For Tanami style deposits focus should be directed to identifying areas where late faults, typically marked by demagnetised zones, intersect lithological boundaries with strong rheological contrasts structurally above carbonaceous or other reducing lithologies. Alternatively focus should be directed to identifying intersections between late faults and iron-rich units such as dolerite and BIF. These structures are discernible in detailed airborne magnetic data. When coupled with appropriate geochemical sampling programs, these interpretations should provide the basis for the rapid identification of anomalous zones meriting more intensive exploration.

Introduction

Airborne magnetic surveys flown by the Northern Territory Geology Survey (NTGS), Australian Geological Survey Organisation (AGSO) and exploration companies provide a regional perspective of the magnetic character of the rocks in the Tanami Region. This paper investigates the geophysical characteristics of goldfields in the Tanami Region with a view to identifying common features that can be used to guide further exploration. Due to extensive thin sand cover in the Tanami Region geophysical datasets are essential in providing geological control and are particularly useful for identifying and targeting potentially mineralised structures.

Regional Geology

The Tanami Region lies 600 km northwest of Alice Springs in the Northern Territory and is one of the most poorly outcropping Palaeoproterozoic provinces in northern Australia. Contacts with the Arunta Complex to the south and the Tennant Inlier and Davenport Province to the east are not exposed but appear to be major shear zones in magnetic and gravity data (Figure 1). Preliminary results of integrated geological studies by NTGS indicate the Tanami Region shares a similar history to the eastern part of the Halls Creek Orogen during the Palaeoproterozoic (Hendrickx *et al*., 2000, 2000a; Dean *et al*., 2001).

The oldest rocks are small isolated outcrops of Archaean gneiss and schist in the northern and southern parts of the region (Page, 1995). The oldest Palaeoproterozoic rocks are deformed and metamorphosed passive margin volcanics and sediments of the MacFarlane Peak and Tanami groups (Hendrickx *et al*., 2000; Figure 5). MacFarlane Peak Group is intensely magnetic and is associated with high Bouguer gravity responses. The lower portion of the Tanami Group (Dead Bullock Formation) is intensely magnetic and has an associated high Bouguer gravity response while the upper portion (Killi Killi Formation) is non- to weakly magnetic and has low Bouguer gravity responses. Dolerite sills (typically highly magnetic) intrude both MacFarlane Peak Group and Tanami Group and predate the first deformation event to affect these units.

MacFarlane Peak and Tanami groups were deformed and metamorphosed during a major orogeny between 1848-1825 Ma (Hendrickx *et al*., 2000). This deformation is associated with three folding (D_{1-3}) events together with greenschist to amphibolite facies regional metamorphism. MacFarlane Peak and Tanami Groups are overlain by Pargee Sandstone-a thick sequence of coarse siliciclastic sediments interpreted as a post D_1 molasse deposit with low magnetic and gravity responses; and Mount Charles Formation-a post D_3 continental rift sequence of intercalated basalt and turbiditic sediment with high magnetic and gravity responses.

Widespread granite intrusion and volcanism occurred between 1825-1800 Ma. This is represented in the Tanami Region by five granite suites (Inningarra Suite, Coomarie Suite, Winnecke Suite, Frederick Suite and The Granites Suite) and two volcanic complexes (Mount Winnecke Formation and Nanny Goat Volcanics) (Figure 5). Low gravity and variable magnetic responses characterise these units (Slater, 2000; Slater, 2000a). Significant deformation took place around 1810 Ma, synchronous with intrusion of the Inningarra Suite.

The youngest Palaeoproterozoic unit in the Tanami region is the Birrindudu Group, a 2 km thick sequence of non to weakly magnetic shallow marine siliciclastics. This unit was deposited onto a subdued landscape sometime after intrusion of the Granites Suite (post 1800 Ma). Significant deformation post dates deposition of Birrindudu Group. The timing of this event is not well constrained in the Tanami Region; it may have occurred during the 1745-1730 Ma Late Strangways Orogeny.

Neoproterozoic and younger sequences mask the underlying geology. Offset in the distribution of regionally extensive Cambrian Antrim Plateau Volcanics indicates significant deformation affected the region during the King Leopold and/or Alice Springs orogenies.

Datasets

Magnetics

The semi-regional airborne geophysical survey coverage over The Granites and Tanami 1:250 000 map sheets comprise a number of surveys acquired by NTGS, AGSO and

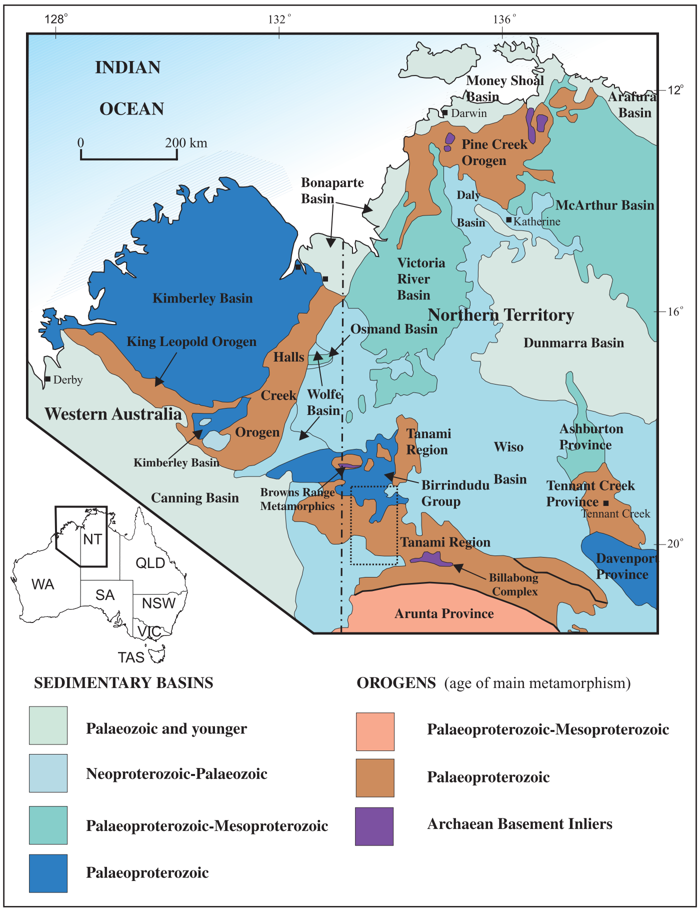

Fig. 1. Regional geological setting of the Tanami Region.

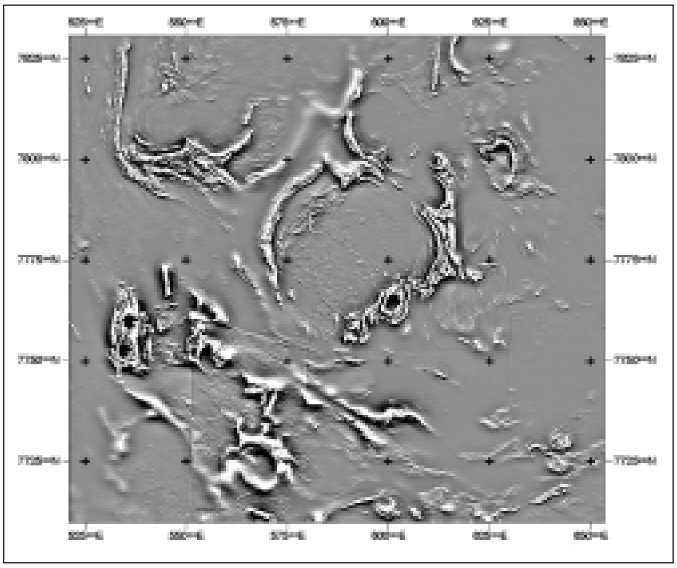

Fig. 2. Magnetic 1VD of part of the Tanami Region; map coordinates are in metres.

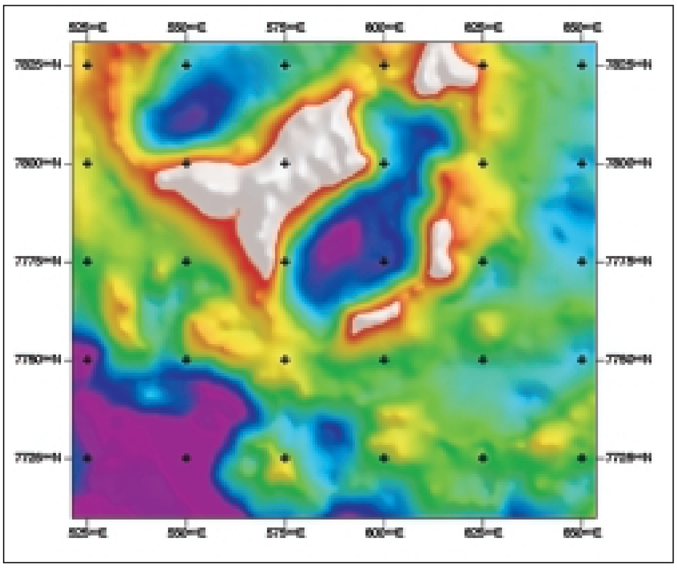

Fig. 3. Bouguer gravity of part of the Tanami Region; map coordinates are in metres.

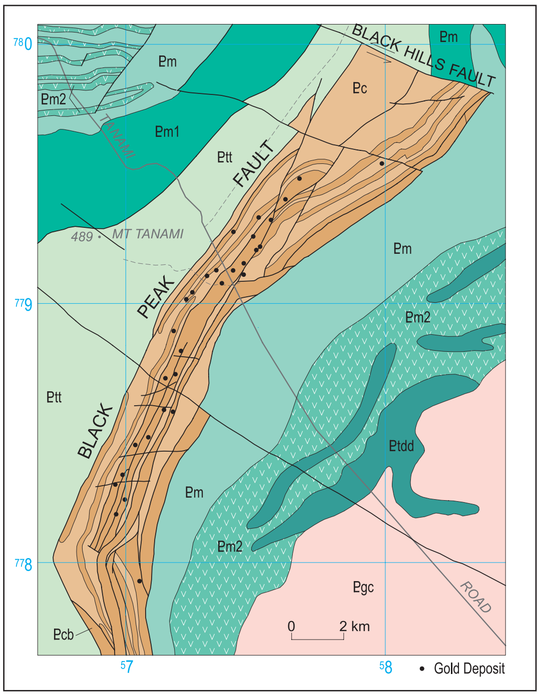

Fig. 4. Interpretation of the detailed airborne magnetic data in the Tanami Goldfield area; note the close spatial relationship between faults and gold deposits (from Slater, 2000, 2000a).
Pgc: Coomarie Suite, granite; Pc, Pcb: Mt Charles Formation, greywacke, siltstone, basalt; Ptt: Twigg Formation, siltstone; Ptdd: dolerite; Pm, Pm1, Pm2: MacFarlane Peak Gp, amphibolite, basalt and volcaniclastic sediment.

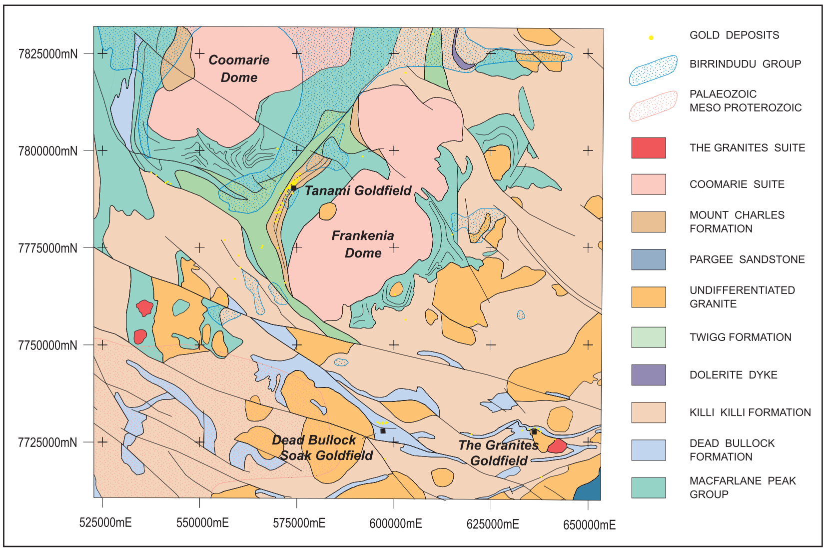

Fig. 5. Summary of the basement geology of part of the Tanami Region; map area corresponds to area in Figures 2 and 3; map coordinates are in metres.

several exploration between 1982 and 1993. The surveys were flown at 90 and 100 m altitude with a line spacing of 500 m. The first vertical derivative of the regional airborne magnetic dataset is displayed in Figure 2.

Many closed file airborne surveys were available for use by NTGS. The corresponding interpretations have been incorporated into the regional interpretations (Slater, 2000; Slater, 2000a). These surveys were flown at altitudes of between 20 and 60 m with flight lines spaced at 25-200 m.

Gravity

Current gravity coverage of over The Granites and Tanami 1:250 000 map sheets is good (Figure 3). The Granites - Tanami gravity survey was acquired on behalf of AGSO and NTGS in 1999. The survey acquired 3488 new 4×4 km stations, 269 1×1 km stations and 100 4×4 km existing stations.

Drilling

Open file exploration and government drill data were used to provide some geological constraint in areas of poor outcrop. 588 drill holes, representing a subset of available data, were used in the interpretations of Slater (2000, 2000a).

Mapping

Detailed outcrop mapping by NTGS was undertaken during the 1999 and 2000 field seasons. Results have been integrated with the geophysical interpretation and are published as separate 1:100 000 and 1:50 000 surface geology maps. The results of numerous magnetic susceptibility measurements taken on outcrops and drill core are outlined in Hendrickx *et al.*, (2000).

Geophysical Characteristics

Tanami Goldfield

Gold deposits in the Tanami Goldfield are hosted by the Mount Charles Formation, a sequence of intercalated submarine basalt and turbidites (Figure 4). The Mount Charles Formation has an associated high Bouguer gravity response (20 ∝ms^{-2}) and an intense magnetic response attributed to basalt horizons. The formation forms an arcuate package on the western side of the Frankenia Dome. In the north the package trends northeast and has an average width of 3 km. In the south the package trends northwest and narrows to 500 m at the southernmost point. Individual basalt horizons can be traced for up to 10 km in the airborne magnetic data, and are truncated by numerous faults. Bedding in the formation shows a consistent dip of around 50 to the west and metamorphic grade is lower greenschist facies. Gold deposits typically form steeply plunging ore shoots where late faults transect the contact between basalt and sediment. Deposits are also hosted solely within individual basalt or sediment packages (Tunks and Marsh, 1998) and inter unit rheological differences may account for gold deposition within these packages. Pervasive alteration in basalt and sediment surrounding mineralised shoots and along late faults has resulted in destruction of magnetite. These zones are hence marked by magnetic lows and are clearly evident in images of detailed airborne magnetic data.

Dead Bullock Soak Goldfield

Mineralisation at Dead Bullock Soak (DBS) is hosted by the Dead Bullock Formation. This unit is characterised by fine grained, thin bedded siltstone, carbonaceous shale, minor iron rich sediments interpreted to be BIF (Smith *et al.*, 1998) and numerous dolerite sills. The rocks are metamorphosed to greenschist facies and have undergone three phases of ductile deformation followed by a number of phases of brittle-ductile faulting (Vandenberg *et al.*, 2001). Structurally the area occurs in the core of a south inclined east plunging D1 anticline. The Goldfield is associated with a local Bouguer gravity anomaly. Of the current pits at DBS three (Callie, Villa and Dead Bullock Ridge) lie on the margin of the anomaly (-245 to -250 ∝ms^{-2}) while two pits (Colliewobble and Triumph) lie almost on the gravity high (-234 ∝ms^{-2}). Two main styles of mineralisation are observed: mineralised shear zones through iron rich sediments (e.g. Villa) and sheeted veins (Callie). Both styles are difficult to interpret directly from the regional magnetic dataset which defines a broad area of elevated magnetic responses over the goldfield. Closer spaced data (150 m) delineates individual stratigraphic units, outlines fold closures and shows a number of short linear zones of weak demagnetisation. One of these corresponds to mineralisation at Villa. The east plunging ore shoots at Callie are not visible in the magnetic data.

The Granites Goldfield

The pits in The Granites Goldfield coincide with a highly magnetic arcuate feature 700 m wide and 8 km long, which forms along the northern margin of granitic intrusions of The Granites and Inningarra suites. The goldfield coincides with a high Bouguer gravity response (-235 to -220 ∝ms^{-2}). A highly magnetic mafic intrusive complex (Borefield Road Complex) occurs just to the northeast of the goldfield and also shows an elevated Bouguer gravity response (-200 ∝ms^{-2}). Iron rich sediments metamorphosed to amphibolite facies host the Granites Goldfield. They may represent a faulted slice of Dead Bullock Formation or an iron rich package of sediments in Killi Killi Formation. The high magnetic response is due to the presence of dolerite as well as metamorphosed BIF and pyrrhotite alteration associated with mineralisation.

Conclusions

All three goldfields in the Tanami Region are characterised by elevated gravity responses. This is due to the nature of host lithologies (dolerite, basalt, BIF and volcaniclastic sediment) and has little to do with the effects of mineralisation. However, the use of gravity on a regional scale may assist in identifying suitable host lithologies. Tanami style mineralisation is characterised by demagnetisation due to alteration and faulting and these zones are readily identifiable in close spaced airborne magnetic data. Similar structures are visible in detailed magnetic data at DBS though they do not appear to be as strongly developed. Development of pyrrhotite in the alteration assemblages at DBS and The Granites account in part for the elevated magnetic responses over these goldfields. Similar zones are visible in the regional magnetic dataset and form worthwhile exploration targets.

Structural and rheological control is a common feature of all deposits. Detailed geophysical interpretation of regional datasets plays an important role in helping to identify intersections between suitable lithological packages and structures that are worthy of detailed followup.

Acknowledgements

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Environmental Geophysics Shows its Paces

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Abstract

Work by the GILMORE project on the SW slopes of New South Wales has established a new role for airborne geophysics and geological systems interpretation in the battle against Australia's old enemy - salinity. Collaboration between AGSO, CSIRO's Division of Exploration and Mining, and the Bureau of Rural Sciences has developed our understanding of how airborne geophysics can be used to map the patterns of salt, material types and water. These patterns lend insight to the movement of salt and water through the landscape. Calibration of the airborne data by drilling enables us to construct a 3D framework which, in turn, is the basis for modelling the rate of delivery of salt to rivers. Land use options and feasible engineering interventions to arrest salinity can then be tested. This capacity is the foundation of the National Action Plan for Salinity and Water Quality.

Salt on the move

Salt has always been a feature of the Australian landscape but now it's on the move. Replacement of deep-rooted native vegetation by crops and pastures that use much less water, has been accompanied by erosion of the topsoil that used to store rainfall until it could be used by plants. This means that more rainfall is percolating down to the groundwater. On its way, it leaches salt stored in the soil and regolith, sometimes contaminating good quality groundwater. Rising groundwater drives already salty groundwater into the rivers or up to the land surface. Leaky irrigation systems have the same effects.

The scale of this problem is detailed by the National Land and Water Resources Audit (2001) which forecasts a crippling further deterioration of water quality, damage to infrastructure and losses of productive farmland. Action on an unprecedented scale will be required to arrest the rising tide of salt.

New applications of airborne geophysics

Recent advances in airborne geophysics have been applied by a multi-disciplinary team to map the salt stores and the conduits that carry water and salt through the landscape (Dent et al., 1999, Lawrie et al., 2000, Wilford et al., 2001a,b). These concepts are now being tested elsewhere, for example, Lane et al., 2001. The first product is a 3D regolith framework. This is the basis for whole-catchment hydrogeological modelling to predict the rate of water and salt delivery under different management options.

The potential of these new technologies forms the basis for the National Action Plan for Salinity and Water Quality

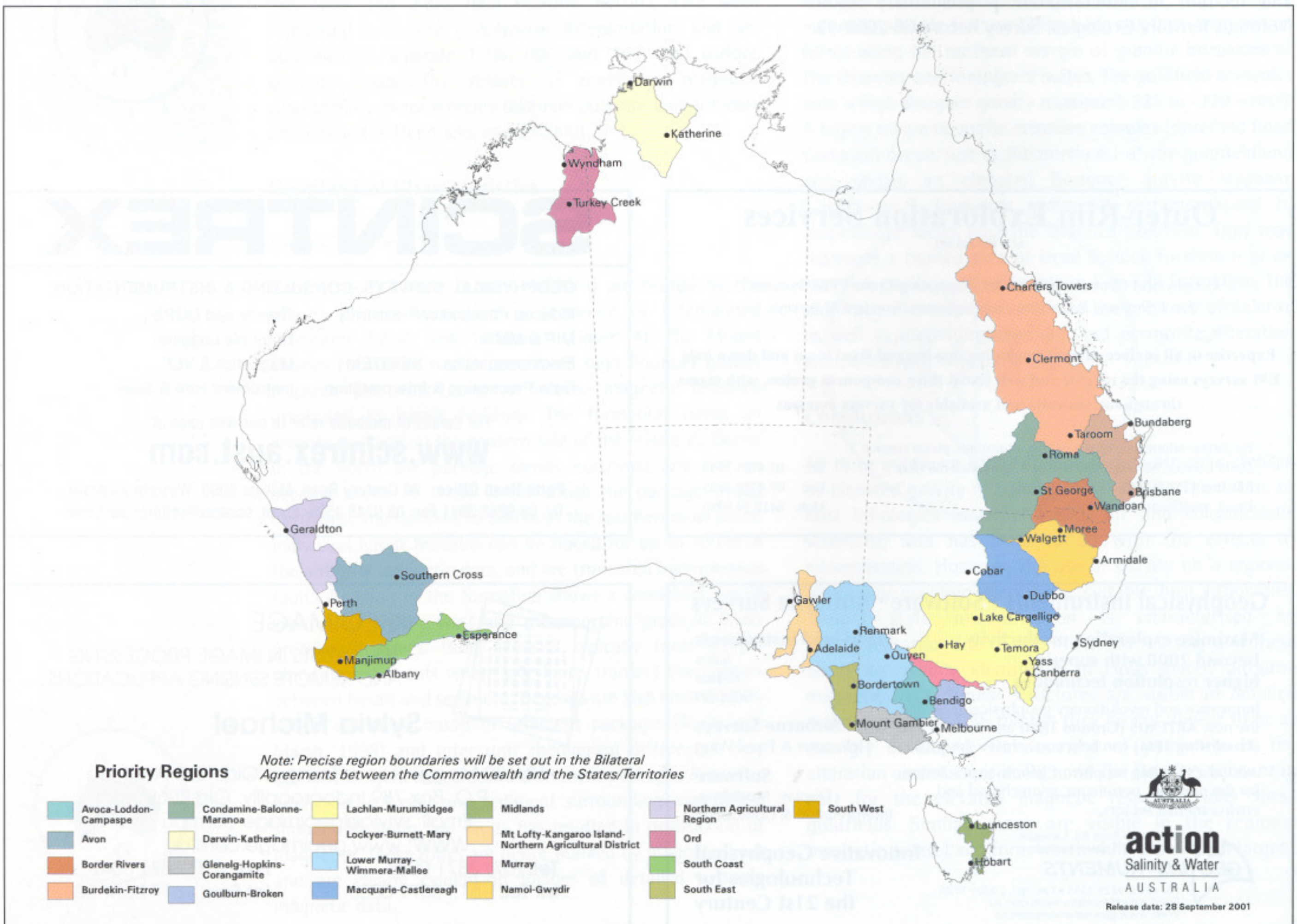

Fig. 1. National Action Plan, Priority Regions.

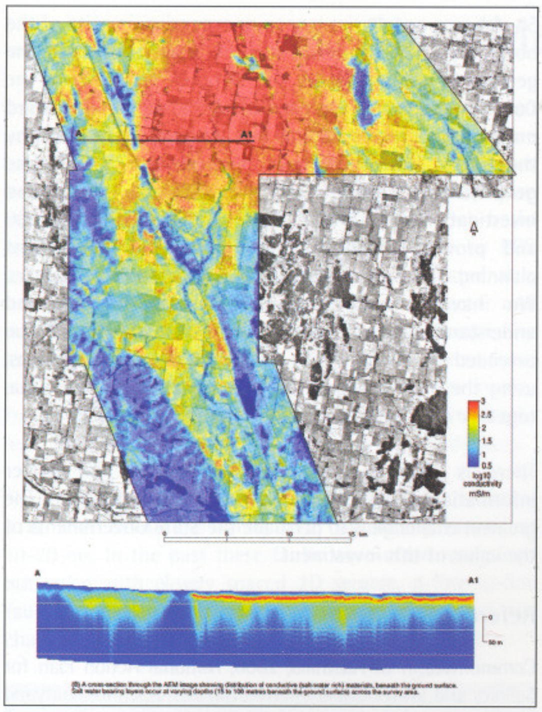

Fig. 2. Conductivity depth image for 30-40 m and cross section of the country around Temora, NSW. High salt concentrations are associated with clay in a former lakebed.

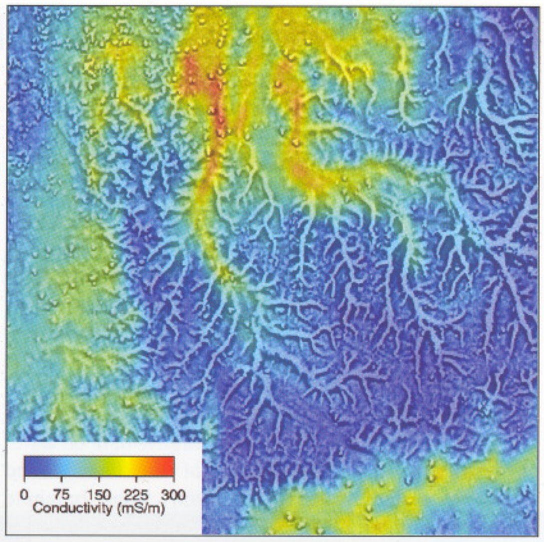

Fig. 3. First order derivative magnetic image (100 m line spacing, 60 m flying height) superimposed on AEM conductivity depth image of the Mid-Broken catchment SW of Shepparton, Victoria. The high salt concentrations appear to be confined to the prior stream channels.

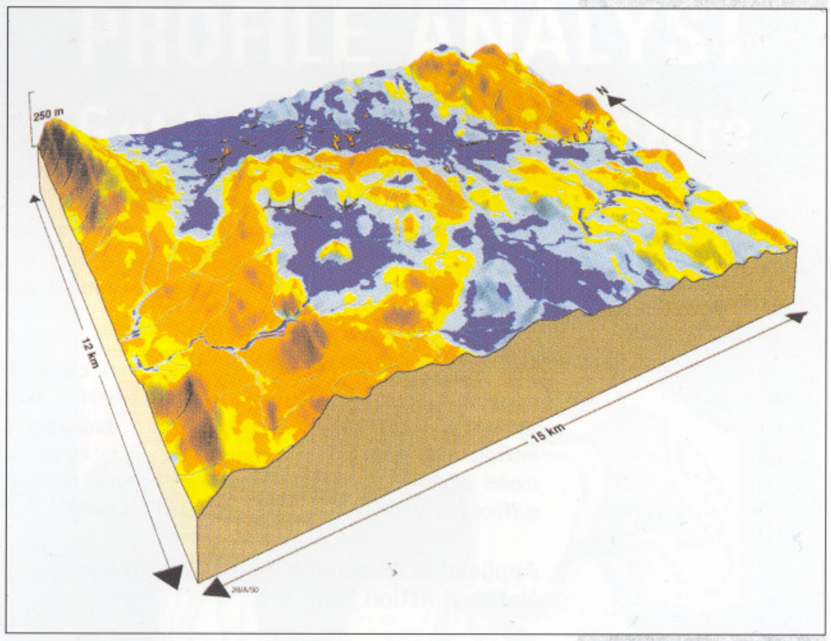

Fig. 4. Bethungra area, Southern Tablelands, NSW (5x vertical exaggeration). Salt stores and potential saline discharge sites in blue. Photo-interpreted salt scalds superimposed in red.

(Commonwealth of Australia, 2000). This is a $1.4 billion program of integrated catchment management in 21 priority regions across Australia (Figure 1). The new information will enable regional communities to negotiate catchment management plans in the knowledge of the effect of various courses of action on each facet of the landscape. Changes of land use and engineering intervention can be undertaken where they will work; and limited resources need not be squandered on ineffective activities.

Airborne electromagnetics

The key tool is airborne electromagnetics (AEM). The 3D conductivity images provide insight to constraints on salt and water movement, and a better appreciation of the distribution and concentration of salt at both regional and local scales. Previously, knowledge was limited to surface outbreaks and borehole data. A vertical resolution of several metres and a horizontal resolution better than 100 m is obtained to a depth of more than 100 m. Resolution may be better with HEM systems.

TEMPEST time domain AEM was flown at 150 m line spacing by World Geoscience Corporation (now Fugro Airborne Surveys) for the GILMORE project on the SW slopes of New South Wales in 1999. Layered earth inversion and, subsequently, conductivity depth imaging, have been calibrated by borehole data to establish depth to bedrock, to calibrate the conductivity signals in terms of salt concentration, and to characterise the regolith facies (Figure 2).

Continued improvements to both the airborne system and the software have been applied to new TEMPEST acquisitions. The Mid-Broken and Murray catchments were flown in July and September 2001 for the Murray Darling Basin Commission, and the Balonne-Maranoa was flown in July-August for the National Action Plan.

AEM has the potential to map the distribution of materials. Recent studies in the Riverland and Tintinara areas of South Australia suggest that AEM can map the geometry of subsurface clay layers. This information is needed to guide future development and management of irrigation schemes. Holes in the clay layers will allow rapid leaching of subsurface salt and deep percolation to the groundwater, rendering irrigation unsustainable in the long term. Groundwater may be unusable for irrigation in the vicinity of the development within 10 to 20 years, and may lead to contamination of the aquifer over 50 to 100 years.

Airborne magnetics

Airborne magnetics and radiometrics, and the digital elevation models produced by radar and laser altimetry, provide crucial supporting data. Indeed, it is only by the combination of all these data sets and targeted drilling that a detailed and reliable regolith framework can be built.

Airborne magnetics has provided spectacular details of prior stream systems where the channels carry magnetic gravels (Figure 3). Prior streams may transmit salt water, fresh water, or none.

A combination of AEM and magnetics gives an immediate, qualitative picture. Confirmation that the conductivity patterns are caused by salt, and quantitative data on water chemistry and the transmissivity of the underground plumbing system has to be won from borehole investigations. The value of the airborne data for identifying the optimum siting of boreholes cannot be overestimated.

Airborne radiometrics

Radiometrics measures the intensity of natural gamma radiation from potassium, thorium and uranium in the topsoil. The combined signal can be interpreted directly as a detailed map of soil parent materials, their degree of weathering, and transport across the landscape. In eroded landscapes, the divergence of the gamma signal from the bedrock signature may be interpreted in terms of the thickness of soil and regolith.

Over the SW slopes of New South Wales, thick clay soils mapped by this technique are strongly correlated with stream salinity. Combination of gamma radiometric interpretation with terrain analysis of the digital elevation model identifies where salt is likely to break out at the land surface (see Wilford et al., 2000a & b, and Figure 4).

Application of airborne geophysics in the National Action Plan

Perhaps the biggest difference between exploration geophysics and environmental geophysics is in the perception of cost and benefit. There is no market in environmental services - they are taken for granted. Even the costs of salinity breaking up roads and buildings have scarcely been estimated because the hazard has been appreciated only recently. The visible loss of agricultural production is small beer in comparison. Knowledge of the biophysical system cannot be readily turned into cash - rather we are looking at asset protection. Where valuable environmental or physical assets can be identified, the value of airborne geophysics can be demonstrated by conventional benefit/cost analysis (George et al., 2001).

While engineering solutions are likely to provide respite in the short term, widespread changes in land use will be needed to reverse the upward trend of regional water tables, where this is the problem. Even radical changes in land use will take decades, at least, to work through the system at a catchment scale. Both the time scales and the uncertainty of the effects discourage action.

So airborne geophysics is seen as expensive, in spite of the obvious cost of continued lack of understanding of the geological systems. Under the National Action Plan, the Commonwealth initially earmarked $50M for salt hazard mapping, in the expectation that it would be matched by the States. This would cover the costs of an airborne geophysics program with the necessary on-ground investigation to map 20 million ha at a scale of 1:50 000 and provide hydrogeological models for catchment planning. The program could be completed in four years. We have already shown that information and understanding won from the relatively costly AEM can be extended over wide areas of similar geological systems, using the much cheaper magnetics and radiometric data, together with existing soil and terrain information.

There is a groundswell of local demand for better information on which to base management decisions. The greatest challenge is to persuade the State Governments of the value of this investment.

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Giant Mud Cracks?

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One of the big benefits of 3D seismic data is the ability to produce seismic displays in map view, allowing us to more easily relate what we see in the subsurface to patterns or processes we can see on the Earth's surface. Figure 1 is an example taken from an offshore Exmouth Sub-basin multi-client 3D survey, recorded and processed by PGS Australia. This is a display of continuity calculated at a constant time above the Intra-Hauterivian reflector and shows a polygonal fault pattern similar to desiccation or mud cracks. There is however a difference in scale as these polygonal features are a few hundred metres across. Polygonal faulting of this nature has been attributed to horizontal contraction of fine-grained, marine sediments.

Figure 2 is a vertical section along the line A-B and shows a number of normal faults with significant throws of 10-20 ms. In the past these faults were often recognized but, even with closely spaced 2D seismic, a line-to-line fault correlation was invariably wrong because of the changeable fault azimuths.

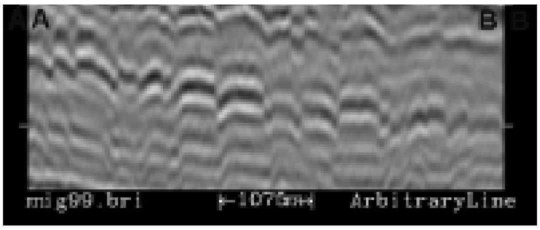

Fig. 1. Polygonal faulting observed on a continuity display extracted from 3D seismic volume.

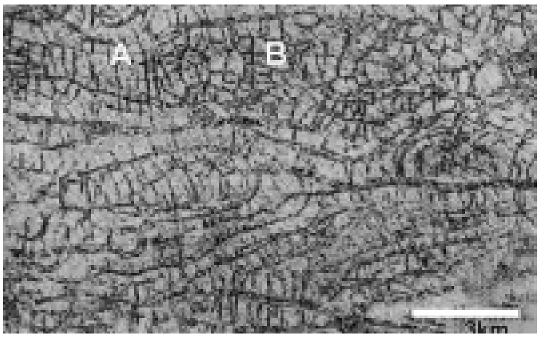

Fig. 2. Vertical section along line A-B showing small scale normal faults (A-B is ~6 km long, vertical tick marks are 100 ms apart).

Further reading

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Acknowledgement

I thank PGS Australia for permission to reproduce these displays from their WG99 multi-

Aeromagnetic Survey over the Yallalie Impact Structure, Western Australia

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In October 2000 Kevron Geophysics Pty Ltd flew 1133 line km of horizontal magnetic gradiometer data over the Yallalie meteoroid impact site. This structure is located approximately 200 km north of Perth at 30° 28' S, 115° 47' E. The structure was formed in Mesozoic sediments of the Perth Basin, and is considered to be of late Cretaceous age.

The survey was flown as part of the ASEGRF-funded PhD project based at The University of Western Australia under the supervision of Mike Dentith. Duncan Cowan of Cowan Geodata Services helped with survey design and Kevron generously collected the data at cost. The survey was flown over a roughly 14 km square area using a 200 m north-south line spacing at a flying height of 60 m. Data were gridded using a 50 m grid cell size.

The resulting dataset provides a spectacular illustration of how useful aeromagnetic data can be even when the rocks in the survey area are only very weakly magnetized. The TMI data, shown in Figure 1, have a dynamic range of only 40 nT. Nevertheless, numerous impact related concentric circular structures are clearly evident. These features are greatly enhanced by the removal of a long wavelength regional anomaly due variations in depth to magnetic basement. A residual magnetic grid was generated by subtracting the magnetic field, upward continued to 5 km, from the measured total field data. The residual data set, shown in Figure 2, has a dynamic range of 13 nT.

Fig. 1. (Below) Total Magnetic Intensity image over the Yallalie meteoroid impact structure.

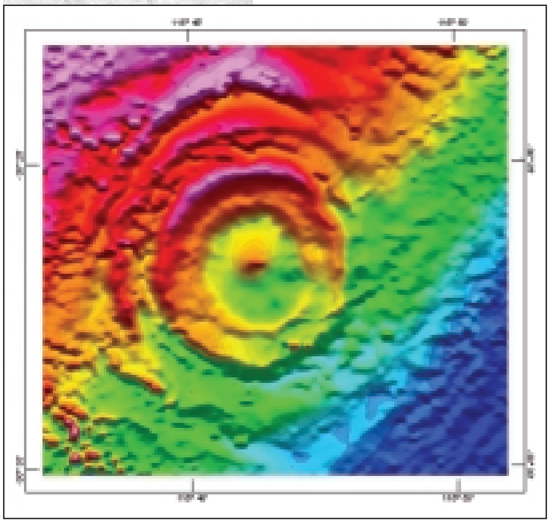
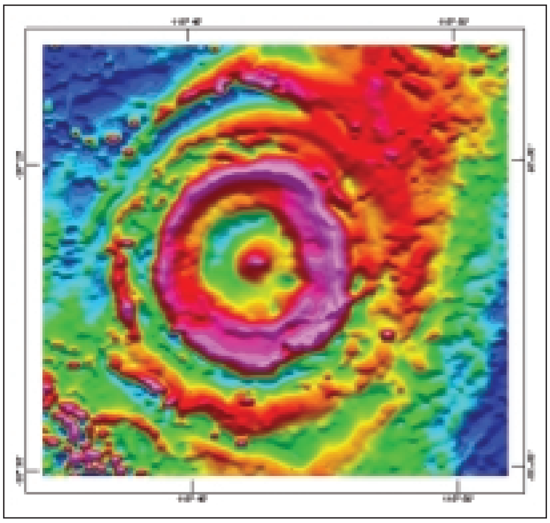


Fig. 2. (Bottom) Residual magnetic image created by subtracting a regional generated by upward continuation from the Total Magnetic Intensity.



The concentric magnetic anomalies are centred on a single peak near the middle of the magnetic survey. The diameter of the outermost ring is approximately 12 km, which agrees with the size of the Yallalie structure estimated from the interpretation of seismic data (Dentith, et al, 1999). In fact, there is a very good correlation between the location of these magnetic anomalies and the major faults interpreted from seismic data.

The innermost magnetic ring, with a diameter of 3.4 km, corresponds with the extent of the crater's central uplift. A torus-shaped positive anomaly, extending from 3.4 to 6.0 km, coincides with the location of the deepest structural depression (the crater "moat"). Weaker, roughly circular, anomalies with diameters up to 12 km are interpreted as slump structures in the outer, terraced, terrain of the crater.

Several post-impact faults cross cutting the Yallalie structure, due to continued deformation and subsidence within the Perth Basin, are interpreted from minor offsets in the magnetic anomalies.

Past investigations into the magnetic signatures of meteorite craters suggest the dominant effect of extraterrestrial impact is to reduce the magnetic susceptibility of the target rock, resulting in an overall negative magnetic anomaly over the crater. (Pilkington and Grieve, 1992). Positive magnetic anomalies are reported to be formed by two different processes. A central peak anomaly may be formed by the structural uplift in large impact structures bringing magnetic basement closer to the surface. Alteration effects (due to shock, thermal and chemical processes) may result in the formation of new magnetic minerals or the resetting of remanent magnetisation. A good example of the later effect is shown at Gosses Bluff (Milton et al, 1996)

Two possible sources for the magnetic response at Yallalie are being considered. The first is the deposition of weakly magnetic impact melt or sediment settling into the topographic lows of the complex crater floor formed by faulting and slumping. This interpretation would suggest relatively shallow, flat-lying sources of the magnetic anomalies.

Alternatively, local heat flow generated by the impact may have led to the production of a small amount of magnetic material along fault planes within the structure by hydrothermal alteration. Deeper magnetic sources, concentrated along the internal faults within the structure, would be implied by this model.

Work to determine the likely source of the magnetic anomalies at Yallalie is continuing.

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AngloGold to Swallow Normandy?

The world's biggest gold miner, South African based AngloGold Ltd, has launched a $3.2 billion bid for Normandy Mining Ltd, in a move that continues the recent trend of consolidation and globalisation in the Australian minerals industry.

The bid involves AngloGold offering 2.15 AngloGold shares for each 100 Normandy shares; in other words, A$1.42 per share. If successful, Anglo will acquire Australia's largest gold producer and the seventh biggest globally. At present Normandy contributes about 30 per cent (~65 t/yr) of the Australian annual gold production.

In recent years both companies have been active with Australian takeovers. Normandy has acquired North Flinders Mines, Mt Leyshon and Great Central, while Anglo has taken over Acacia Resources. They should therefore both know what games they are playing.

The Normandy Board has appointed Macquarie Bank to assist them in assessing AngloGold's offer and in preparing a formal recommendation to Normandy shareholders.

However, it seems that the Board will view the bid in a positive way. The Chairman and CEO of Normandy, Robert Champion de Crespigny, said:

"It is fair to say that the objectives AngloGold has in this offer are similar to the strategies we at Normandy have expressed for some time. Consolidation in the gold and other commodity sectors is necessary as companies seek to gain critical mass, both operationally and in order to gain more efficient access to capital through greater liquidity and better market ratings. AngloGold is one of the leading companies in this industry and its offer is a logical industry move.

However, we need to complete a full review of the offer so that we can make a recommendation to Normandy shareholders."

The takeover may be good for Normandy shareholders but the effect on the Australian exploration industry is not likely to be as positive. Anglo spent $US63 million on exploration globally in 2000 and is expected to reduce this in 2001 to $US46 million. At the same time Normandy has cut its exploration expenditure by 25 per cent in the 2000/2001 financial year to $US30 million and like Anglo is concentrating on 'brownfield' investment close to existing infrastructure. A takeover would almost certainly reduce the exploration activity even more.

Musgrave Block Opening Up

Good Nickel finds have been reported from the Musgrave Block, which straddles Western Australia and South Australia. In May last year WMC found a 26.5 m intersection of 2.45% Ni, 1.78% Cu and 7.4% PGEs in its Nebo Prospect. This discovery was based on airborne EM and is comparable to the grades found at Inco's Voisey Bay discovery in Canada.

Since then West Musgrave Mining, ReLODE and Acclaim Exploration and Goldsearch have taken up land in the region and will be using airborne EM and detailed magnetics to identify conductors associated with massive sulphides. On the South Australian side of the Musgrave Rio Tinto and Delta Gold have secured exploration licences and the Pitjantjatjara Mining Company also has 20 000km^2 under application. So, as they say on the billboards: Watch this Space.

Mineral Exploration in the Doldrums but Petroleum Numbers are Good

Figures 1 & 2 provided with permission of the Australian Bureau of Statistics.

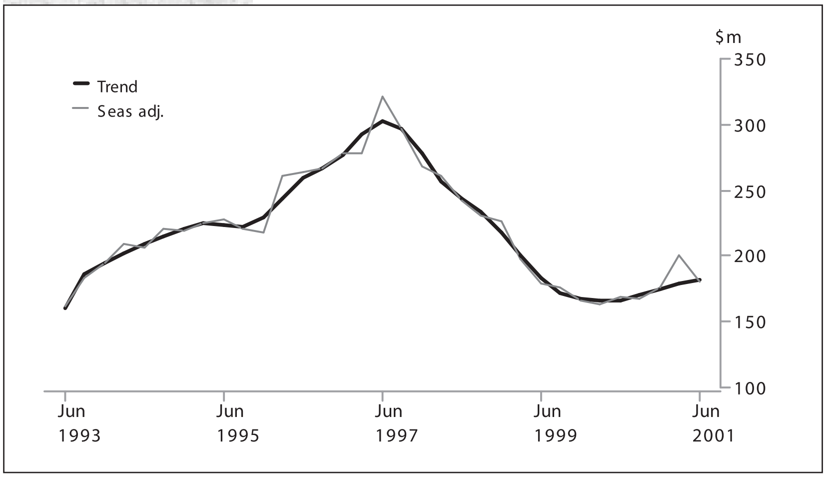


Fig. 1. Mineral exploration expenditure, June 1993 to March 2001.

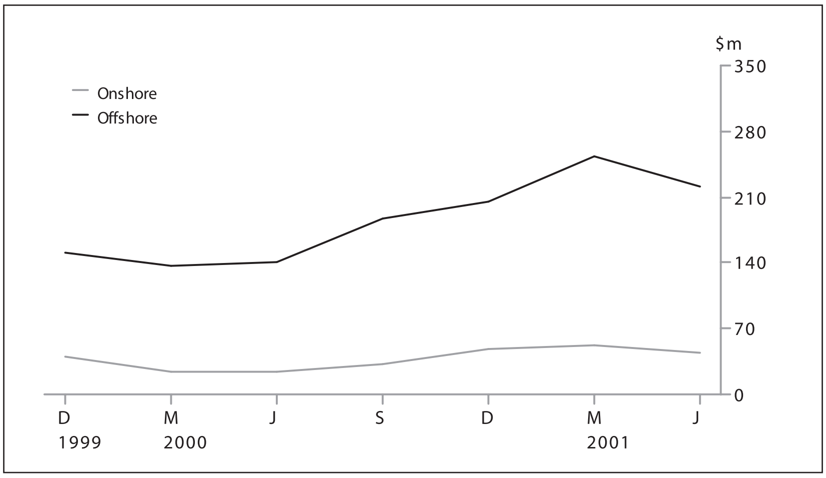


Fig. 2. Petroleum exploration expenditure, December 1999 to June 2001.

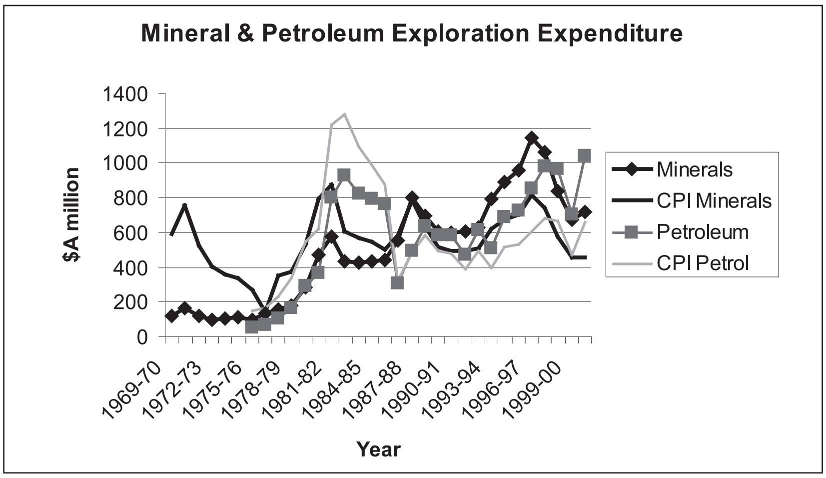


Fig. 3. Long-term trends in mineral and petroleum expenditure from 1969/70. The lines with symbols show the original dollar numbers, and those without symbols show the expenditure adjusted for the CPI to a 1969/70 standard.

Minerals sector still sluggish

Figures released by the Australian Bureau of Statistics showed that mineral exploration rose in the June quarter 2001, continuing the small increases that have been occurring since the March quarter 2000.

The June quarter 2001 trend estimate of $182M was 10% higher than the trend estimate of $166M for the June quarter 2000.

The largest increase between March and June quarters 2001 occurred in Western Australia (up $3M), while in New South Wales, Victoria and South Australia the estimates increased only marginally.

Expenditure in Tasmania remained unchanged, while in Queensland and the Northern Territory the estimates showed small decreases.

Figure 1 shows the trends for the last eight years.

The total mineral exploration expenditure for the June quarter 2001 was the highest reported since June quarter 1999 and reinforces the slow increase in mineral exploration investment.

The rise in total mineral exploration in the June quarter 2001 was mainly due to a 21% ($28M) increase in expenditure reported on 'all other areas'. The majority of the increase on 'all other areas' occurred in Western Australia, up 34% ($25M).

Overall, Western Australia was the main contributor to the June quarter 2001 increase, up $29M to a dominant $113M.

Between the March and June quarters 2001, exploration expenditure for gold rose by $22M (26%), coal by $8M (99%) and copper by $7M (112%).

These numbers are reflected in the drilling results. Since the March quarter 2001 drilling on 'production leases' has increased by 19%, to 400 km, and drilling on 'all other areas' has increased by 24% to 1100 km.

The 2000/01 estimate of mineral exploration was $721M, compared to $676M for 1999/2000, but much lower that the 1997/98 estimate of $1067M.

Petroleum exploration effort is healthy

Reported expenditure on petroleum exploration in the June quarter 2001 was $266M, 13% ($39M) lower than the March quarter 2001, but 61% ($101M) higher than the June quarter 2000.

The decrease in total petroleum exploration expenditure from the March quarter 2001 occurred mainly as a result of a 27% ($26M) decrease in offshore non-drilling expenditure.

Continued On Page 39

AMF Faces New Challenge

Like many other companies and service organizations in the resources sector, the Australian Mineral Foundation has, over the past 12 months, faced financial pressures, and cash flow difficulties in particular.

In order to deal with a potential problem, the AMF Council decided to go into Voluntary Administration. This is not receivership and it is not liquidation. It is a prudent mechanism that allows a business to carry on operating while it restructures to put itself back on to a more secure financial footing.

That is AMF's present position: we continue to operate as normal while a plan is formulated to resolve the problems. The intention is to carry on, operating from our secondary building due to the high maintenance costs of the main AMF building. It is important to mention that the current building is not necessary for AMF's present mode of operation.

The change of location will not in any way impinge on AMF's services: we will continue to provide valuable library and information services; we will continue to offer some of the industry's best professional development opportunities in Courses, Conferences and International Study Tours; and the AMF Bookshop will continue to offer a unique range of books and other publications sourced from all over the world.

AMF is a membership organization, and we aim and need to attract members. So we invite companies - large and small, government agencies, educational institutions, and individual professionals to look at the services and benefits offered by AMF and consider the value of membership. The use of the Internet now means that the AMF information services and the bookshop catalogue are accessible to members from anywhere in the world. Membership support is vital in helping AMF to achieve a successful future.

For information on AMF Membership please go to the Promotional Website at www.mineralsinfo.org or the main AMF site at www.amf.com.au or contact us at:

Australian Mineral Foundation
63 Conyngham Street Glenside SA 5065
Phone: 61 8 8379 0444
Fax: 61 8 8379 4634

This statement by the AMF clarifies the situation regarding its business operations at the time of going to press.

Continued On Page 38

Between the March quarter 2001 and the June quarter 2001, expenditure for petroleum exploration on 'all other areas' decreased by 12% ($29M), and exploration on 'production leases' decreased by 15% ($9M).

Western Australia was once again the main contributor, with a reported $162M expenditure on exploration, a decrease of 25% ($55M) from the March quarter 2001. Victoria, meanwhile, reported the largest increase of 327% ($34M). The increase in Victoria was mainly due to offshore drilling on 'all other areas'.

Figure 2 gives an indication trends in the last two years.

The 2000/01 estimate of petroleum exploration was $1044M. This is the largest ever annual investment in petroleum exploration in Australia and compares to the 1999/00 estimate of $723M and the 1998/99 estimate of $868M.

Figure 3 shows the longer term trends in mineral and petroleum exploration expenditure both in original dollars and in with adjustments made to the CPI.

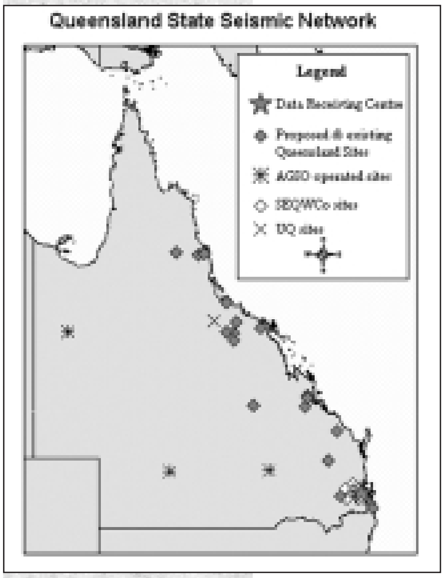
Delta and Goldfields Merge

In keeping with current trends, the mergers and take-overs just keep on coming.

The latest happening was the joining of Delta Gold and Goldfields to form an $825 million enterprise, which will create Australia's second largest producer (~26 t/yr).

Apparently the merger was friendly with Goldfields chairman, Dick Warburton, chairing the new company and Peter Cassidy, Goldfields managing director, becoming the non-executive director of the new board. The new company will also break into the top 150 largest companies on ASX.

Mindata Monitors Queensland



The Seismology Research Centre (SRC) a Division of Mindata Australia Pty Ltd has recently won a contract to re-establish the Queensland State Seismic Monitoring Network. The contract involves the re-establishment of existing sites, the upgrading of outdated equipment and the installation of several new sites over a three-year period, and the operation of the network and all data analysis for an additional two years. This long-term contract comes after a protracted period of negotiations in which State Government funding for the operation of the regional network by the University of Queensland was discontinued. The contract was negotiated principally by the Department of State Development and will be managed by the Department of Main Roads. The five-year guarantee of funding, which comes from a consortium of Queensland State Government Departments, ensures a period of stability in which a viable state network can be established and operated.

Existing SRC Kelunji Classic recorders of the Joint Urban Monitoring Program (JUMP) in the major urban population centres of Queensland (Gold Coast, Toowoomba, Brisbane, Rockhampton, Townsville and Cairns) will be refurbished and installed in permanent housings. Data from these installations will be accessible via dial-up modems.

Outdated smoked paper and digital cassette recorders previously used to monitor Sunwater dams will be updated to the SRC Kelunji D Series recorders. Equipment at some sites will be moved to dams that Sunwater consider should be monitored. The recorders at these sites will be accessible either via dial-up modems or via modems connected to the Internet.

Continuous data from at least five sites throughout the State will be transmitted in near real-time to allow for a basic alarm system for the State's emergency managers and dam operators. Seismically triggered information from additional sites will be regularly transmitted to further improve the alarm capability.

Information from the state network will be shared with other network operators (AGSO, South East Queensland Water Corporation, University of Queensland) to improve reliability and increase data redundancy.

To manage the project, SRC has set up a regional office in Brisbane under the management of Russell Cuthbertson. This office will form an additional node in the large network of seismographs operated by SRC in Tasmania, Victoria, New South Wales and Queensland. The sharing of data between the SRC nodes will ensure a continued operation of an alarm service should any one node become inoperable in the event of an earthquake.

In addition to upgrading, re-establishing and operating the state network, the contract requires that the seismic data obtained be used for regular upgrading of hazard estimates, which would subsequently be used in updating the Earthquake Loading Code.

The head office is currently located on the Technology Park of Latrobe University in Melbourne; for more information contact Desmond FitzGerald, Chairman on des@dfa.com.au

Pasminco in Voluntary Administration

With a debt to its bankers of about $2.6 billion, and an after tax loss of $716 million for the year ended 30 June 2001 Pasminco called in Ferrier Hodgson as a voluntary administrator (see August Preview for earlier reports) after failing to secure an agreement with its lenders over its debt levels. It is thought to owe about $1.7 billion to its lenders, an additional $750 million on its currency hedging contracts and another $450 million to its trade creditors and employees.

Pasminco, which was formed in the late 1980s through a merger of unwanted mining and smelting assets of Rio and North, bought the Century deposit from Rio in 1997, for $345 million, and committed itself to spend a further $1 billion on its development. It is now trying to sell this asset to maintain liquidity.

However, weakening metals demand has led to a 13 year low of US$805/t for zinc and corresponding increases in inventory levels throughout the year.

Trading in Pasminco's shares was been suspended on 19 September but its administrator has secured a $330 million line of credit to keep the company's mining and smelting operations going until 30 June 2002.

Its main assets are up for sale include: Century in Queensland, Rosebery in Tasmania, Elura in NSW and Broken Hill in NSW.

Pasminco's share price has reflected the company's fortune. In 1997 this was at ~$2.50, in July 2000 it had fallen to about $1.00 and before trading was suspended it had dropped to $0.05. Put another way, its market capitalisation has fallen from close to $2 billion to less than $200 million in two years.

An unfortunate outcome for a company that had very pro-active exploration activities.