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Preview

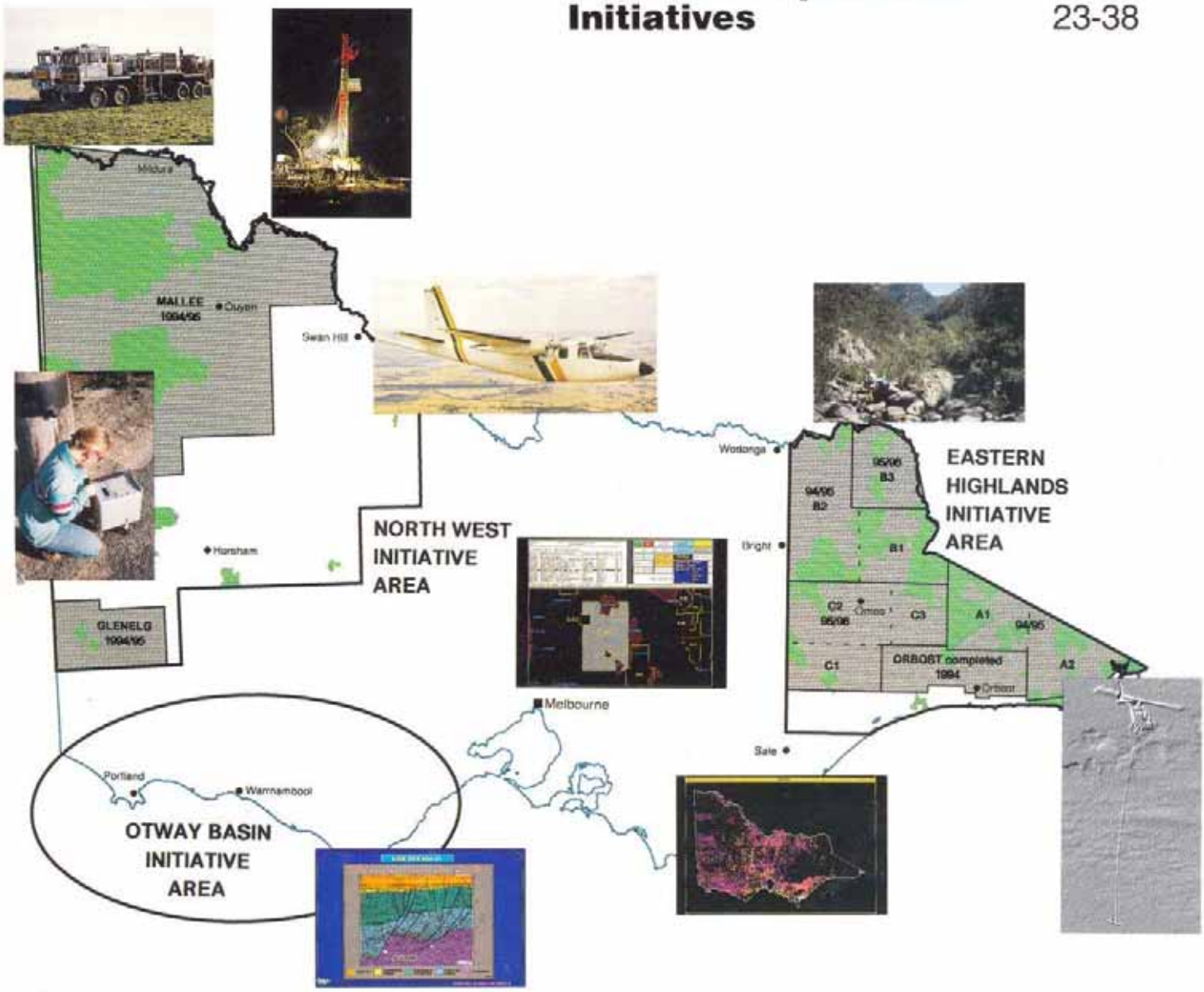
June 1994

Issue No. 50

JUBILEE ISSUE

Special Feature

Victorian Exploration Initiatives 23-38



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Editors Desk

Preview Jubilee

In this 50th issue of Preview the ASEG has some right to self congratulation. A special thanks goes to all contributors - people and companies, advertisers and to past editors Peter Elliott and Anita Heath that have made Preview a vital part of ASEG life over the last 50 issues.

Colour advertising starts this issue enabling a colour front cover as a regular face to Preview. Thankyou to Earth Resource Mapping for their support of Preview in this way. A change of printer has reduced the cost of a colour feature article to $1,500 (4 pages of colour, colour front cover and 4 to 12 pages of B&W text). This cost compares very favourably with just one single page of advertising ($1,100). Our colour articles make excellent promotional reprints at $1.00 each.

Excellent opportunities for use of colour to educate and promote new techniques or state of the art, present themselves at a reasonable cost. If your company/ organisation wishes to contribute a colour feature article or advertise in colour in Preview, please contact either Greg Turner (03-881 1279) or myself.

A major feature on Victorian Exploration Initiatives over the next 3 years is our colour feature (p23). Thankyou to the Department of Energy and Minerals and staff for compiling this informative article. This follows on from SAEI (Preview No 47, August 1993) and it is hoped other States will follow suit soon through the colour pages of Preview.

Reader's attention is drawn to news of ASEG-GDF2 (p46) from Dave Pratt (assisted by Bill and Ted - p49). Other items: Seabed imaging (p16); Don Pridmore's Perth Conference keynote address on funding geophysics R&D (p41); Magnetic Susceptibilities in hydrocarbon search (p12) and volcanics on seismic (p50) make for a bumper and interesting 50th milestone issue.

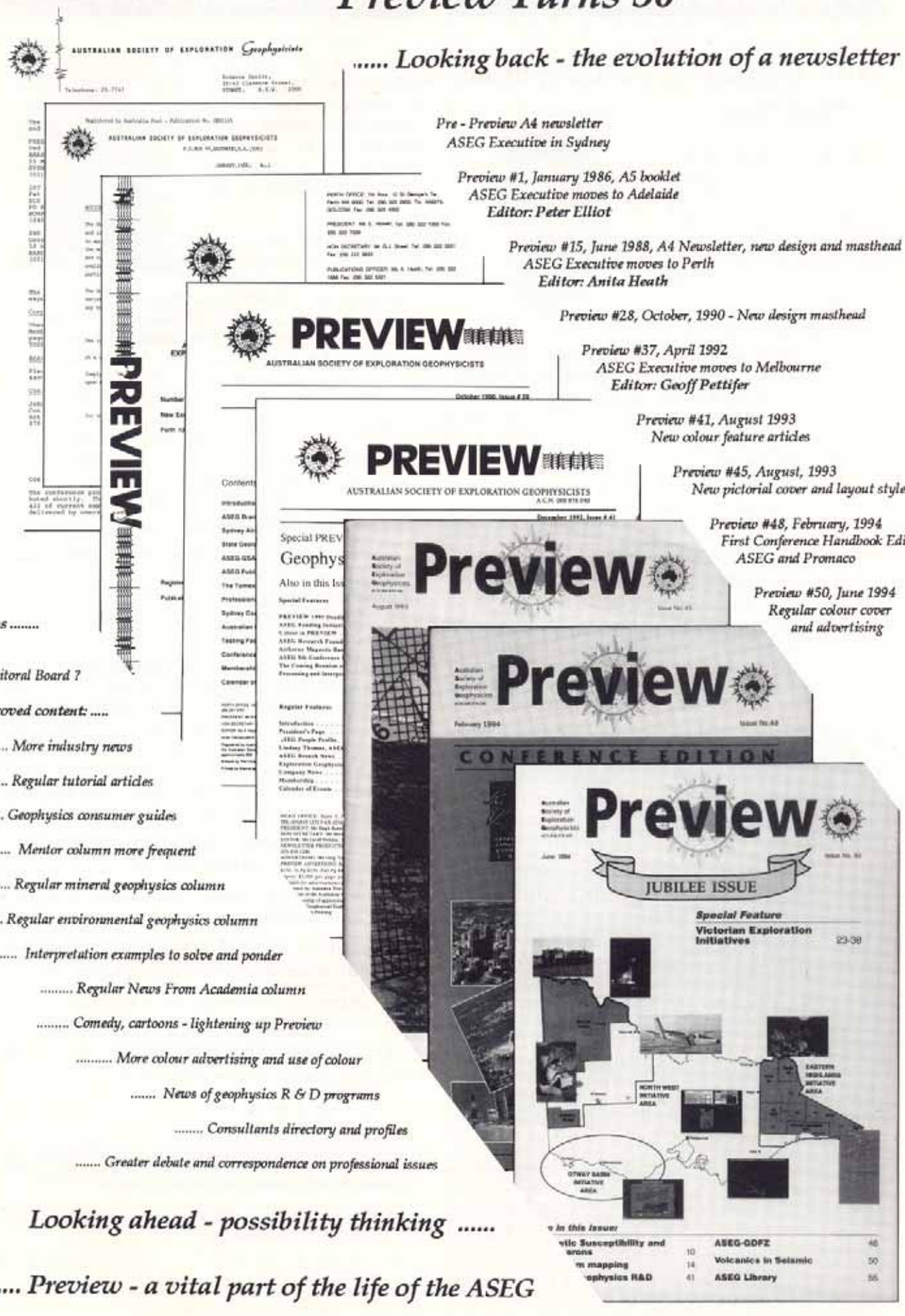
Initiatives by the Publication Committee to raise the international profile of Australian geophysics by making Exploration Geophysics more accessible are featured on p6 and p8.

Finally we remember Bruce Harley (p57) whose passing saddened his many colleagues; and pay tribute to new Honorary member Roger Henderson (p11) and ASEG Grahame Sands Award Winners for 1994 - Stuart Nixon, Richard Kurzeja and David Hayward (p51).

Geoff Pettifer
Editor

Preview Turns 50

..... Looking back - the evolution of a newsletter



Pre - Preview A4 newsletter
ASEG Executive in Sydney

Preview #1, January 1986, A5 booklet
ASEG Executive moves to Adelaide
Editor: Peter Elliot

Preview #15, June 1988, A4 Newsletter, new design and masthead
ASEG Executive moves to Perth
Editor: Anita Heath

Preview #28, October, 1990 - New design masthead

Preview #37, April 1992
ASEG Executive moves to Melbourne
Editor: Geoff Pettifer

Preview #41, August 1993
New colour feature articles

Preview #45, August, 1993
New pictorial cover and layout style

Preview #48, February, 1994
First Conference Handbook Edition
ASEG and Promaco

Preview #50, June 1994
Regular colour cover and advertising

Plans .....

Editoral Board ?

Improved content: ....

..... More industry news

..... Regular tutorial articles

..... Geophysics consumer guides

..... Mentor column more frequent

..... Regular mineral geophysics column

..... Regular environmental geophysics column

..... Interpretation examples to solve and ponder

..... Regular News From Academia column

..... Comedy, cartoons - lightening up Preview

..... More colour advertising and use of colour

..... News of geophysics R & D programs

..... Consultants directory and profiles

..... Greater debate and correspondence on professional issues

Looking ahead - possibility thinking .....

..... Preview - a vital part of the life of the ASEG

President's Piece

Early Influences on Geophysics in Australia

In my address at the recent ASEG Conference in Perth I commented on the status of geophysics used for mineral exploration in the late 1960's and early '70's. I inadvertantly linked the names of a number of eminent geophysicists visiting from Canada and the USA with some of our early mistakes; if blame was construed, let me hasten to add that is was not intended. We all benefited from the experience and expertise of these visitors, who, in their own particular way, influenced the developing direction of exploration geophysics at that time.

Tom Barringer introduced INPUT® to Australia. The system went through a series of instrument upgrades and is the basis of such systems as Questem and Geotem, that are used widely today.

Stan Ward visited in 1970 and provided much needed advice on how to improve the field usage and interpretation of I.P. in Australia; the directions were being set for the future. Stan also played a major role in the establishment of the CSIRO Division of Mineral Physics, as it was known then, with Ken McCracken as its first Chief (see Preview February 1994). We are all aware of the successes that flowered from that seed.

Harry Seigel and Phil Hallof were early visitors to Australia, and both took time to visit field locations out of Kalgoorlie to see the local conditions at first hand. Did the beginnings of Magnetic I.P. and Spectral I.P. find their place here?

And Arthur Brant, well known for his early work in time-domain EM, a method used extensively today.

These are only a few of the people who provided a positive influence on the early geophysics in Australia. There were many others, not just in mineral geophysics but also in petroleum exploration. Looking back it is often difficult to know who made the comment, that formed the germ of an idea, often over a few glasses of beer.

If anyone has a "how it really happened" story, let the editor know and we will do our best to include it in Preview. I have mentioned five people, only briefly; there are many stories to tell.

Innovation and invention are not just factors of the past; we still see the sparks of brilliance today. Some are recognised by awards such as the Grahame Sands Award; others are not. Well, maybe not yet, but their turn will come.

Hugh Rutter, President

Vice-President's View

Thanks to the not altogether amicable exchanges between our former and present prime ministers, it is now fashionable to reflect on Australia's position in the world.

Those of us who periodically work overseas will agree that the standard of geophysical practice in Australia is equal or superior to anything in the world. This especially true of our very successful biennial Conferences. However it is equally evident that we have enjoyed far less success in gaining recognition of our work, as measured by circulation of our technical journal Exploration Geophysics, and citation of its papers in scientific literature. This despite the fact that the specialty sessions in recent conferences (e.g. Epithermal Gold; Coal, Groundwater and Engineering, Mt Isa Block; West Australian Ore Deposits) have produced geophysical case histories of outstanding value.

It was alarming recently to hear researchers at a leading North American university comment that, while titles in Exploration Geophysics are easily located using the SEG Digital Index, they did not receive and could not easily access hardcopy of our journal.

This month sees the start of a new initiative to make our case histories more accessible to overseas geophysicists, and the journal more attractive to overseas authors. The announcement on page 8 makes back issues of Exploration Geophysics available free of charge to Universities who commence a subscription. A similar scheme offering deeply discounted back issues to overseas subscribers will be announced next month.

Three other current initiatives aimed at raising visibility of Australian geophysics are:

- negotiations with the SEG on holding a joint ASEG - SEG international conference in Australia in 1997.
- negotiations with the SEG to assist in marketing special issues of Exploration Geophysics.
- no charge for colour figures in technical papers in non-conference issues of Exploration Geophysics.

Each member of the ASEG can help in our task of raising the Society profile. Each could:

- write up a good case history and send it to Exploration Geophysics.
- contact an overseas colleague and invite them to send a paper and/or join the ASEG.
- forward the details of the Offer to Universities (page 8) to contacts overseas.

Michael W Asten
First Vice President

Executive Brief

There have been two meetings of the ASEG Executive since the last Preview, but unfortunately I missed both of them. Thanks to Greg and Geoff who "volunteered" to take the minutes on these occasions. Below is an accurate summary, I trust, of the proceedings of these meetings.

- John Denham has been confirmed as Exploration Geophysics editor to the end of 1994. This position is to be re-advertised for 1995 to enable all interested members to apply (see opposite).
- Jenkin Buxton have been appointed the new printers for Preview (they also print Exploration Geophysics) with cost savings in colour printing in particular. The price for a colour article in Preview (4 pages) has been reduced to $1,500 to encourage greater participation.
- Mike Asten has given some copies of Exploration Geophysics to other associate editors of Geophysics. They indicated interest in reprinting some Exploration Geophysics case histories.
- A draft ASEG budget is being prepared by Andrew Sutherland and Lindsay Thomas.
- Archived publications have been transferred from Adelaide to Melbourne - 16 pallets arrived recently (6.6 tonnes!) and are currently being sorted and compiled. Offers of complete sets of Exploration Geophysics will be made to education institutions. See Mike Asten's report (p6) and page 8. All Adelaide accounts have been transferred to Melbourne.
- We welcome a new Corporate Member - R.G.C.
- Koya Suto is designing a prototype exploration tester for use in geophysics demonstrations to schools (p11).
- GIS software will be available to schools from ArcInfo for only $150. Thanks to Robyn Gallagher for arranging this discount (p11).
- It was agreed that publications will no longer be sent to students in arrears who have had the benefit of a free years subscription. Reminder notices to be sent.

A reminder to all members that there will be an update of the membership booklet distributed in October. Please get any name, address, title, e-mail etc changes ASAP to Janine Cross, ASEG Office or myself.

Brenton Oke, Secretary

Preview Deadlines

Issue	Deadline
August '94	July 29 1994
October '94	September 30 1994
December '94	November 25 1994

EDITOR

SPECIAL EDITORS (Adelaide Conference, 1995)

EXPLORATION GEOPHYSICS

(Published by the Australian Society of Exploration Geophysicists)

Applications are called from interested members of the society for these positions for 1995-96.

The Editor is responsible for the technical content, standard, and professional image of the journal, which is the "flagship" of the ASEG.

The Editor is appointed for a one or (preferably) two year term. Special Editors are appointed for major single issues of the journal, in particular, Conference issues. The next Conference issue will be for the ASEG 11th Geophysical Conference in Adelaide, in September 1995.

Editorial positions are honorary, however the Federal Executive has approved payment of expenses and an honorarium for these tasks.

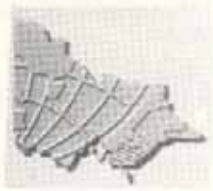
For further information contact the ASEG Secretariat (Ph: (03) 818 1272) or Michael Asten, Chairman of Publications Committee (Ph: (03) 810 7767).

Preview - Next Issue

- *Imperial Geophysical Survey Revisited*
- *Magnetics and Non-Uniqueness*
- *Preview Tutorial - Map Datums, Spheroids and AMG*
- *Shallow seismic for Sweden - Denmark Tunnel*

ASEG Branch News

Victoria



The Victorian branch is alive and well. Reborn again, some might say.

In May a new committee was elected, with a huge support base developing. We wish to thank all those members who have willingly donated their time to be a part of the committee. The incoming President is Assoc. Prof. Jim Cull of Monash University. Your new committee members are listed below.

The new committee and Victorian members would like to thank outgoing members for their time and effort during their service. We would also like to thank those members who are continuing to give their time on the committee. Much gratitude goes to Schlumberger, who provided both financial and personnel support during Zis' time as secretary.

Recently John Peacock gave a talk on GPS in gravity. An upcoming talk by Dr Alistair Brown on 3-D Seismic Evaluation will be a combined GSA/ASEG meeting to be held in July at Melbourne University (stay tuned for your next flyer).

The new committee is as follows:

President:	**Jim Cull**	Monash University
	Ph: 905 4897	Fax: 565 4903
Vice-President:	**Paul McDonald**	Geological Suvey
	Ph:412 7866	Fax: 412 7803
Secretary:	**Paul Basford**	Pasminco Expl.
	Ph: 288 0468	Fax: 288 0211
Treasurer:	**Andrew Boyd**	Melbourne Uni
	Ph: 344 6911	Fax: 344 7761

Committee:

Zis Katelis	Schlumberger Seaco	Ph: 696 6266
Ron Palmer	Stockdale Prospecting	Ph: 863 5208
Steve Carroll	Melbourne Uni	Ph: 344 6911
Nigel Hungerford	Hungerford Geoph.	Ph: 818 8989
Kathy Hill	VIEPS	Ph: 905 5773
Andrew Barrett	GFE Resources	Ph: 652 5778
Kunal Chakravorty		Ph: 534 8596
Ron Angove	Esso Australia	Ph: 270 3918

Paul Basford, Secretary

Queensland

After our three meetings in March, we have had a quiet time. We did not have any meetings in April or May.

Our next meeting will be the student night when we hope to hear about four presentations.

The Queensland Department of Minerals and Energy is having a two day symposium on 29 and 30 November. We are currently looking for an ASEG workshop or similar to have in conjunction with this. A minerals topic would be appropriate. Anyone with ideas can contact the Qld Executive.

Our best wishes go to Joe Williams who is recovering from illness and will have a rest from lecturing duties for a while.

Wayne Stasinowsky, President

Western Australia

The WA branch is operating again under its new committee elected at the AGM on the 21st April 1994.

Most technical meetings for the year have already been planned although we are still short of several speakers, particularly for minerals topics. If you are interested contact one of the committee members. It is planned to split the meetings between the Raffles Hotel and Celtic Club and charge no fee in the interest of improving attendances. These moves appear to be successful with the first meeting on the 2nd of June being well attended.

In lieu of a Christmas party last year we held a family barbecue on Australia Day. This event was well received and will be repeated in the future.

The new committee is:

President:	**Andy Padman**	Woodside
	Ph: (09) 224 4111	Fax: (09) 325 8178
Vice President:	**Keith Mayes**	North Exploration
	Ph: (09) 277 8033	Fax: (09) 277 3844
Treasurer:	**Kevin Tucknott**	Poseidon Exploration
	Ph: (09) 480 3232	Fax: (09) 480 3270
Secretary:	**Allan Perry**	World Geoscience
	Ph: (09) 383 7833	Fax: (09) 383 7166

Committee:

Anita Heath	Consultant	Ph: (09) 367 3827
Dave DePledge	Woodside	Ph: (09) 334 4194
Brian Evans	Curtin University	Ph: (09) 351 7092
Andie Lambourne	Geco Prakla	Ph: (09) 321 5477
Martin Bawden	NOPEC Australia	Ph: (09) 321 6854
Michael Lees	BPB Slimline Services	
Bill Peters	Southern Geoscience	Ph: (09) 316 2814
Shane Wright	Rust PPK Pty Ltd	Ph: (09) 389 8668
Dave Abbott	Tesla-10 Pty Ltd	Ph: (09) 364 8444

Allan Perry, Secretary

ASEG People Profile

Roger Henderson Honorary Member

Some might conclude that Roger was awarded Honorary Membership for his extensive service to the Society in particular and to the profession in general. Another reason could be that he had at last attained an age where the loss of his annual subscriptions for the rest of his career would not be a great burden on the Society and it was hoped then that it might finally stop him pestering the Federal Executive with his suggestions and "we didn't do that when I was President" type comments (like certain former Prime Ministers).

Nevertheless, Roger was Federal President on two occasions, Federal Treasurer once and a Conference Co-Chairman. He has served on the Conference Advisory Committee, represented the Society on the Australian Geoscience Council and is currently Chairman of the Geophysical Activity Committee. Roger is now General Manager of Geo Instruments, one of the most important, wholly Australian owned geophysical companies. Also, as a member of the Sydney University Earth Resources Foundation and a recently appointed Honorary Research Associate of the Department of Geology and Geophysics, he is currently very interested in seeing that the ASEG plays a useful role in the appointment of geophysicists to academic posts in the Sydney Universities.

Since leaving Macquarie University in 1971 as a Lecturer in geophysics to work abroad, Roger has travelled extensively throughout the world, so much so that he has been on the same flight as Bob Smith three times. His employment with Huntings Geology and Geophysics of the U.K. and Barringer Research, firstly in the U.K. and subsequently in Canada, resulted in him travelling all over Europe, including Poland and Czechoslovakia, doing VLF in Morocco and resitivity in Tunisia, with many sales trips to parts of the United States to promote the Barringer airborne conductivity mapping system which used radio stations as a source.

On return to Australia in 1977, Roger joined Geoex as a Director and immediately gained the licence from CSIRO for Geoex to commercialise SIROTEM. This caused Roger to travel once again back overseas and eventually to every continent, where he has given seminars, exhibitions and performed field demonstrations which have produced enough stories to one day make a good book. Not even the airship that used to hover over Sydney escaped Roger's involvement in having a SIROTEM installed on it. Still to this day, SIROTEM is one of the few successful indigenous geophyiscal instruments which as been promoted overseas and as a result Roger has enjoyed getting back at the Canadians who have tended to dominate the geophysical instrument manufacturing scene, often producing instruments that were not particularly suitable to our own environment (such as striving to have a temperature spec to -30^0C but never more than $+40^0$C).

When Geo Instruments began to manufacture a magnetic susceptibility meter, the network of SIROTEM agents around the world gave Roger the incentive to ensure that it was of world class standard so that it too could be promoted through this network.

In addition to this interest in building up a local geophysical instrument manufacturing base, Roger is also interested in the promotion of geophysical methods for environmental applications. To further this he is currently the Australian representative of the U.S. based Environmental and Engineering Geophysical Society.

The ASEG is grateful for Roger's dedication to the geophysics profession and the society and is proud to honour him in this way.

ASEG Promotion Committee

"Geophysics has an image problem," said Don Pridmore in the opening address of the 9th ASEG Conference and Exhibition in Perth in February this year (see p41 this issue).

What can we do to improve the image of geophysics? And how: how can we improve the understanding and recognition of geophysics by society: mums, dads and kids?

One of the groups ASEG is focussing on is secondary students: telling them about geophysics; encouraging them to choose geophysics as a tertiary subject; and perhaps to proceed with geophysics as a major. We are not that naively optimistic to think of doubling the number of geophysics graduates by doing this, but we hope it will increase society's general understanding.

We are preparing a geophysics education kit, and later this year Kim Forward of Wesley College will present it at the Science Teachers' Association Conference in Melbourne. The presentation kit includes a slide set, a package of GIS software and geophysical data, and an SP and resistivity experiment kit. If accepted, the kit will be made available to schools for science teachers to present to their students. Other states will be approached in a similar way after reviewing the response in Victoria.

This is a long term project. The students we are hoping to influence will be graduates in five to seven years' time. Hopefully they will be future members of ASEG.

Promoting .....

..... Geophysics

Magnetic Susceptibility Variations, Sedimentary Rocks And Hydrocarbon Deposits

Khamphira Viravong and Richard Facer
Department of Geology and Geophysics
University of Sydney

(Report on 1993 ASEG Research Foundation funded program)

In 1993 the ASEG Research Foundation provided a grant which enabled a successful study of variations in magnetic susceptibility in sedimentary basin rock - where those variations are thought to have been influenced by hydrocarbon migration. The study was able to show marked variations in magnetic susceptibility in rocks of the Sydney Basin. Those variations were such that it was necessary to acquire extensive baseline data for Sydney Basin, which inhibited extension of the study to known oil fields.

The rocks studied were Permian to Triassic sandstones, shales and related sedimentary rocks, mainly from diamond drill holes in the Huntley/Robertson area, and at Bunnerong. Some tests were also performed on intrusive rocks encountered in the drill cores. Magnetic susceptibility studies were also carried out on surface and near surface samples from Woodford (Blue Mountains), Coalcliff (Wollongong) and the Ulan/Breakfast Creek area. The magnetic susceptibility measurements were complemented by other petrophysical studies, a brief petrographic study and chemical analyses. The magnetic susceptibility results showed what appears to be characteristic values on different lithologies.

One of the goals in this study was to test the feasibility and versatility (if applicable) of the integrated use of magnetic susceptibility studies as a hydrocarbon exploration tool, a "non-conventional" but straightforward exploration tool. The potential use of a *non-destructive* technique (such as magnetic susceptibility measurements) is attractive because it could detect remnant effects of hydrocarbon migration because of oxidation/reduction effects. The integrated use of magnetic susceptibility studies (with other exploration procedures) was emphasised in the study because it can be successful as a ground-based tool to complement other surface and downhole geophysics. The magnetic data presented here were acquired using a Geo Instruments GMS2, with measurements taken in the field and in the laboratory (a fuller description, and comparative comment re alternative measurements, is beyond the scope of this note). By studying rocks in the Sydney Basin, the possible effects of "leaking" methane from rocks containing coal measures should provide a measure of control on the proposed exploration technique. This opportunity was enhanced by availability of fully cored drill holes - which are rarely

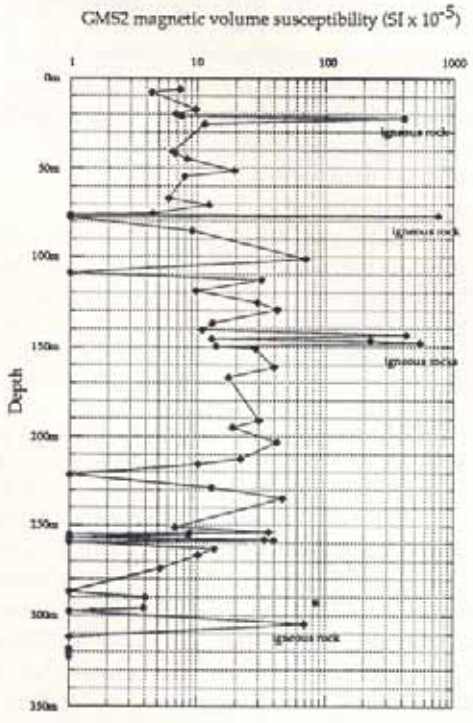


Figure 1. The GMS2 magnetic volume susceptibility vs depth, Elecom Huntley Diamond Drill Hole 15

available from petroleum exploration. Results indicate that, just as with a number of other geophysical techniques, ready application to Australian conditions may not be valid because of the depth of weathering. In some drill holes the weathering apparently extends to over 100m in depth, and hence any secondary hydrocarbon-induced reduction is countered by the oxidation of magnetite to hematite (and various other iron oxides/hydroxides).

The results showed no overall linear trends between depth and the petrophysical properties but an important relationship was observed. Magnetic susceptibility of the sandstones varied from 1×10^{-5} SI to 40×10^{-5} SI, of the shales from 1×10^{-5} SI to 70×10^{-5} SI and of the igneous rocks from 100×10^{-5} SI to 1000×10^{-5} SI (Figure 1). The density varied between 2 $g.cm^{-3}$ and 3 $g.cm^{-3}$ and the porosity ranged from less than 1% to over 20% (Figure 2). The permeability ranged from less than 0.1 md to over 2000 md. Likewise, the resistivity varied from 30 ohm.m to over 4600 ohm.m. The variation of magnetic susceptibility did allow the characterisation of lithological zones in the drill holes studied (Table 1). This lithological characterisation also included the other petrophysical parameters studied (Table 2).

Diagenetic magnetite was not found, although high amounts of siderite were observed in rocks overlying and interbedded with the coal seams. This may be due

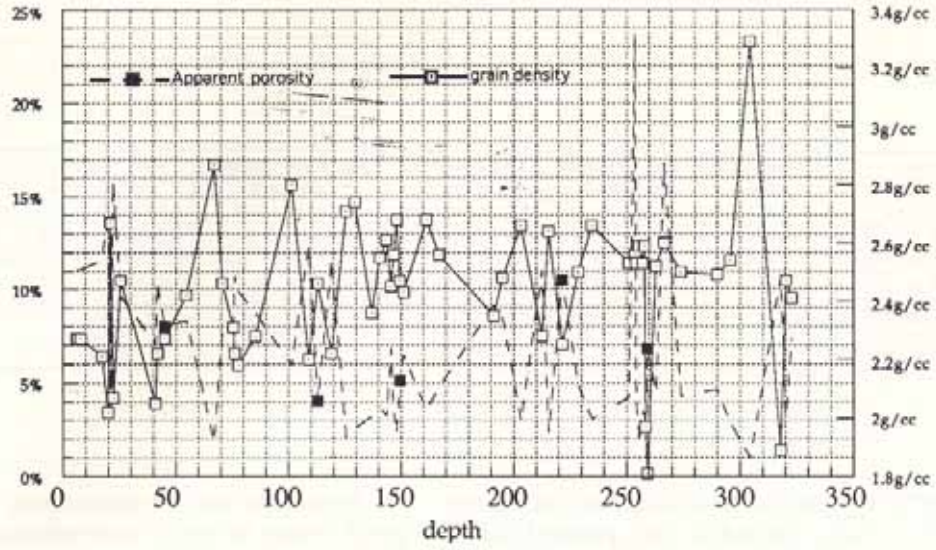


Figure 2a. Dual plot grain density / apparent porosity vs depth, EHDDH15

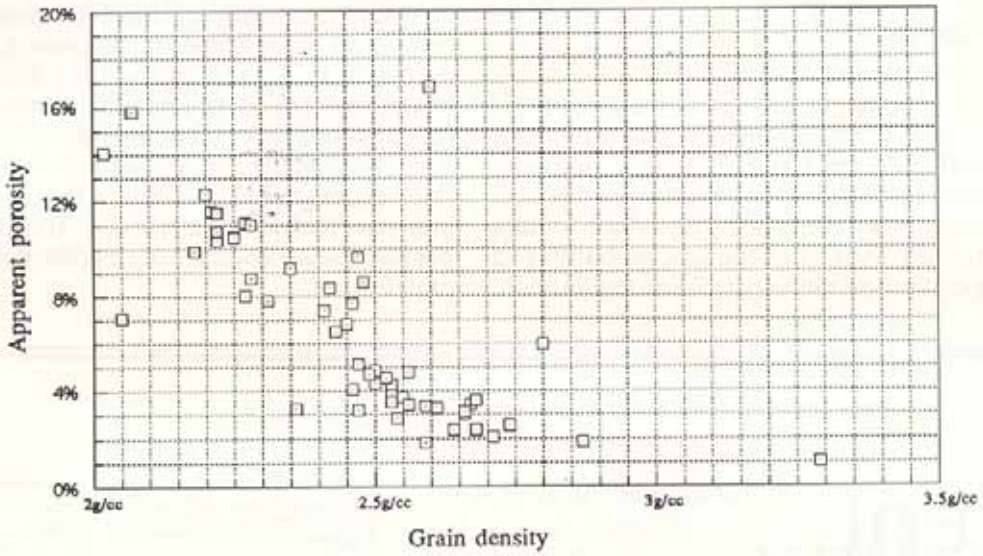


Figure 2b. Cross correlation of grain density and apparent porosity, EHDDH15

Table 1. Lithological zonation of EDDHD15

Depth metres	Zone	Lithology	Stratigraphic unit
0 to 107 (29 samples)	A	Quartzose sandstone, weathered, ironstones and iron staining, massive bedding and shale lenses	Wianamatta Group
107 to 126 (4 samples)	B	Quartz sandstone with some shale lenses	Hawkesbury Sandstone
126 to 152 (24 samples)	C	Green and "chocolate" (red) shale with some sandstone lenses	Narrabeen Group
152 to 255 (14 samples)	D	Quartz-lithic sandstone with some shale lenses	Narrabeen Group
255 to 281 (15 samples)	E	Interbedded coal, shale and sandstone (partly intruded)	Illawarra Coal Measures
281 to 320 (20 samples)	F	Interbedded coal and mudstone	Illawarra Coal Measures
320 to 330? (5 samples)	G	Interbedded sandstone and shale	Shoalhaven Group?

EHDDH15 = Elecom Huntley Diamond Drill Hole no.15.

Table 2. A petrophysical characterisation of EHDDH15

Depth	Lithological	Mag. suscept.	Grain density	Apparent porosity	Permeability	Resistivity
metres	zone	SI *10**-5	g/cc	percent	millidarcies	ohm.m
0 to 108	A	1-70; 10.6	2.51-3.07; 2.7	5-21; 12.35	0.07-2000; 285	162-1250; 1186
108 to 126	B	10-32; 23.6	2.77-2.87; 2.82	1-4.6; 2.82	0.36-0.67; 0.52	98-496; 297
126 to 152	C	13-42; 20.2	2.62-2.75; 2.7	1.37-6.57; 5.4	0.07-14.56; 3.42	345-4663; 1652
152 to 257	D	1-46; 18.9	1.97-2.97; 2.68	0.17-14; 6.12	0.07-14.51; 2.78	437-2260; 1190
257 to 281	E	1-40; 17.2	2.68-2.88; 2.76	2.4-8.8; 5.6	0.22-0.24; 0.23	27-2383; 1129
281 to 320	F	1-4.0; 1.8	2.66	4.58	0.12	492
320 to 330?	G	1	2.68	6.95	0.29	474.1

to igneous activity and/or hydrocarbon influence. Results of this study indicate that petrophysical characteristics, especially magnetic susceptibility, can be used to distinguish sedimentary rocks, including coal seams. The presence of methane in the coal indicates that variation in such properties may be influenced by leaking hydrocarbons.

There are petroleum occurrences in the Sydney Basin, but no commercial accumulations of "conventional" petroleum deposits are known. This study has indicated that the interplay between petrological composition, coal-bearing sequences and (relatively) deep weathering are important factors which may interfere with magnetic susceptibility (and other petrological) properties in petroleum exploration, especially surface techniques - but that there is a good reason to study such relationships in petroleum exploration.

We appreciate the support given by the ASEG Research Foundation. That support enabled purchase of a Geo Instruments GMS2 magnetic susceptibility meter and other expenses. Because it was considered necessary to expand the Sydney Basin phase of this study, interstate work was not undertaken and so some funds will be returned to the Foundation. The study is to continue in the Sydney Basin, including on drillholes that encountered oil, and expansion to study of interstate material is under way. This project was made possible by assistance from Pacific Power, and we are grateful.

Spectacular maps and images of an area of seabed south and west of Tasmania, three times the size of the island

N.F. Exon[1], P.J. Hill[1], J.Y. Royer[2] and R.V. *L'Atalante* shipboard scientific party.

1. Australian Geological Survey Organisation, P.O. Box 378, Canberra, 2601

2. Laboratoire de Geodynamique Sous-Marine, BP 48, 06230, Villefranche-sur-mer, France

Introduction

From 19 February to 27 March 1994, the large French Research Vessel *L'Atalante*, as part of a French-Australian scientific cooperation program, carried out a major mapping exercise south and west of Tasmania (Figure 1), in waters beyond the continental shelf. It used one of the most sophisticated mapping systems in the world, a system of a type that Australia does not possess. The work will provide the equivalent of the onshore topographic maps and satellite images that we all take for granted. The Australian Geological Survey Organisation (AGSO), for which the work was done, has been given the task of mapping offshore Australia, with the primary aim of helping industry find and develop new petroleum and mineral deposits.

This present project also has wider aims in finding out how and when Australia and Antarctica split apart, and what effects this had on Tasmanian geology, and also in documenting climatic change in the last 50 million years. The work started with cruises of the German vessel *Sonne* and AGSO's vessel *Rig Seismic* off Tasmania in the 1980's, and will continue with *Rig Seismic* seabed sampling and reflection seismic cruises next year. The cruise was led by Neville Exon and Peter Hill of AGSO, with Jean-Yves Royer from France as a senior collaborator. University staff and students from Australia and France participated in the cruise, and three will write theses on aspects of the results.

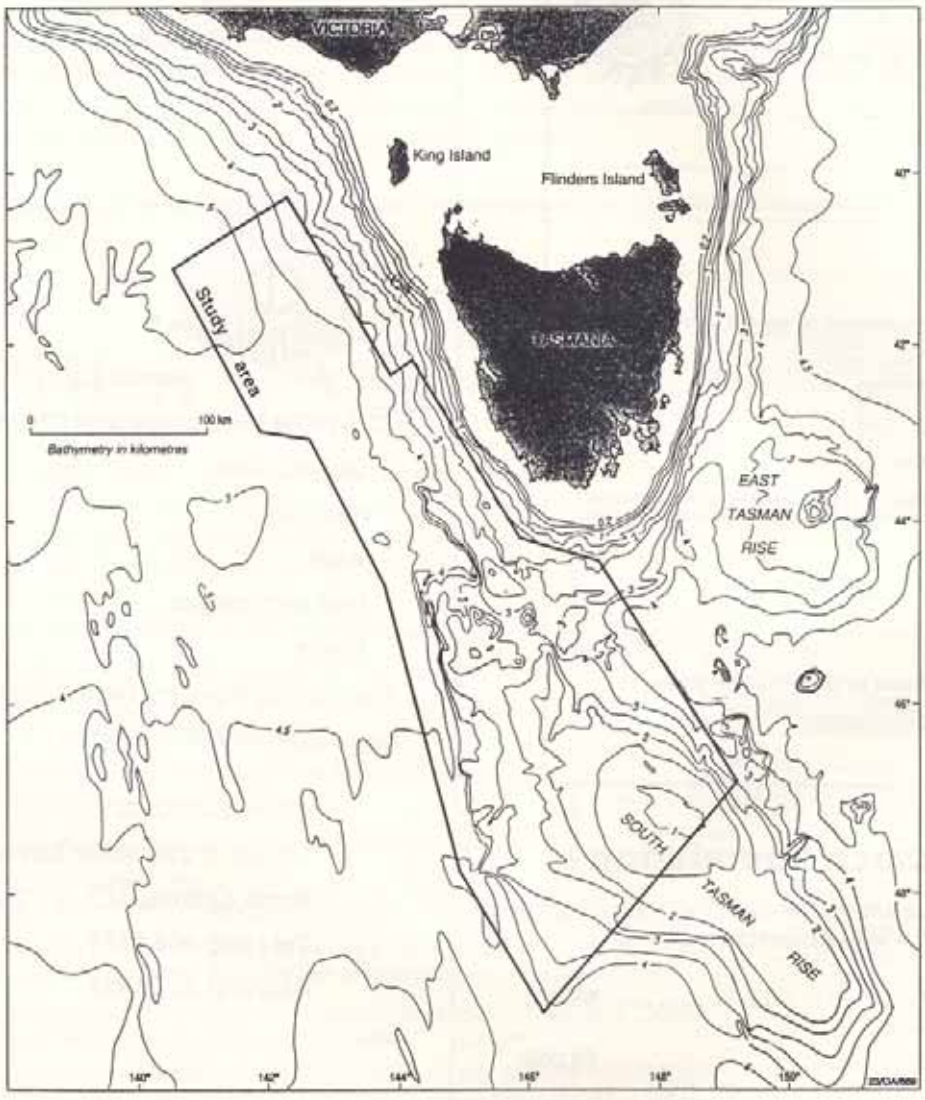


Figure 1. The area surveyed by R.V. L'Atalante of Tasmania during the "Tasmante" south mapping and reflection seismic arise. The total area is about 200,000km^2.

Shipborne systems

The *L'Atalante* used its multibeam sonar system for detailed mapping of almost 200 000 km^2 of the continental margin in the Tasmanian region and the adjacent abyssal plain (three times the size of Tasmania). The "Tasmante" cruise (name derived from Tasmania and L'Atalante) employed the SIMRAD EM12D system (Figure 2) to map an area along each ship track, up to 20km wide, at a speed of 10 knots or nearly 20km/hour. Average pixel size is of the order of 100 x 100m. The system provides bathymetric maps with 20m contours, and images of the sea bed texture, with a degree of accuracy and rate of coverage unobtainable in any other way. In addition, the ship records seismic reflection profiles with penetration of up to 2.5 seconds (two-way time) that show the structure several kilometres below the sea floor, and magnetometer and gravity data.

Regional geology

The region's structural pattern and geological history is largely controlled by the separation of Australia and Antarctica from 130 to 40 million years ago and thus has a bearing on the history of the entire southern margin of Australia. The southeastern part of the Australian continental margin is already a major producer of petroleum from the Gippsland Basin, and the Otway Basin is the scene of major recent BHP offshore gas discoveries. The Sorell Basin west of Tasmania is a southward prolongation of the Otway Basin and is also prospective for petroleum (Moore et al. 1992). The Strahan Sub-basin of the Sorell Basin is under active exploration. The very accurate bathymetric maps and sonar images from this survey allow the mapping of any fault patterns that come to the surface, and faults are often a key component of petroleum traps.

South Tasman Rise

The continental South Tasman Rise, a submerged continental block larger than Tasmania, extends from south of Hobart to 50°S. We mapped about 150 000km^2 (three quarters) of it (Figure 3). It is bounded on three sides by oceanic crust of Late Cretaceous and Palaeogene age. Spectacular faults and giant fault blocks have been mapped by *L'Atalante*, in water depths of 2500 - 4500m, on its western and eastern sides. The submarine cliffs dwarf anything on Australia, reaching 2300m high in one place (Figure 4). The South Tasman Rise only sank completely below the ocean in the last 20 million years, and parts of it are less than 1000m deep. It is current-swept and hence Neogene sediment cover is thin or absent. It gives a similar impression on the imagery to much of inland eastern Australia, with similar proportions of outcrop and sedimentary cover, and outcrops of schist and gneiss, granite, Palaeozoic and Mesozoic sediments, and Tertiary basalts.

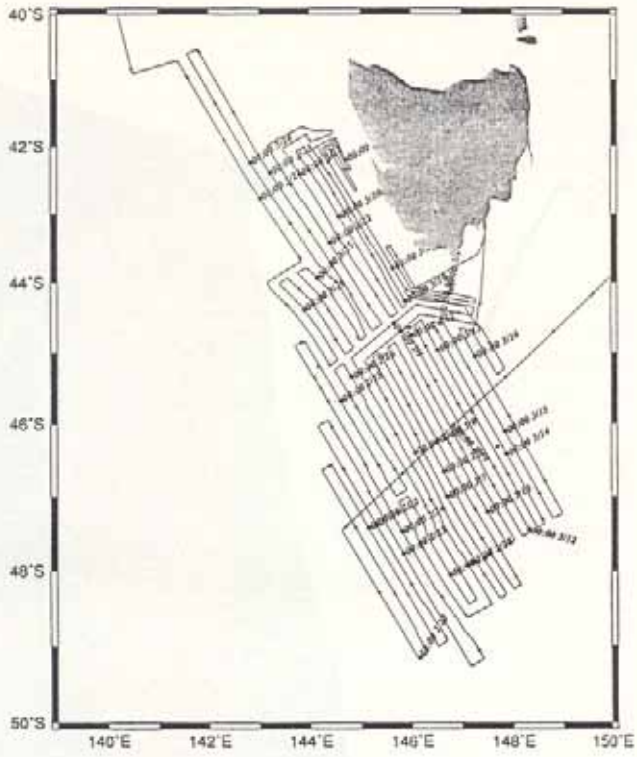
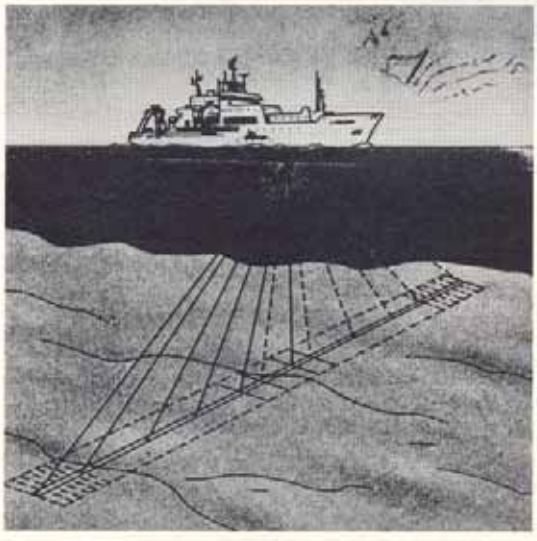


Figure 3. The tracks of L'Atalante for the area surveyed on the South Tasman Rise adn off West Tasmania. Coverage of swath mapping is essentially 100%.



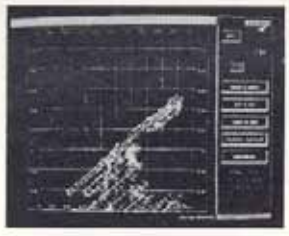


Figure 2. The EM 12 - Dual multibeam echo sounder (1) provides bathymetric data in real time (2). These data are processed on board in order to obtain digital terrain modeling (3).

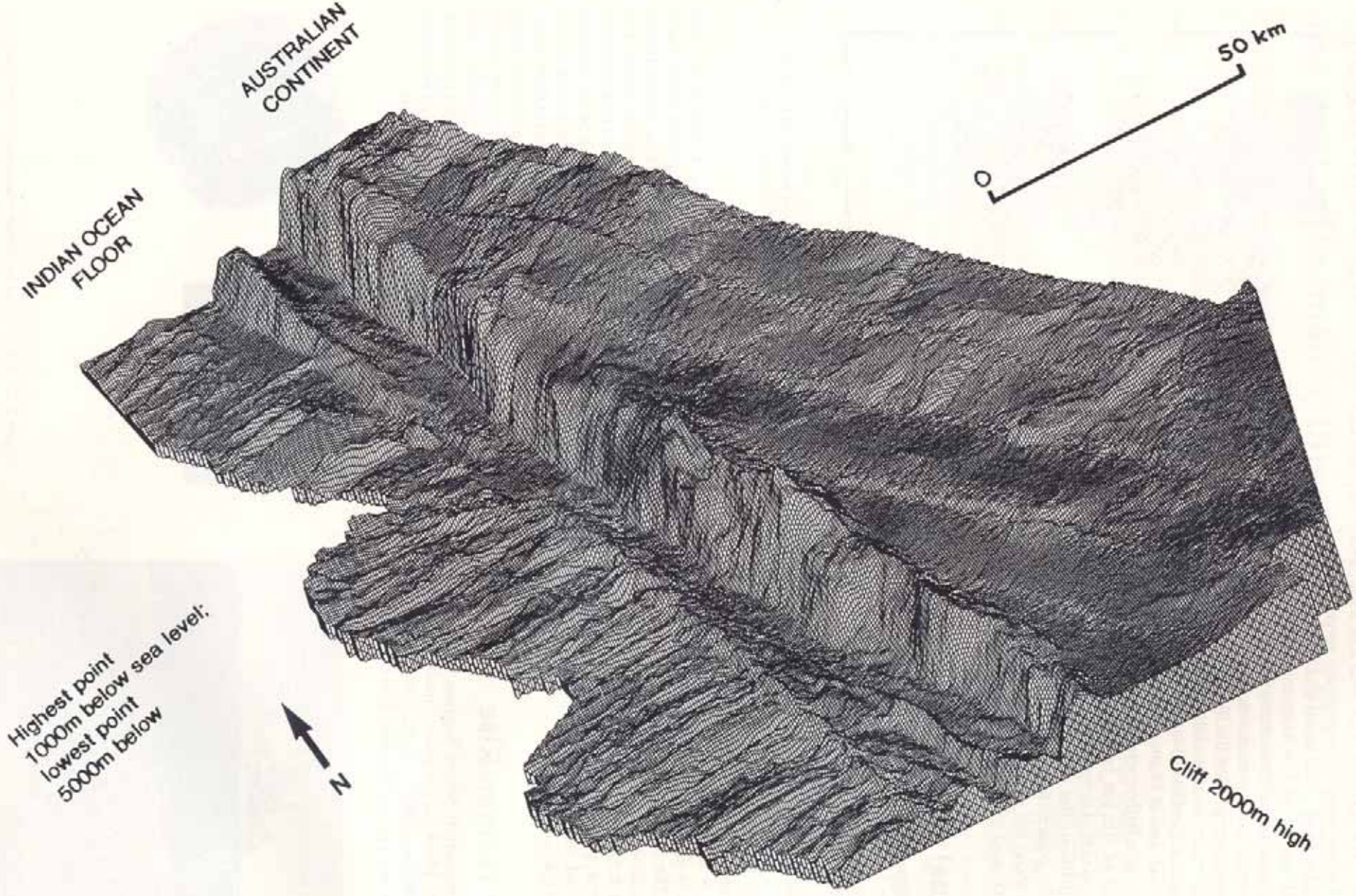


Figure 4. Block diagram of part of the western margin of the South Tasman Rise showing the continental cliff 2000m high above the abyssal plain with its spreading fabric.

The complexity of the South Tasman Rise geology will surely rival that of Tasmania, and the basement is sliced to form deep transpressional/tensional basins by faults trending N to NW. What is interpreted as the eastern limb of a NNW-trending anticline in Palaeozoic sediments is of the order of 100km long and 40km wide, and is bounded by cuestas hundreds of metres high. The western side fo the structure is faulted out, with large rotated blocks there. The petroleum potential of the South Tasman Rise is not known, but the existence of thick sections in strike-slip basins, and the geochemical evidence that thermogenic hydrocarbons are being generated, suggests that it does have some potential (Hinz et al. 1985).

Sorrel Basin

The Sorell Basin off west Tasmania is a remarkable contrast to the South Tasman Rise, being very heavily sedimented in Tertiary times. Therefore the swath-mapping of this area has been more restricted than the South Tasman Rise, but still covers about 50 000km^2. On the shelf are several basement blocks that separate four strike-slip related depocentres containing more than 3000m of Cretaceous and Tertiary sequences much like those in the Otway Basin. Some of the basin-forming faults have been imaged, as has a 2500m high fault scarp trending NNW on the lower slope, from which Cretaceous shallow marine sediments have been dredged. The area needs a careful review using all existing data, including the excellent *L'Atalante* regional seismic grid, to reassess its petroleum prospects. The existence of a thick sedimentary section, oil and gas shows, and some structuring, suggests that it has considerable petroleum potential (Hinz et al. 1986; Moore et al. 1992).

Australia-Antarctic breakup

The oceanic basalts on the abyssal plain, 4500 - 5000m deep west of Tasmania and around the South Tasman Rise, record much of the history of the breaking apart of Australia and Antarctica that started perhaps 130 million years ago, with Antarctica grinding slowly past Tasmania and finally clearing it about 40 million years ago. Thereafter, what had been dry land or a shallow marine embayment west of Tasmania, subsided thousands of metres below the sea, as did the South Tasman Rise. At the same time the easterly flowing Circum-Antarctic Current, that had previously flowed north of Australia, broke through in the south, leading to major climatic changes. The "Tasmante" sonar mapping gives us more detail of how these things happened. In addition, it will enable future sampling to be precisely targeted to resolve the important scientific question of where and how the continent ends and the oceanic crust begins.

The "Tasmante" mapping of sedimentary patterns on the continental slope will help document the changes as the slope subsided following the departure of Antarctica. The mapping of rocky outcrops and sedimentary patterns is invaluable in planning next year's AGSO seafloor sampling cruise, using R.V. *Rig Seismic*. Dredged older rocks will provide information on the history of the area before it subsided. Cores of marine sediments will be used to study changes in oceanic circulation and climate as Australia moved steadily north away from Antarctica. The *L'Atalante* mapping cruise is the key to a treasure house of information about Tasmania's ancient history, as it gradually became separated from land masses to the west east and south.

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Moore, A.M.G., Wilcox, J.B., Exon, N.F., O'Brien, G.W., 1992 - Continential shelf basins on the west Tasmania margin. *Australian Petroleum Exploration Association Journal*, vol 32(1), pp. 231-250.

Department Of Energy And Minerals

- Initiatives and Activities to Stimulate Exploration in Victoria

1994 - 1997

The Department of Energy and Minerals was created in October 1992 and reflects the Government's commitment to delivering economic recovery and prosperity to Victoria, through the revitalization of the energy sector and the effective utilization of our substantial mineral resource endowment.

The mission of the Department is to optimise the economic benefit to Victorians from the development of Victoria's mineral, stone, petroleum and energy resources.

The Department has been restructured into three divisions - one focusing on Mineral and Petroleum Resources, one on Energy, with both supported by a Corporate Management Division. The head office is based in Melbourne with regional offices in Bendigo and Ballarat.

The Victorian Government is undertaking a 3-year, $16.5 million dollar program: the Victorian Initiatives for Minerals and Petroleum (VIMP) and the Otway Basin Initiative to support the exploration industry. The money will be channelled into major programs of geophysics, mapping and stratigraphic drilling to delineate the structural framework of hard rock and basin areas of the state.

Announcing the 3 year VIMP initiative, on April 18th, 1994, the Minister for Energy and Minerals, Mr Jim Plowman, said "Victoria was embarking on a new era of mineral development which would bring major benefits to the State's economy". Mr Plowman said "a major initiative by the State Government to assist exploration companies would lead to a resurgence of the mineral industry. This is the most major initiative of its kind ever undertaken in Victoria and shows the confidence the Government places in the industry's capacity to play a significant role in the State's economic recovery."

The initiatives are outlined in detail later in this article. VIMP covers the Northwest of Victoria and the Eastern Highlands. Plate 1 shows the Initiative areas and target dates. The extent of current mineral exploration activity in Victoria can be seen in Plate 2.

Paul Dowd, the Deputy Secretary of the Resources Development Division of the Department of Energy and Minerals, said "Victoria had set about creating a positive environment for the industry to ensure the State's mineral wealth was fully utilized. Recent amendments to the MRDA have overcome impediments to investment posed by regulation and the department is looking at more innovative ways to improve the industry's ability to become part of Victoria's economic revival. The innovations being considered will give the department the ability to implement more flexible regulations and to react to changing circumstances without the need for cumbersome legislative change."

"The department had improved facilitation by restructuring its Resources Development Division.

The restructure will enable the division to provide greater customer focus and address all the needs of investors in Victoria's mineral development. As part of that process the department is advertising for the appointment of regional managers who will be senior officers of the department with responsibility for providing information services at a regional level (including GEDIS and other tenement management data). The managers will also have the important task of liaising with other State and Local Government agencies to ensure that exploration and/or mining applications are approved as quickly as possible. "

"Victoria had previously been ignored by exploration/mining investors in modern times. As a consequence, the state had not had the benefit of modern exploration techniques to unlock the immense mineral wealth that was clearly indicated by recent geological and geophysical work undertaken by the GSV.

The new initiatives announced by the Minister for Energy and Minerals meant exploration and mining investment in Victoria had never been so attractive. The geological and geophysical survey of virtually the whole state, particularly over areas of high prospectivity for gold, diamonds, petroleum and base metals, puts Victoria into a new era of mining industry growth. Given the extensive and modern infrastructure of Victoria and its high geological prospectivity it is expected that these initiatives by the Government will create a mining boom for Victoria that will bring significant new wealth for all Australians."

VIMP

Department of Energy and Minerals

Government of Victoria

DEVELOPING VICTORIA'S RESOURCES

Victorian Exploration Initiatives

Victorian Initiative For Minerals and Petroleum (VIMP)

The Victorian Initiative For Minerals And Petroleum (VIMP) is a $13.2 million major initiative over 3 years, to encourage mineral and petroleum exploration in Victoria.

Projects to be undertaken in the initiative centre on the acquisition of geophysical data, including airborne magnetics, gravity and seismic data, in areas where industry is currently not exploring, stratigraphic drilling to provide basic geological information and geophysical and geological mapping interpretation products.

A number of databases and data compilations are also included to assist in focussing attention on the mineral and petroleum potential of the state. Particular attention is being given to the North West of the state and the Eastern Highlands, where major airborne surveys are to be carried out.

Companies will be invited to participate in the airborne programs and tenders will be called for work programs for awarding of followup exploration licences.

Plate 1 shows the VIMP initiative areas and the proposed timing of the airborne surveys areas (shown in grey). Table 1 shows the proposed detailed scheduling for surveying, company participation and product release of the initiative areas. Plate 2 shows the extent of present onshore mineral exploration in relation to the Initiative areas. Figure 1 shows current petroleum exploration permit areas in Victoria.

North West Initiative Area

A total of $4.85 million is budgeted for the Northwest Initiative which has the dual objectives of promoting mineral and petroleum potential of the northwest of the State. The Initiative has the folowing component programs:

- High resolution airborne magnetics and radiometrics at 400m line spacing.
- Regional gravity surveying over the area (20 000+ stations).
- Depth to Palaeozoic basement modelling.
- 450 km of reconnaissance seismic across the basin.
- Compilation of existing deep drillhole data and other pre-Tertiary geological data.
- Deep stratigraphic drilling to test for source, reservoir and seal rocks.

The airborne survey in the North West area covering part of the Murray Basin and the Glenelg Province to the south (Plate 1) will be undertaken in the winter months of 1994. The survey will be a magnetics and radiometrics fixed wing survey of approximately 120 000 line kms. with east - west flight lines at a line spacing of 400 metres and flight height of 80 metres. Contracts for this survey are currently being finalised. It is expected that this programme will be completed in late 1994 with data being available in February 1995 (Table 1).

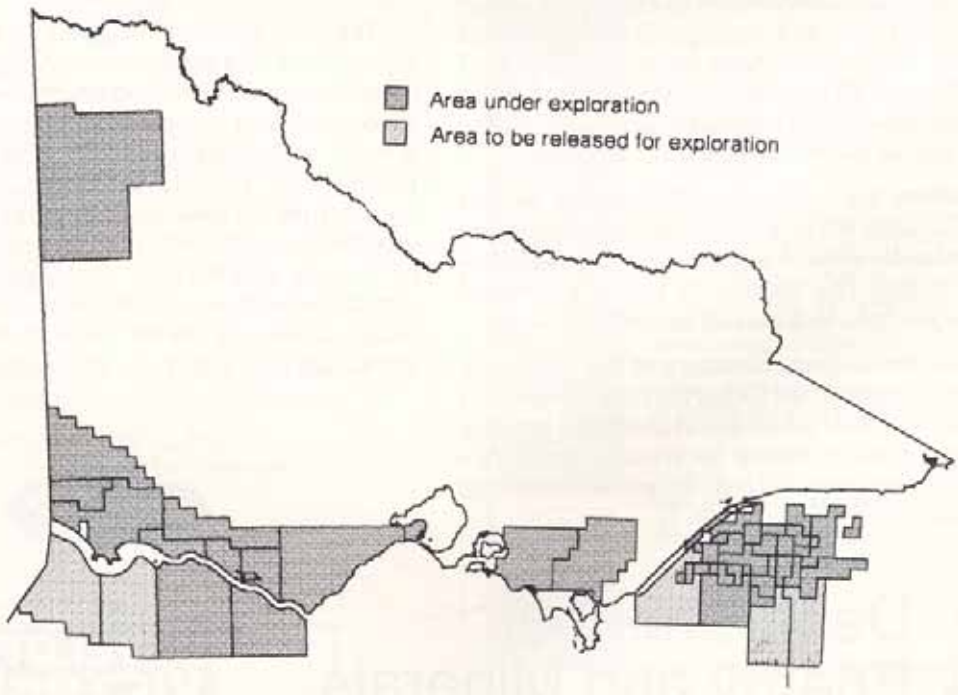

Figure 1. Petroleum Exploration Permits in Victoria.

Eastern Highlands Initiative Area

The Eastern Highlands surveys will be helicopter geophysical surveys conducted over a two year period with a budget of $7.75 million. These surveys will be restricted to flying in the summer and autumn in times of better weather conditions and no snow cover. Tenders for the first phase of these surveys (Areas A1, A2, B1, B2) will be called for in July 1994. The surveys will be a magnetics and radiometrics with flight line spacing of 200 metres on east-west or north-south lines. The survey data will provide an excellent data set for mineral exploration. The surveys will be flown in blocks such that the data can be released in a timely manner (see Table 1). Follow up geological mapping will be undertaken in strategic areas together with a compilation of previous exploration and mining.

Otway Basin Initiative

The Otway Basin, the site of recent gas and oil discoveries by BHP and Sagasco has been an area of active hydrocarbon exploration since the late 1950's. In the onshore Otway Basin, sub-commercial gas was encountered in Port Campbell 1 in 1959. Further exploration lead to significant gas accumulations at North Paaratte (1979), Katnook (1987), Iona (1988) and Ladbroke Grove (1989).

A recent upsurge in exploration activity in the offshore area was rewarded by two large gas discoveries in early 1993 by BHP (the Minerva and La Bella accumulations) off Port Campbell in Western Victoria. Together with this year's find by Sagasco at Wynn 1, these recent gas discoveries have established the Otway basin as a major gas province.

The Otway Basin Initiative (see Plate 1), with a budget of $1.4 million (1994 - 96) follows on from the earlier NGMA Otway Basin Project. Components of this initiative includes:

- Interpretation of regional offshore and onshore seismic lines to produce basin wide maps of key unconformities.
- Port Campbell Embayment 1:100 000 Geological Map and Notes.
- Colac 1:250 000 Geological Map and Notes.
- Stratigraphy, structure, geophysics and hydrocarbon prospectivity report on the onshore eastern Otway Basin.
- Regional gravity surveying over the Otway Basin.
- Compiling regional structural elements maps.
- Production of palaeogeography maps, and identification of hydrocarbon plays.
- A high resolution offshore airborne magnetic survey (joint AGSO, GSV, MESA and BHP consortium).
- Detailed palynological analysis of the Early Cretaceous.
- Deep stratigraphic drilling to test stratigraphy and tectonic models.
- A compilation and review of all subsurface geological information.
- Review of Tertiary biostratigraphy.
- Determine the early tectonic history of the basin.
- Interpretation of seismic data in the Torquay sub-basin.

Table 1. Detailed Program for Victorian Initiatives and related activities.

Part A - Airborne Surveys, Exemption Areas Only

Initiative area		Call for tenders	Data gathering (flying)	Processing (maps)	Public data release & call for tenders	Exemptions lifted & EL tenders close	DEM data interpretation
North West	Mallee	21 May - 7 June 94	Aug - Oct 94	Oct - Nov 94	1 Feb 95	28 Feb 95	March - Dec 95
	Glenelg (a)	21 May - 7 June 94	Dec 94 - Jan 95	Jan - Mar 95	1 Jul 95	31 Jul 95	June - Dec 95
	(b)	Sep - Oct 95	Dec 95 - Jan 96	Jan - Feb 96	1 Jul 96	31 Jul 96	Aug - Dec 96
Eastern Highlands	Orbost	Oct 93	Completed Apr 94	Completed Jun 94	1 Aug 94	31 Aug 94	Aug - Dec 94
	A1, A2, B1, B2	Jun - Aug 94	Oct 94 - Apr 95	Nov 94 - Jan 95	1 Feb 95	28 Feb 95	Aug 95 - May 96
				Apr - Jun 95	1 Jul 95	31 Jul 95	
	B3, C1, C2, C3	Jun - Aug 95	Oct 95 - Apr 96	Nov 95 - Jan 96	Jan/Feb 96	28 Feb 96	Jul 95 -Dec 96
				Apr - Jun 96	Jun/Jul 96	31 Jul 96	
	Other areas (c)	Jul 96	Oct - Dec 96	Jan - Feb 97	May - Jul 97	1 Jul 97	Aug 97 - Feb 98
	EM survey	Sep - Oct 95	Jan - Feb 96	Mar - Apr 96	1 July 96	31 July 96	Aug - Dec 96

(a); airborne aeromagnetic surveys: (b); airborne EM surveys: (c) Wangaratta East (NGMA) and part of Warburton: (d) Mt Wellington survey completed 1994

Part B - Initiatives Area Programmes Other than Airborne Surveys

Initiative area	Survey type	Call for tenders	Data gathering	Processing (maps)	Public data release	Exemptions lifted & EL tenders close	DEM data interpretation
North West	Seismic	Oct 95	Nov 95 - Mar 96	Apr - Jun 96	Jul 96	28 Feb 95	Jul 96 - Dec 96
	Gravity	Aug 94	Sep 94 - Jun 97	Dec 94 - Jun 97	Jul 95, 96, 97	to	Sep 94 - Jun 97
	Reprocessing	Oct 94	-	Nov 94 - Feb 95	Feb 95	31 Jul 96	Nov - Dec 94
	Compilation	Jun 94	-	-	Jul 97	(where exemption is	Jul 94 - May 95
	Interpretation	Jan 95	-	-	Feb 96	applicable)	Feb - Dec 95
	Drilling	Jan 96	Mar - Jul 97	-	Jul 96		Jul - Sep 96
Eastern Highlands	93/94 initiatives (d)	Oct 92	Dec 92 - May 94	-	Sep 94	31 Aug 94	Oct 93 - Jul 94
	Compilation	Jun 94	-	-	Feb 95, 96 Jul 95, 96	to	Jul 94 - Dec 95
	Mapping	-	Jul 94 - Jul 97	-	Ongoing	31 Jul 96	Jul 94 - Jul 97
Otway Basin	Airborne	May 94	Jun - Jul 94	Jul 94	Aug 94		Aug 94 - Oct 95
	Gravity	Sep 94	Oct 94 - Feb 95	Jan - Mar 95	Jul 95	Not applicable	Aug 94 - Oct 95
	Seismic Interpret.	Apr 94	Jul 94 - Jul 95	-	Jul 95	(non exemption	Jul 94 - Jul 95
	Mapping	-	May 94 - Dec 95	-	Feb 96	area)	May 94 - Dec 95
	Geochemistry	Jul 94	Aug 94 - Jun 95	-	Feb 96		Aug 94 - Jun 95
	Drilling	Sep 94	Oct 94 - Mar 95	-	Feb 96		Jan - May 95

Airborne Survey Otway Basin

During May and June, 1994 a high resolution airborne magnetic survey was flown in the Otway Basin region in south west Victoria and south east South Australia (see location Figure 2).

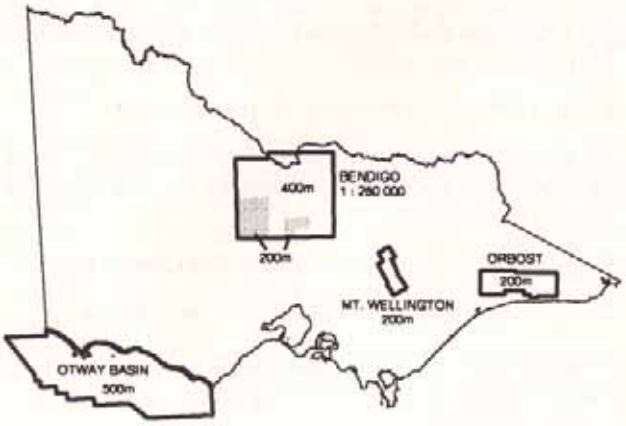

Figure 2. Detailed Airborne Surveys by the Department of Energy and Minerals, AGSO and industry in Victoria (1993 - 94).

The survey is being managed by the Australian Geological Survey Organization (AGSO), in cooperation with the Department of Energy And Minerals Victoria, the Department of Mines and Energy South Australia and a BHP consortium. The Department of Energy and Minerals contributed as part of the Otway Basin Initiative.

The survey area of approximately 40 000 line kilometres will integrate with a survey of high resolution magnetics flown in the western part of the Otway Basin by AGSO in November-December 1992.

The current survey was flown under contract for AGSO by Kevron Geophysics P/L, along north-south traverses spaced 500 metres apart at a height of 100 metres above sea level. East west control traverses will be flown at 5 kilometres line spacing. Along line sampling is 7metres and navigation is by GPS.

The magnetic data can be used to help map the geometry of the early rift segments of the basin and map the distribution of Tertiary volcanics, and will provide new insights into the structural architecture and hydrocarbon potential of the Otway basin.

Information on release of this data may be obtained from Dr Peter Gunn AGSO (Tel: (06) 249 9226).

Geological Survey of Victoria

The Geological Survey of Victoria (GSV) promotes the exploration industry through its geological mapping, geophysics and basin studies projects. The GSV's emphasis is on encouraging the effective and responsible exploration and development of Victoria's earth resources.

The Organisation

The GSV is organized into four groups :

- Geological Mapping: investigate the geological framework of Victoria and provide basic data for industry programs;
- Mineral Resources : identify and promote the exploration of prospective mineral and stone resources;
- Basin Studies : research Victoria's sedimentary basins and their potential resources; and
- Geophysics : conduct regional geophysical surveys and interpretations in accordance with the mineral industry's needs and in conjunction with the Geological Mapping, Mineral Resources and Basin Studies groups.

GSV projects draw upon personnel from all four groups as needed, including land information and cartographic staff.

Software Facilities

The GSV has a modern Unix and PC based computing environment using ER Mapper for image processing; ECS GPC, Petroseis and Surfer for gridding and contouring; ECS AGP and Model Vision for magnetics interpretation, Charisma and Petroseis for seismic interpretation and mapping, Geolog for geophysical log interpretation and display; and Genamap, INGRES and Microstation for GIS / database, mapping and cartography. GSV is also currently developing a digital PC field mapping system based on the Datcol software.

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Geophysics

The Geophysics Section of GSV provides geophysical services to the Basin Studies and Mapping groups. It is clearly recognized that geophysics is an important component of basin and mapping projects. Geological mapping programmes are now as a policy, only undertaken in an area following acquisition of detailed magnetics and radiometric data. On each of the mapping areas, there is a geophysicist assigned to interpret the geophysical data and integrate this data with the mapping.

An important role for the section is to manage the geophysical data for the State, notably airborne data, gravity data and geophysical logs.

State - wide Geophysical Maps and Databases

State Magnetic Image And Digital Grids And Data

The first edition of the State Magnetic image is shown in Plate 3. The image is based on BMR/AGSO, GSV and mineral and oil exploration airborne surveys, which have been gridded and merged to a 150m x 150m grid covering the State. The magnetics uses the Australian Geological Survey Organisation regional data with more detailed company data superimposed. Thirty two surveys have gone into the State-wide image, which is currently being updated with a new edition, due for release later in 1994. The colour image of the State magnetics can be purchased at 1:1 000 000 scale.

In addition a digital grid of the magnetics for the State is available in ER Mapper format (at a cost of $2500). The grid is regularly updated. Digital geophysical data is available for many of the company airborne surveys undertaken in Victoria. Products available include located data and grids for individual surveys.

Airborne Survey Index For Victoria

An index of airborne surveys has been prepared by the Geophysics Section of the Geological Survey of Victoria (GSV) and is available on the Department of Energy and Minerals Geological Exploration Development Information System (GEDIS). The GEDIS system (p37) provides details of the survey boundaries and basic information on the survey details. A client can zoom to an exploration area or other area of interest and determine the surveys conducted on or nearby an exploration licence. The GEDIS system can be accessed via a counter service or directly in conjunction with the Geophysics section. A simplified colour schematic from GEDIS, of the present airborne survey coverage of Victoria, classified by line spacing is shown in Plate 4.

Advice on the quality of these surveys, maps and digital data is available from the Geophysics Section of GSV. The airborne surveys are plotted on a three map series at 1:1 000 000 scale. The maps show analogue and digital only surveys and a combination of the two and are available on request.

Digital airborne data which have been collected for companies and are now on open file are available for the cost of reproducing the tape. Digital data for company surveys cost $100 for each tape. Digital data for surveys which have been flown for AGSO and/or GSV are available from AGSO at standard AGSO prices.

State Gravity Image and Database

The State gravity image is shown in Plate 5, gridded from approximately 50, 000 stations (Figure 3) from over 100 gravity surveys in the Victorian gravity database. The basic operational details and references for all gravity surveys have been computerised into GEDIS. This data is available as point data or as a digital grid in ER Mapper format (cost $500). The grid is upgraded as data becomes available.

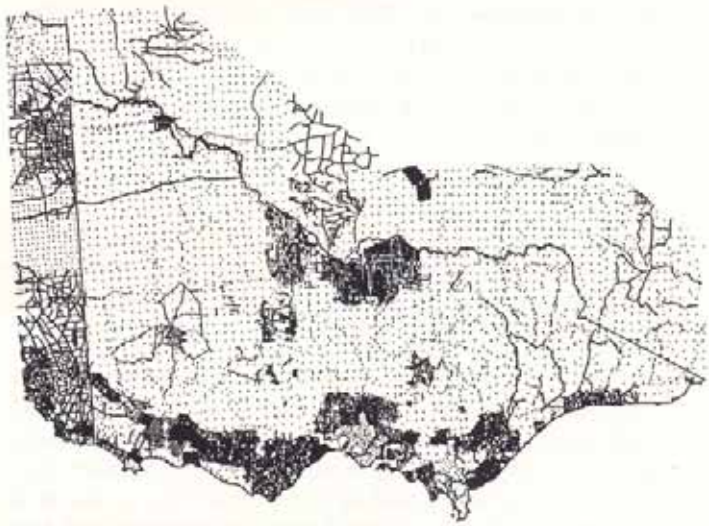

Figure 3. Gravity station distribution in Victoria.

The Victorian State (VIC) gravity database was initially (pre-1984) compiled and maintained by the Bureau of Mineral Resources (BMR), now Australian Geological Survey Organisation (AGSO). At that time the VIC gravity database was tied to the Australian gravity base-station network which was based on the Old Potsdam datum (Isogal 65).

In 1980, AGSO recalculated the Australian base-station network on the IGSN 71 (Isogal 84) datum, to improve the accuracy of the gravity values to absolute scale and datum.

Updating the current VIC gravity database has included the conversion by the Geological Survey of Victoria of the database to the IGSN 71 (Isogal 84) datum, validation and editing of the gravity data and the addition of new gravity data.

The VIC gravity database is made up from the following sources:

(i) Victorian state gravity file as supplied by AGSO in 1989

(ii) Surveys conducted by GSV, other government bodies, universities, open file data collected under mineral and petroleum exploration licences

(iii) Data from South Australia, New South Wales, Tasmania and the Australian Capital Territory as supplied by AGSO in 1989 to provide control around the border of Victoria. This data extends approximately one degree of latitude and longitude around the border of Victoria

New Airborne Geophysical Data Releases

Orbost Airborne Magnetic And Radiometric Survey

The Geological Survey of Victoria has recently undertaken an airborne magnetics and radiometrics survey in the Orbost area between Ensay and Club Terrace (see location Figure 2). The helicopter survey was undertaken for GSV by Geo Instruments. The survey was (15 200 line kilometres) acquired to exploration industry specifications using a line spacing of 200 metres. Navigation for the survey was differential GPS.

The flying for the survey was completed in April. The data is expected to be released on August 1 1994 in digital (located data and grids) and map format. The map series will consist of flight line maps, profiles, contour maps and images of the magnetics and radiometrics data (see below).

The survey was undertaken to encourage mineral exploration in this area. It will assist geological mapping and evaluation of mineral potential of the area as well as map local soil variations. CRAE has taken two exploration licences and applied for a third in the area as a result of the survey being undertaken and has contributed to extension of the survey.

Bendigo Airborne Magnetic and Radiometric Survey

The Australian Geological Survey Organization and the Geological Survey of Victoria are currently undertaking an airborne magnetics and radiometrics survey of the Bendigo 1:250 000 map sheet area (see location Figure 2) as part of a National Geoscience Mapping Accord project for the Lachlan Fold Belt.

The standard specification for the survey is 400 metres line spacing. However, GSV has encouraged industry to contribute to the survey to do infill flying at 200 metres in their areas of exploration interest. As a result of the industry and GSV contributions, the entire Bendigo 1:100 000 map sheet as well as four other 1:25 000 map sheets will be flown with a line spacing of 200 metres to provide a high quality magnetics and radiometrics survey across the Bendigo goldfield.

The data is being acquired by AGSO with the data being available to the contributors in August 1994.

Mt Wellington Airborne Magnetic and Radiometric Survey

In 1993, the Geological Survey of Victoria undertook a helicopter borne magnetics and radiometrics survey in the area between Licola and Jamieson (see location Figure 2). The survey was undertaken for GSV by Geo Instruments.

The survey covered 7 200 line kilometres at a line spacing of 200 metres. Navigation for the survey was differential GPS. Prior to this survey, the only airborne geophysical data was from regional surveys with flight line spacing of 1500 metres. The improvement in quality of the images from the 200 metre spacing data is illustrated in Plate 7.

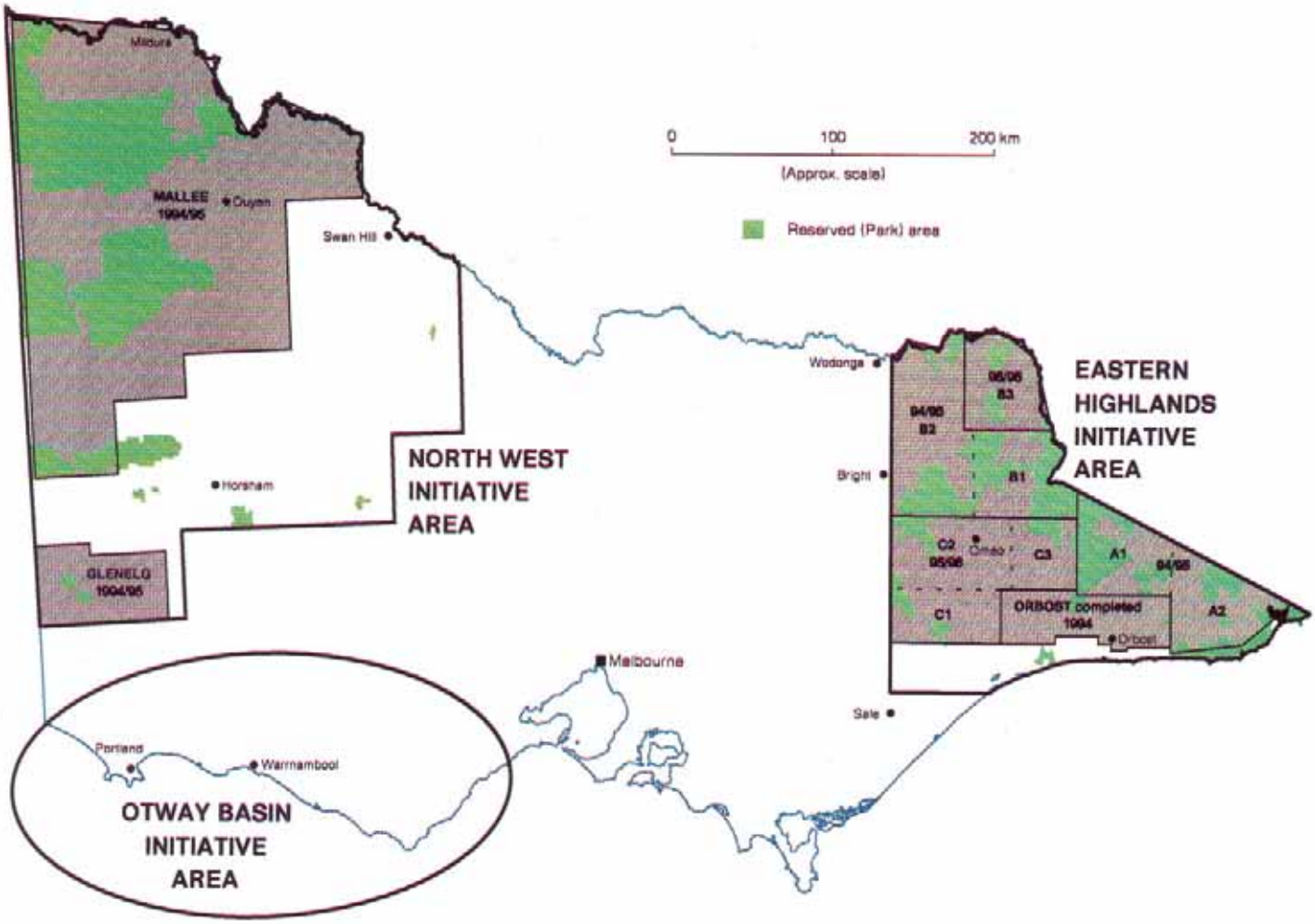

Plate 1: Victorian Initiative for Minerals and Petroleum (VIMP) and Otway Basin Initiative areas. Airborne geophysical survey areas to be flown under VIMP are shown in grey. Refer to Table 1 for details of flying and release dates. The Northwest area is to be flown at 400 m. line spacing, the Eastern areas at 200m. National Park areas shown in green are to be flown at 400 m. spacing.

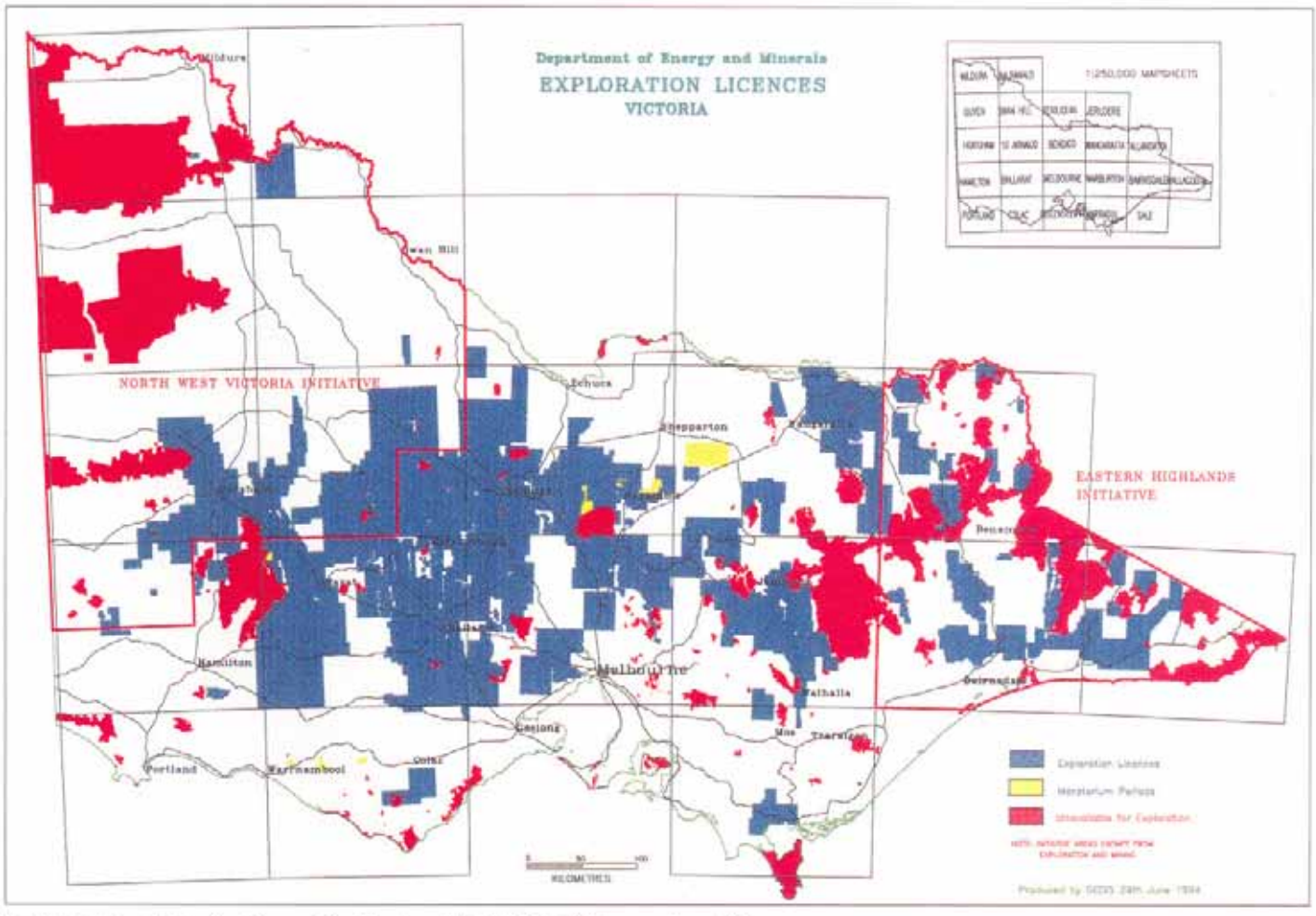

Plate 2: Victorian Exploration Licences for minerals and the VIMP Initiative areas, June 1994.

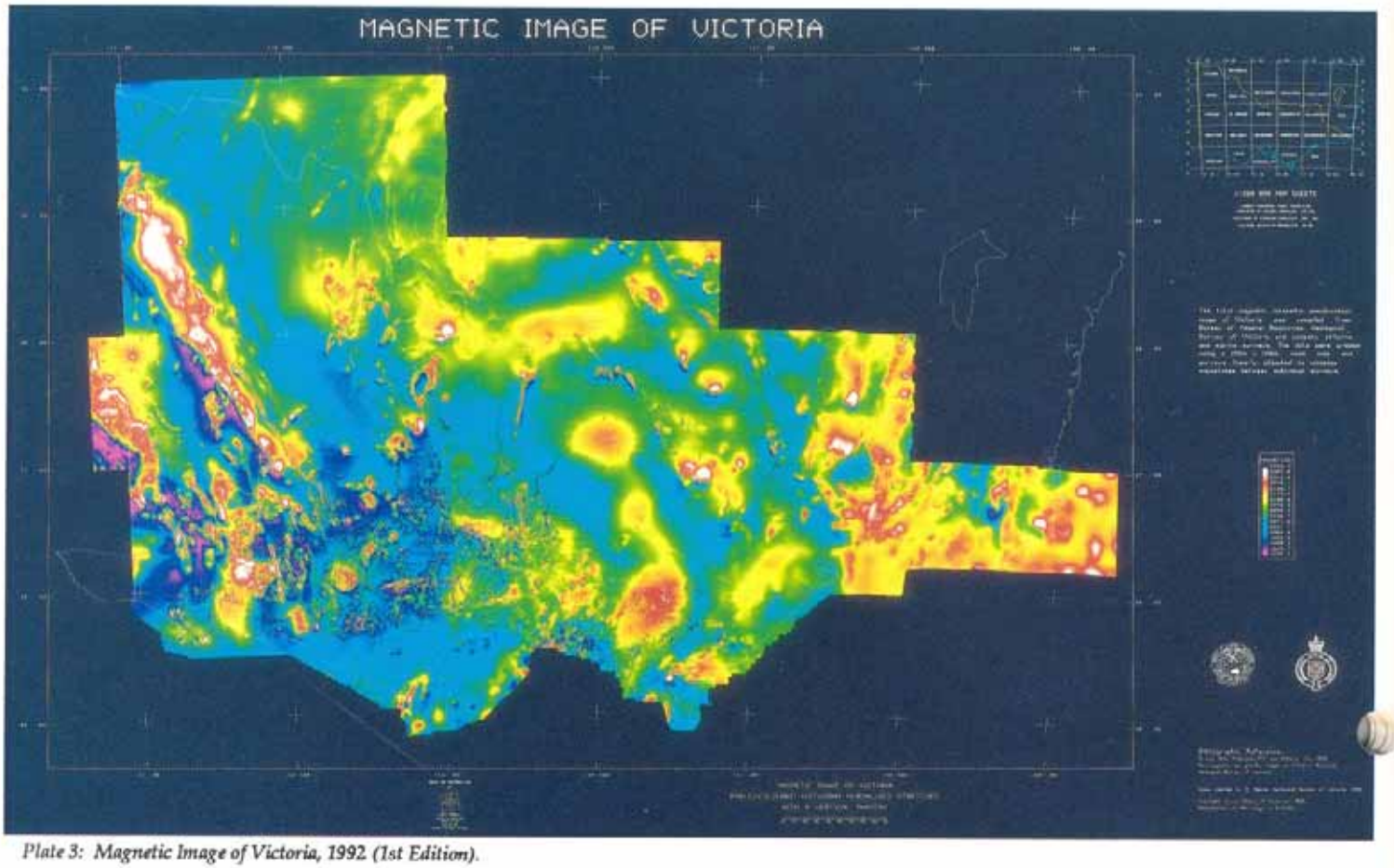

Plate 3: Magnetic Image of Victoria, 1992 (1st Edition).

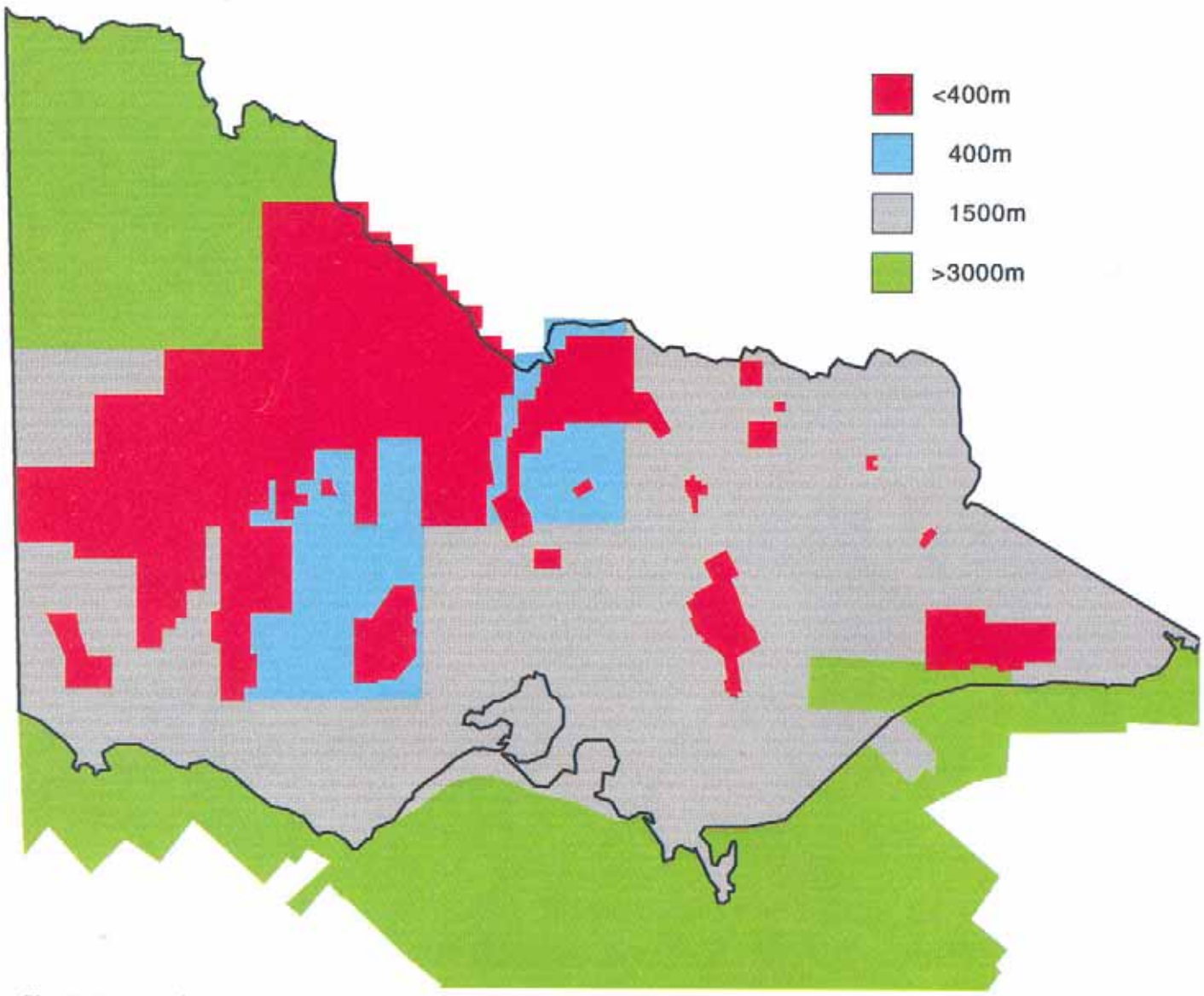

Plate 4: Aeromagnetic survey coverage of Victoria showing surveys categorised by line spacing.

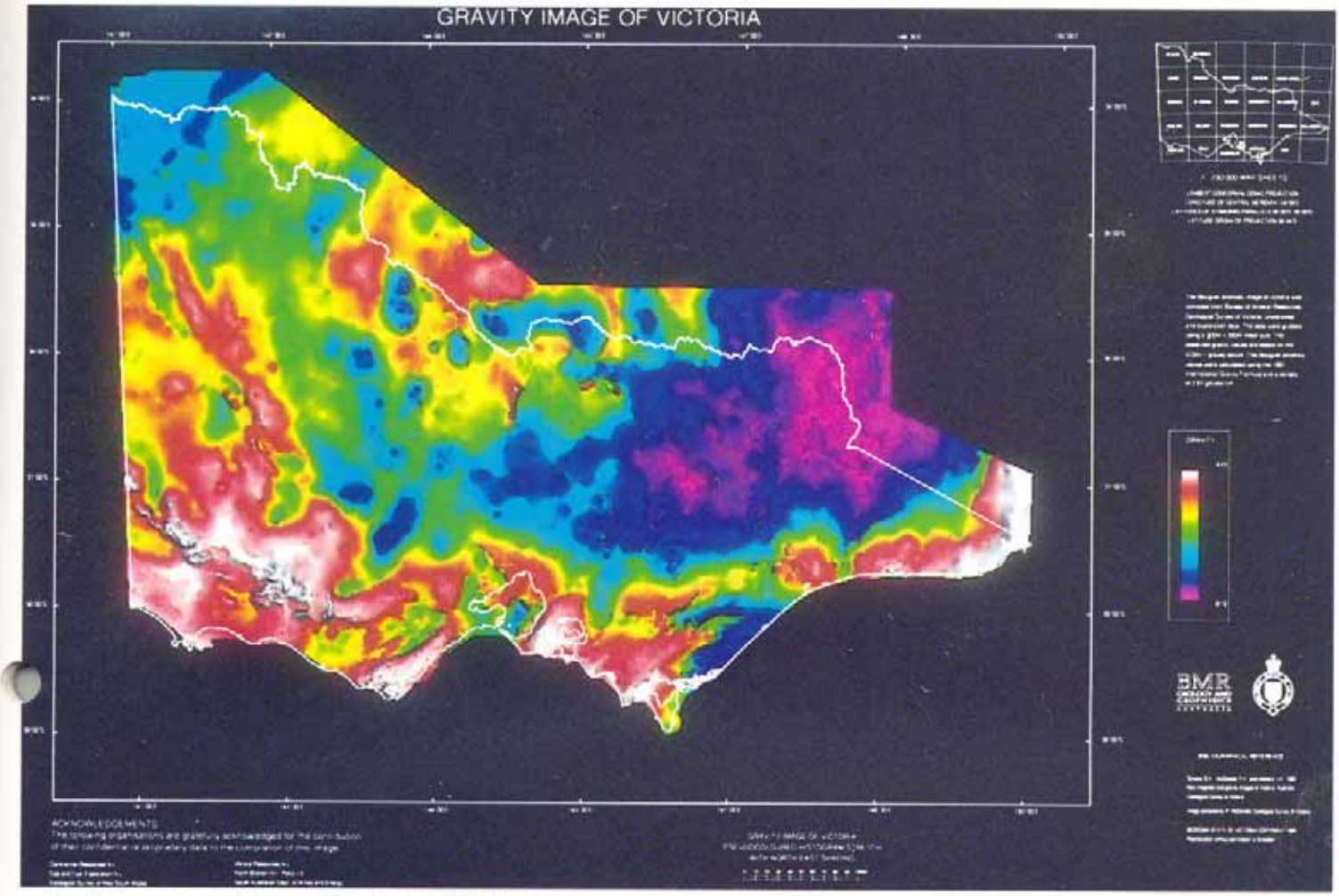

Plate 5: Bouguer Anomaly Image of Victoria, 1992 (1st Edition).

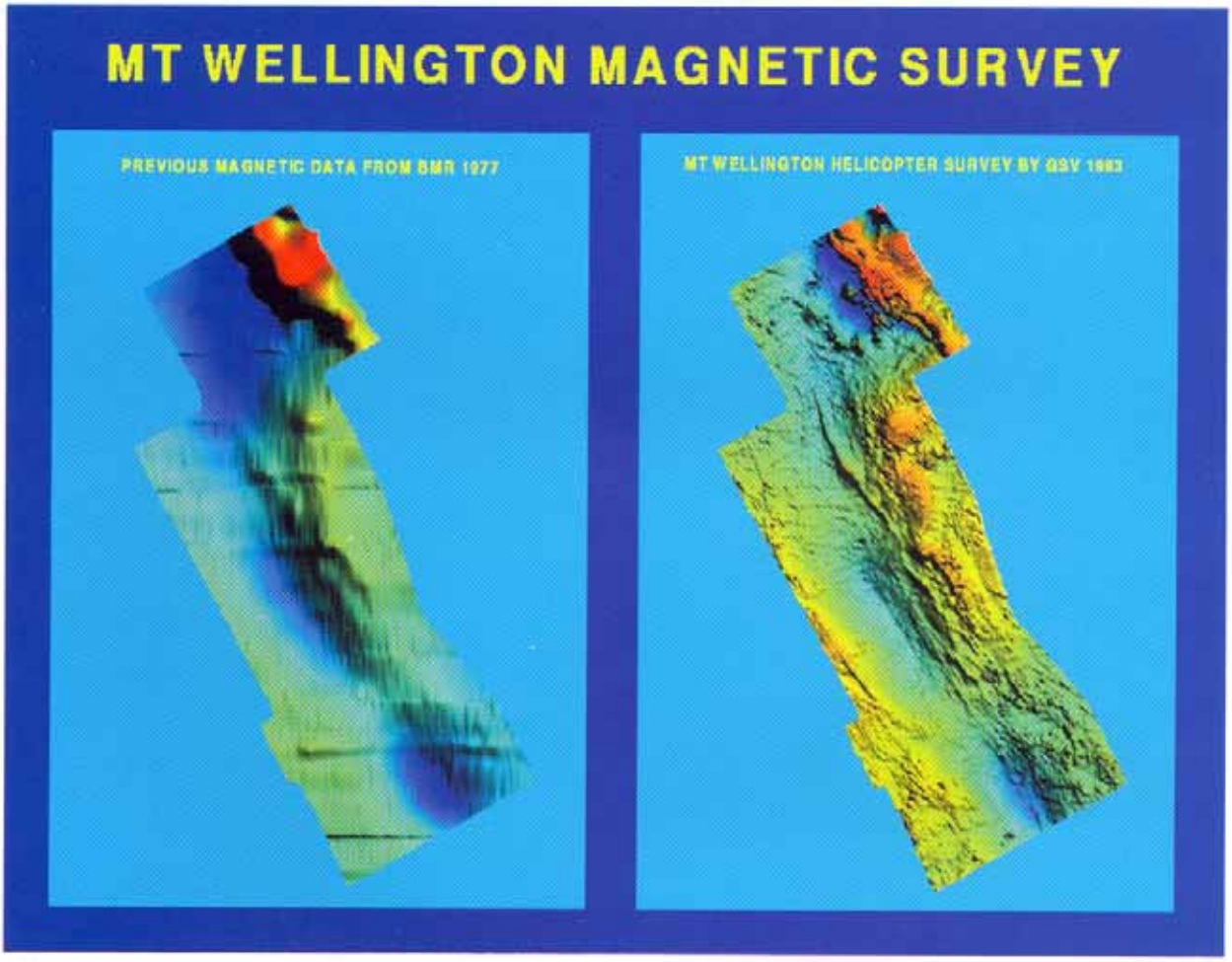

Plate 6: Mt. Wellington helicopter magnetics image (200 m. line spacing, 90 m. terrain clearance) compared with the existing BMR regional aeromagnetics image (1.5 km. line spacing, 1800 m. constant altitude).
See Figure 2 for survey location and Plate 7 for regional geology.

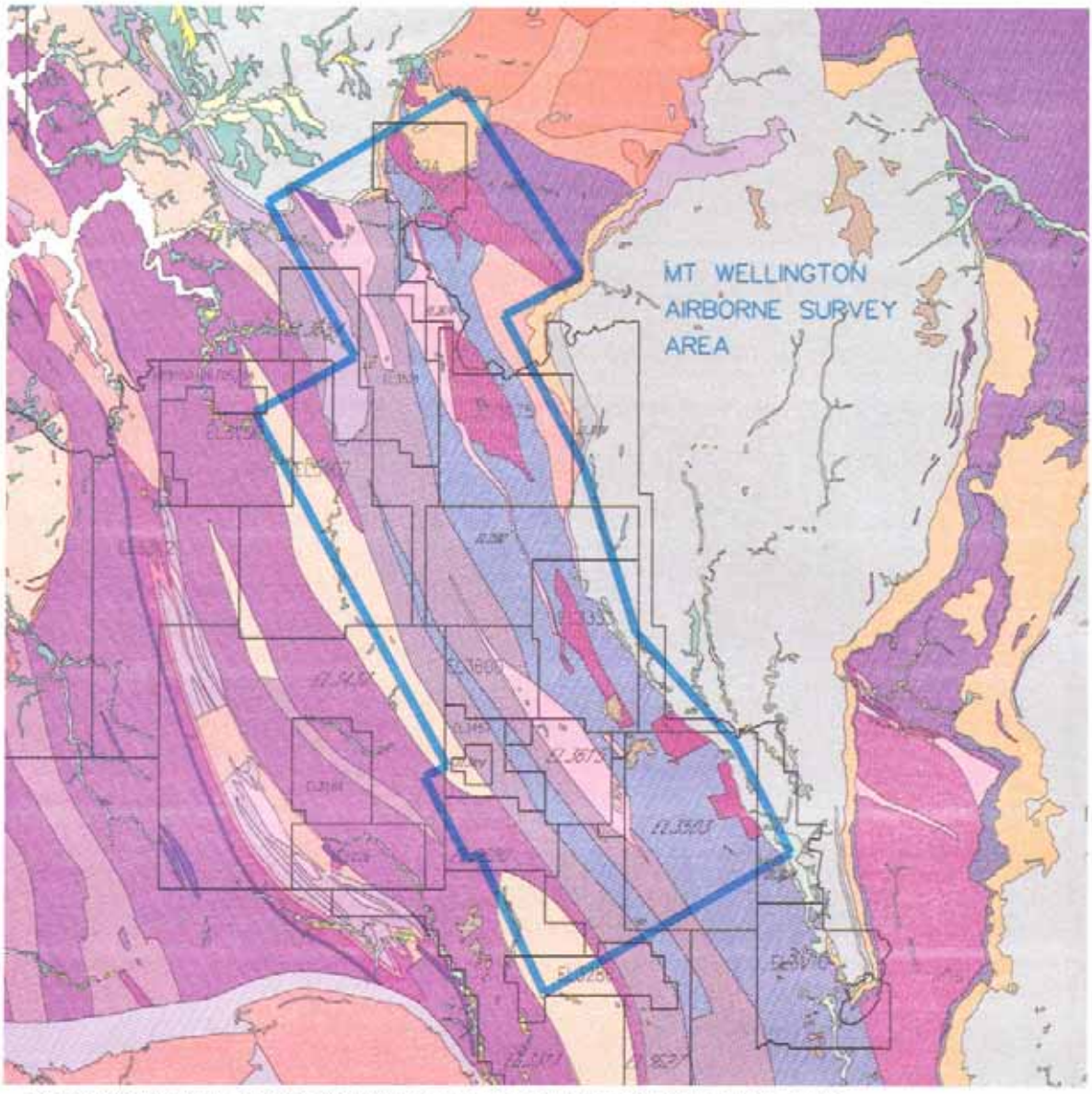

Plate 7: Digital geology map of the Mt. Wellington helicopter magnetics and radiometrics survey area. showing detail of the available State-wide digital 1:250 000 geology mapping coverage. See Figure 2 for survey location and Plate 6 for the magnetic image.

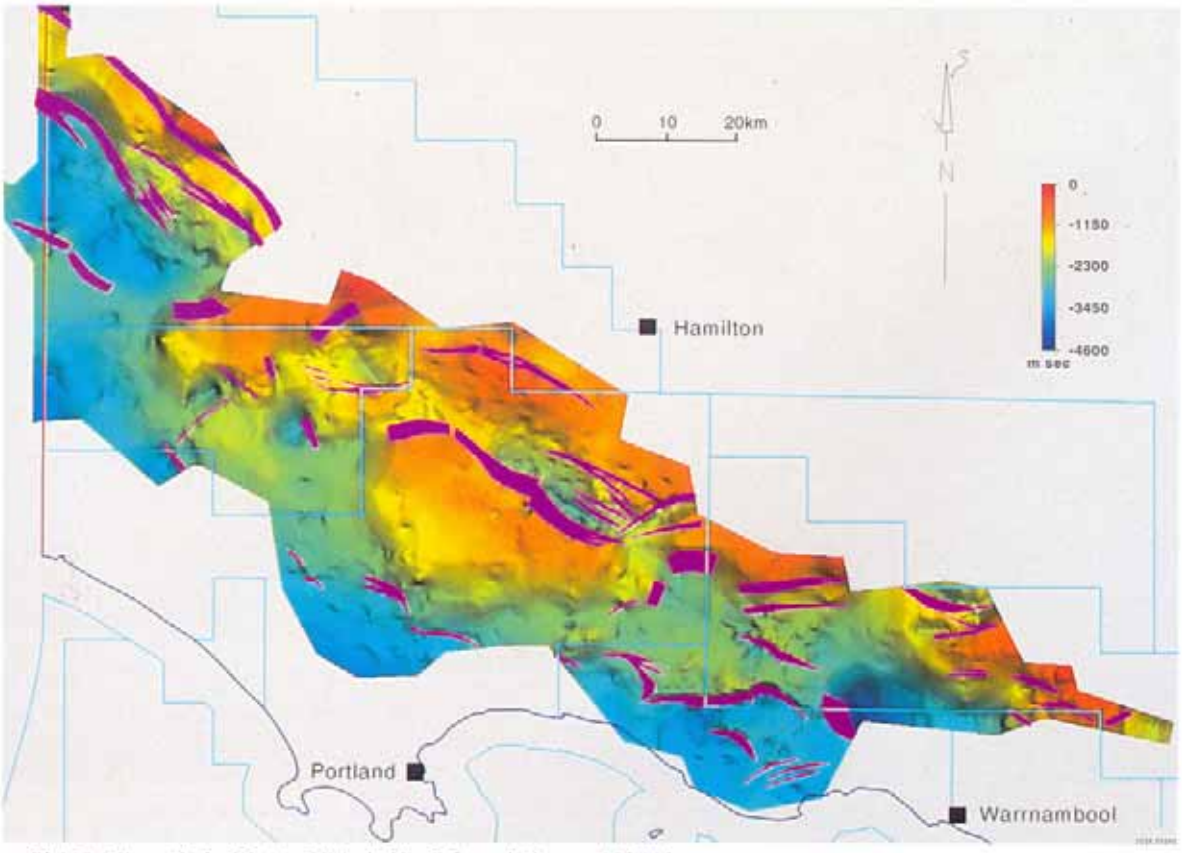

Plate 8: Otway Basin, Western Victoria, Top Palaeozoic Basement 2WT Image.

The survey is over a prospective area of Cambrian greenstone volcanics and Ordovician and Silurian sediments to the east of the Woods Point dyke swarm and the A1 mine. An interpretation of the geophysical data has been undertaken by GSV. A field mapping programme mapping the structure and lithology of the area is currently being undertaken with a number of geophysical anomalies are being followed up. Plate 7 is a digital regional geological map (1:250 000 scale mapping) covering the survey area and showing existing exploration activity from the GEDIS system. The map was prepared on the GSV in-house Genamap / Microstation cartographic system.

Exploration in the area has increased significantly as a result of this survey. A number of companies have purchased the maps and digital data for the area. As a way of promoting this area, the GSV has been providing an image processing and interpretation service to the industry. This has been extremely popular with the smaller companies who do not have in-house access to these tools. The GSV is able to provide geologists and geophysicists who have the expertise in the geophysics and geology of the survey area, to discuss ideas and exploration strategies with explorers.

Data from this survey was released in August 1993. The data are available as a map set comprising flight line, TMI profiles and contours, total count contours and a tenement overlay ($100 per set), colour contours and images ($150 each) and digital located data and geology overlay ($750).

Other GSV Geophysics

Gravity and GPS

At present, a large proportion of Victoria is covered only by 11 km spaced gravity data (see Figure 3). As part of the Geological Survey of Victoria's brief, to supply regional geological and geophysical information across Victoria, the Geophysics Section will be reducing the gravity data coverage from an 11 km grid to approximately a 1.5 km grid. This equates to about 1000 gravity stations per 1:100 000 mapsheet.

The ultimate objective is to make gravity a routine geological mapping tool, as accepted as much as airborne magnetics currently is in mapping programs. This second phase gravity program will bring the Victorian gravity coverage down to a level approaching that of the BMR / AGSO 1.5 km. reconnaissance airborne magnetics coverage of Australia.

The rationale is that gravity responds to a whole rock property (density) and ultimately is of greater potential benefit in geological mapping than magnetics mapping which relies largely on magnetite geochemistry.

This program will be conducted on a 1:100 000 mapsheet basis in conjunction with GSV's National Geoscience Mapping Accord commitments, North-west (Murray Basin), p24, and the Otway Basin Initiative areas (p25). Gravity data acquisition began in May 1994 with the Dunolly 1: 100 000 mapsheet to be followed by Ararat and Beaufort 1:100 000 sheet areas.

To achieve the 1-2 km station spacing in a realistic time the Geophysics Section has purchased two survey grade SERCEL GPS receivers which use kinematic, rapid static and trajectography post processing

Figure 4. Sercel Base and Roving GPS receiver. In open country, Trajectography or Kinematic heighting is feasible and cost effective.

software. Sercel's trajectography software is able to deal with and correct for satellite signal breaks. Sub-metre accuracies (location and elevation) are achievable with this software. Figure 4 shows the base and roving GPS receivers used in the program. Figure 5 shows a gravity station being established in lightly forested country.

The gravity data is being collected using GSV's La Coste-Romberg and Scintrex gravimeters. The gravity and GPS data is processed and combined using both commercial and in-house software.

For a semi-regional gravity survey (1.5 km spaced data) sub-metre accuracies are acceptable to define lithological units and boundaries and provides more information on sub-surface rock relationships.

Figure 5. Rapid static GPS and gravity is ideal in lightly forested areas.

To further improve the quality of gravity data collected in Victoria, the Geophysics Section conducted a project to establish the condition of all gravity isogal stations in Victoria. A report is available which outlines the status of each isogal station. A result of the work is that AGSO will be upgrading Victoria's isogal gravity station network later this year.

Radiometrics And Salinity

The Geophysics Section has conducted a study to investigate the application of airborne radiometrics to soil mapping for salinity purposes for Rural Water Commission of Victoria (RWC) and the Department of Conservation and Natural Resources (DCNR).

The study area was located on the Colac, Horsham and Hamilton 1:250 000 mapsheets. The area is covered by data from the Otway Basin airborne magnetic and radiometric survey, flown by Kevron in 1989.

The aim of the study was to classify the radiometric responses from the soils into characteristic regions with specific radiometric signatures.

Airborne radiometric surveys are useful in geological mapping but are also seen as having potential to map soil types using the potassium (K), thorium (Th) and uranium (U) signature of the ground surface and is therefore in a sense airborne radio-geochemistry.

As a soil remote sensing technique, airborne radiometrics has the advantage over conventional remote sensing techniques (eg. satellite) in that it is relatively unaffected by vegetation.

The geochemistry of the elements K, Th and U is either directly related to or influenced by the general geochemistry of the soil. In turn geochemistry of the soil is a factor in soil classification, groundwater salinity and recharge. Clayey soils (high K) play a part in groundwater recharge. Soils with high clay contents hinder groundwater recharge by acting as a barrier whereas soils containing little to no clay are potentially excellent rainwater/runoff infiltration zones. Hence, the clay content (K content) of soils are a target for the radiometric classification.

Data integration - Geophysics, topography and remote sensing

Using ER Mapper image processing and data integration capacity geophysical data can be readily integrated with topography, remote sensing and indeed any gridded geological datasets. To this end, the GSV Geophysics group has recently acquired State - wide mosaiced Landsat MSS and TM satellite data and is gridding and imaging progressively available AUSLIG 1:100 000 and State mapping 1:25 000 digital contour data combined with other elevation data (benchmarks, gravity and seismic survey traverse stations, borehole surface elevations) and airborne geophysical derived digital terrain data.

This data will be used in conjunction with digital geological maps and geological databases to assist geological and basin study projects and produce innovative products for industry.

An example of topography and bathymetry data imaging for the eastern Otway Basin studies is shown in Figure 6. This data was integrated with airborne magnetics and radiometrics, gravity onshore and offshore and gridded subsurface seismic two-way time and borehole and seismic depth horizon data, to increase the understanding of the complexity of structure in the area.

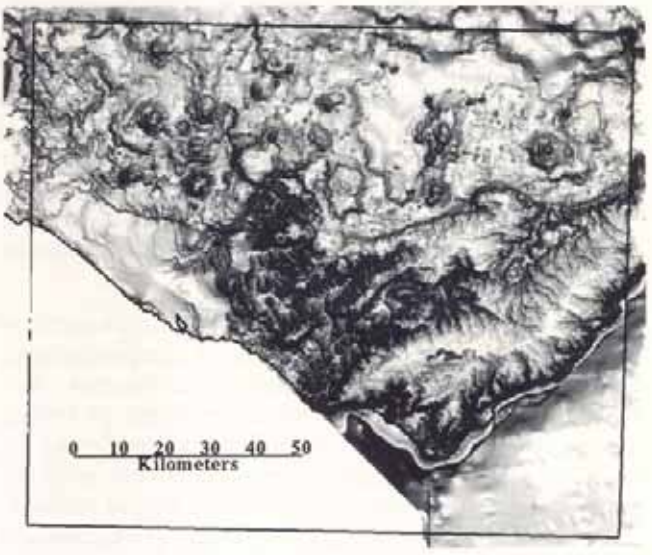

Figure 6. Topography/bathymetry image of Colac 1:250,000 area in the Eastern Otway Basin from AUSLIG and other elevation data.. (Acknowledgements:AUSLIG).

NASA / AIRSAR airborne radar data was recently acquired as an experimental dataset over the Mt Wellington airborne geophysical and geological mapping project area (see location Figure 2 and airborne magnetics image Plate 6). Digital terrain model data was available from the helicopter altimeter and GPS navigation data to supplement existing terrain data from digital contours and to assist structural mapping.

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Geological Mapping

The Geological Mapping Section of Geological Survey of Victoria produces geological maps in order to guide mineral and hydrocarbon exploration programs, and enable informed decisions to be made in the areas of development and conservation.

A major development in geological mapping in recent years has been the availability of detailed airborne magnetic and radiometric data, collected both by the Department and by AGSO as part of the National Geoscience Mapping Accord. Through the use of ER Mapper for imaging this data is now routinely used by geologists to aid in geological interpretation of project areas.

Current geological mapping programs are shown in Figure 7 and include:

- Mount Wellington project
- Ballarat NGMA project
- Castlemaine 1:100 000 mapsheet
- Dunolly 1:10 000 mapsheet
- Updating the 1:250 000 series geology coverage of the State in digital format (see a sample Plate 7)

The Mount Wellington project area, is essentially the area covered by the Mt Wellington 200m line spacing helicopter magnetics and radiometrics survey (p28 & 33; see location Figure 2). The project area covers a belt of Lower Palaeozoic sediments and volcanics between the Walhalla Synclinorium and the Barkly River greenstone belt in the eastern part of the Melbourne zone. Plate 7 shows the existing digital 1:250 000 mapping, the project / airborne survey area boundaries and existing Exploration Licences.

A team of seven GSV geologists and geophysicists, with technical assistance back-up will produce a new 1:50 000 geological map and information package for release late 1994 A major result of this mapping is that blocks of Cambrian volcanics in the area have been shown to be antiformal culminations bounded by low angle thrusts, rather than parts of an imbricate thrust stack as previously proposed.

Geological mapping in the Mount Wellington project area will greatly assist exploration companies searching for gold and base metals to develop new orebody models and narrow down their target areas.

A major joint GSV / AGSO NGMA program to remap the Ballarat 1:250 000 sheet was commenced in 1992. This constitutes part of a larger program to remap 1:250 000 sheets subsequent to flying minimum 400 metre line spacing detailed magnetics and radiometrics. Previous 1:250 000 scale geological map coverage of Victoria was completed in 1977 with the backup of 1500 metre line spaced airborne magnetics and radiometrics, and is largely out of date.

As part of the current program AGSO have mapped the Willaura and Skipton 1:100 000 sheets within the Ballarat 1:250 000 sheet area, and GSV are mapping the Ballarat, Ararat, Creswick and Beaufort 1:100 000 sheets.

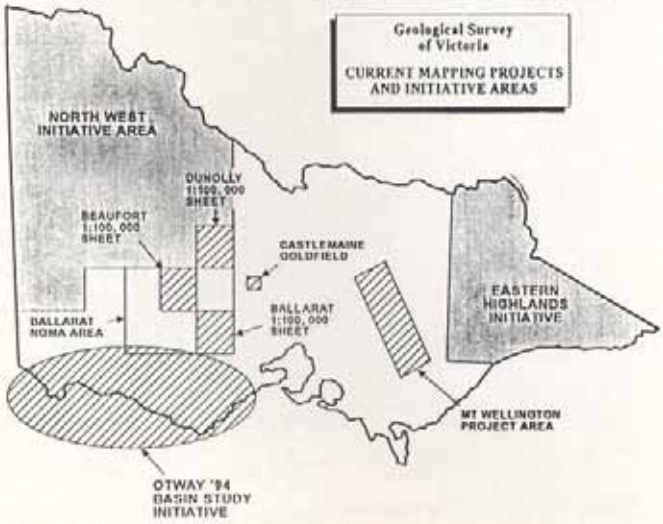

Figure 7. Current and Initiative Geological Mapping programs by GSV in Victoria.

In the Willaura 1:100 000 sheet AGSO have recognised a new greenstone belt west of the Stavely Belt from interpretation of detailed magnetics.

In the Beaufort 1:100 000 sheet area GSV geologist Ross Cayley has developed a new model for primary gold mineralisation as a result of his detailed structural mapping, while on the Ballarat 1:100 000 sheet GSV geologist David Taylor has successfully used radiometrics to recognise areas of Tertiary alluvial gravels.

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Basin Studies

Promoting exploration for minerals and hydrocarbons within Victoria's geological basins is the prime function of the Basin Studies Section of the Geological Survey of Victoria. This involves producing regional geological and geophysical datasets and interpretations over the basins to assist exploration companies in determining prospective areas.

Eastern Otway Basin

As a result of recognising the hydrocarbon potential of the Otway Basin, the section has concentrated its activities in this basin in recent years. This involved surface mapping and producing the Colac 1:50 000 geological map and explanatory notes, the Port Campbell Embayment 1:100 000 geological map and explanatory notes, and completing outcrop mapping of the Colac 1:250 000 Geological Map.

Further work is being carried out in the western part of the basin to use all available borehole data to map the subsurface extent of all Otway Basin formations. This work will eventually form the basis for depth converting seismic interpretation and developing stratigraphic models for the basin.

As part of the Otway Basin studies a number of preliminary reports and published papers have been prepared. These include presentation and interpretation of geophysical data (GSV Unpublished Report 1992/1), compilation of biostratigraphic data (GSV Unpublished Report 1993/18), and a revision of stratigraphic nomenclature (GSV Unpublished Report 1993/14). Reports currently being edited include a refined interpretation of surface and subsurface structures, a study of the hydrocarbon potential of the onshore Eastern Otway Basin, and a revised biostratigraphy for the significant Tertiary section at Browns Creek near Glen Aire (GSV Unpublished Report 1994/7).

Stratigraphic Drilling

A deep stratigraphic hole, Bus Swamp 1, was drilled northwest of Casterton as part of the western Otway Basin project. This hole, drilled to a depth of 1850 metres, involved company sponsorship, and significantly increased the understanding of the geology and source potential of the northern margin of the basin. This is the third in a series of deep stratigraphic holes drilled by GSV in the Otway Basin in recent times with company sponsorship, the first two being Mocamboro 11 (GSV Unpublished Report 1991/65) and Warracbarunah 2 (GSV Unpublished Report 1991/66).

BOREHOLES Database

Database development and maintenance plays a significant role in the ongoing activities of the section. The databases managed by the section are incorporated within the BOREHOLES database. BOREHOLES was developed by the Department's GEDIS (Geological Exploration Development Information Systems) section to handle all borehole related data. Figure 8 shows a GEDIS plot of all bores in the BOREHOLES database.

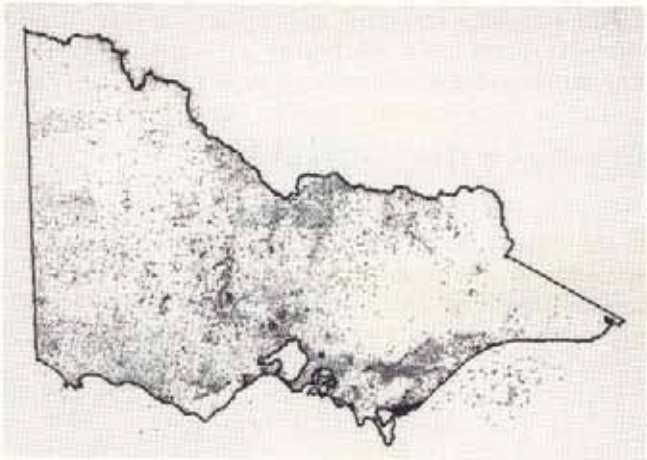

Figure 8. Boreholes in the Victorian BOREHOLES database. The total number of bores is 114,000.

In addition to borehole header information (co-ordinates, depth etc) also stored within this database is core and cuttings information and storage location details, lithologies, stratigraphy, wireline log information, temperature data and biostratigraphy data (BIOSTRAT). Managing all Victorian Government and some industry core and cutting material, stored at the Port Melbourne core storage facility, is a key function carried out by the section.

The BOREHOLES database runs on Sun 'Sparc' workstations and uses Genamap GIS and INGRES software. Full interaction between the spatial and textual databases has been developed by GEDIS, allowing quite specific, complex searches of the BOREHOLES database to be undertaken. Reports are available in hardcopy and digital formats.

NGMA Otway Basin Project

In conjunction with the AGSO, Minerals and Energy South Australia, and the Victorian Institutes of Earth and Planetary Sciences, a National Geoscience Mapping Accord project over the entire onshore Otway Basin was initiated in 1991. As part of this project, GSV Basin Studies and Geophysics Sections were committed to carrying out a seismic interpretation of the western part of the onshore Otway Basin. Four key unconformities were mapped, namely top basement (Plate 8), top Crayfish Group, top Eumeralla Formation and top Sherbrook Group, by interpreting 150 seismic lines (3000 line km). The interpretation was digitized and then machine and hand contoured to produce two-way time and isochron contours and images for significant horizons within the basin, at both regional and detailed scales. The western Otway Basin was divided into 9 areas and contoured maps produced at 1:50 000 in Petroseis, for the four horizons, from scanned hand contoured maps . Figure 9 is an example of the one of these detailed maps.

A structural elements map, showing age of faulting of all major faults, has been produced. The results have identified a number of new features within the basin, and a variety of play types of interest to explorers. A stratigraphic nomenclature for the entire basin was also finalised in conjunction with MESA geologists.

In addition to these products, the Otway Basin Project has resulted in new ideas being developed on the tectonic evolution of the basin. These include early rifting models involving half-grabens of alternating vergence, separated by complex transfer zones and Miocene to recent compression, resulting in strike slip faulting.

The results of the NGMA Otway Basin Project were presented to industry at a one day symposium held in Melbourne in conjunction with the other NGMA partners, and organised by the PESA Vic/Tas Branch.

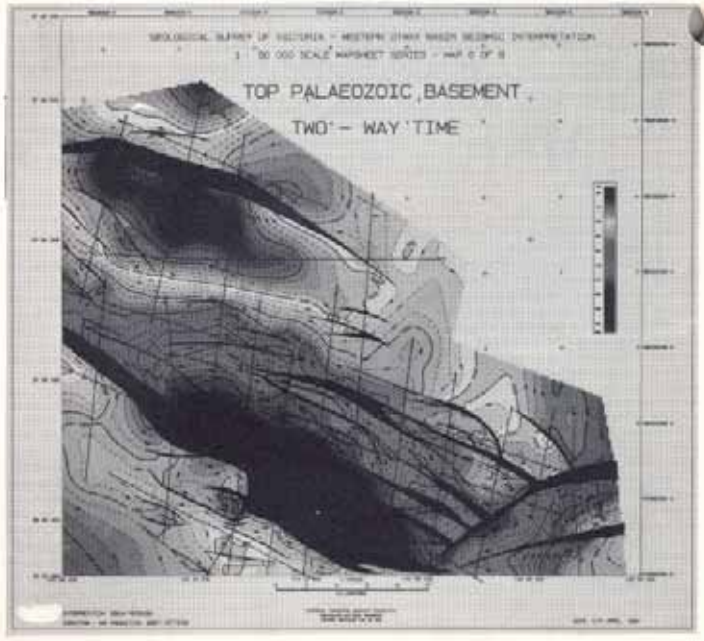

Figure 9. Detailed map of Palaeozoic Basement 2WT Western Otway Basin, Victoria.

Initiatives and Basin Studies

Future work under the Otway Basin Initiative (p25) involves extending the current seismic and subsurface interpretation from the onshore western Otway Basin into the eastern Otway Basin and offshore using recently acquired Charisma interpretation workstation software. and the flying of a detailed offshore airborne magnetic survey, in conjunction with AGSO, MESA and industry. A contract to interpret 5000 line km of seismic data in the offshore Otway Basin commences in July, 1994, to supplement in-house interpretation.

For the Northwest Initiative (p24) airborne, seismic, gravity and stratigraphic work is to be carried out.

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GEDIS

The Department of Energy and Minerals is the recipient of vast amounts of geological, exploration and other earth resources data which is collected by the Department or reported to it by industry under various legislation. This information may be in hard copy of digital format and is widely used by exploration companies and consultants to the industry.

The Department has developed a Geological Exploration and Development Information System (**GEDIS**) to manage this data. GEDIS uses an integrated group of computer systems (Genamap GIS and Ingres database), to provide an invaluable new information tool for those interested in the development of Victoria's earth resources.

GEDIS services the mineral exploration, mineral development, petroleum and extractive industries and is capable of supplying information on:

Figure 10. GEDIS Counter Enquiry Service.

- all current tenements, as well as additional information such as up-to-date identification of restricted areas and base mapping including roads, towns and rivers.;
- expired exploration tenements area and tenure;
- comprehensive indexes to reports;
- significant exploration surveys including all airborne geophysics;
- mineral, coal and Government bores; and
- information about petroleum wells.

Information that once took days to collect can now be located within minutes with a counter enquiry (Figure 10).

Simplified tenement searching

Explorers can use GEDIS to quickly identify land that is immediately available for exploration and areas subject to a moratorium period. GEDIS can inform clients about aspects of land ownership, such as who occupies the land, under what conditions and for how long.

GEDIS can give full details of all current exploration, mining and extractive industry tenements and all expired exploration licences via graphic/lens enquiry screen (Figure 11).

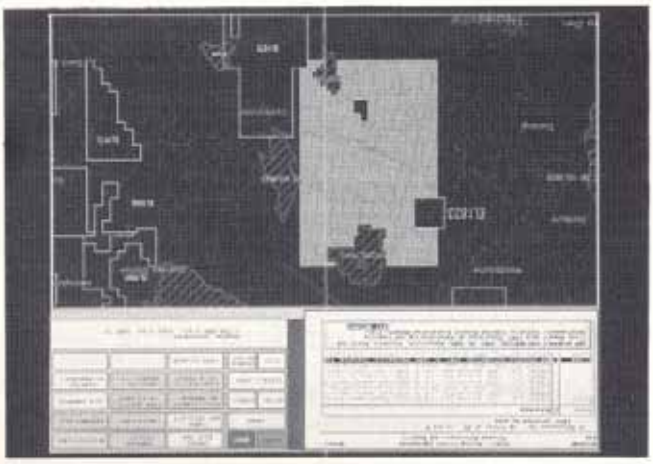

Figure 11. Typical GEDIS graphics text enquiry screen.

Current information such as the title type, tenure, status, location and proximity to other titles or restricted areas is also readily available.

Past exploration

With GEDIS, it is now possible to quickly browse the exploration history of an area including the locations of past holdings and their reporting history.

GEDIS indexes company reports for all expired exploration licences. These indexes include full citations and basic key words. Recent company reports, for example, will be categorised by key words (e.g.

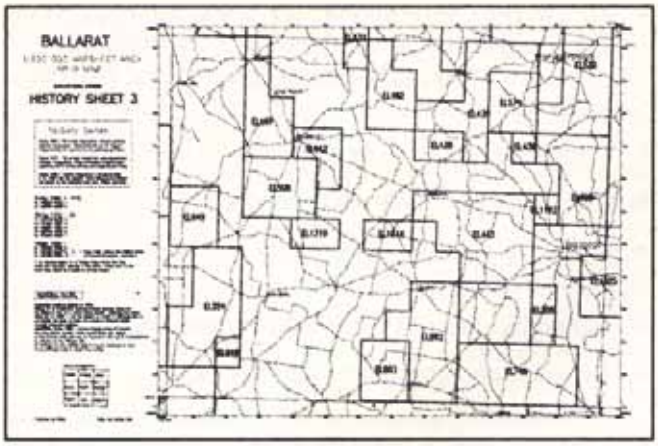

Figure 12. A GEDIS self-help historical exploration plot.

commodities, localities, prospect or mine name). Information available will include summary details of a company's work and expenditure. Abstracts are also included if supplied by the Company.

Self-help sets of GEDIS-generated plots and indexes are also available at the Department's counters and library (Figure 12).

Reference searches

A large number of general references, including citations for departmental publications, Unpublished Reports of the Geological Survey of Victoria (GSV) and historical plan collection are available. The Department is also gathering an increasing number of general and historical mining bibliographies for addition to GEDIS.

Research geologists and industrial minerals explorers are able to specify commodities such as rutile or ilmenite and, by using a categorised key word search, GEDIS will provide details of all recent reports including full citations, key words, tenements and tenure histories and map sheet areas.

Petroleum exploration

Petroleum explorers searching for information about bores and petroleum wells are able to assemble sets of data valuable for exploration planning.

Information on exploration wells, ground water and mineral bores such as stratigraphic and age determination data, details of lithological and geophysical logs.

Indexes and details of seismic and other geophysical survey traverses are also included.

Drilling data

GEDIS holds records of 114,000 bores that date back to the first recorded diamond drill bore in 1878. All major petroleum wells are also covered, as are all government-drilled bores and significant mineral industry bores.

A consultant geologist assessing a basalt resource is able to collate sets of bores that can be used to identify the extent of the resource. From a starting point of using a map, enquiries can then be further qualified by criteria such as depth or lithology.

Airborne Geophysics

GEDIS includes details of and area covered by all airborne geophysics including magnetic, radiometric and electromagnetic.

Further work

The Geological Survey of Victoria and GEDIS are working to expand GEDIS on such projects as:

- Mine data system to manage the Departments large historical mine data. The system will maintain records and locations for around 10,000 mines from the Bendigo and Ballarat goldfields and eventually sites in Victoria. An example mine data screen display is shown in Figure 13.

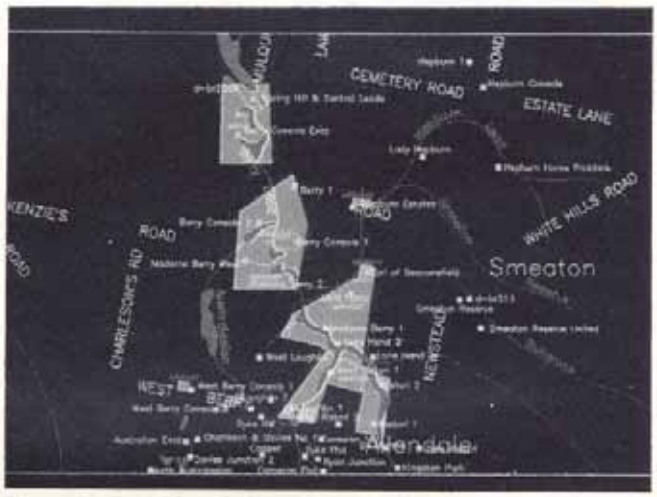

Figure 13. Detail of a mine data enquiry screen - Central Goldfields, Victoria.

- A Geological database will also be developed that will support geological mapping. Its components will include geological features, structure, geochemistry, petrology and palaeontology. The Geological database will manage geological data from its field acquisition through to its incorporation into standard departmental products such as published reports and geological maps.
- The existing surveys system will be expanded and its functionality increased to support the Department's new airborne Geophysics initiatives.

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Funding Research and Development in Geophysics

Key Note Address for the ASEG Conference in Perth, Australia 1994

by
Don Pridmore
World Geoscience Corporation

The business of non-seismic geophysics with an estimated annual turnover of $200 million in the Western world is a weak infant in the business world at large. Virtually unknown by mums and dads in the wider community, by politicians, stock brokers and merchant bankers, our industry has discovered and will increasingly continue to deliver billion dollar resources to struggling economies, directly affecting the lives and well being of our community.

Today in 1994 I believe the long-term health of the industry is not assured. Oil and mineral exploration groups, together with a recent publication (Spies and Winterstein 1994), clearly indicate that funds for major research and development projects, sufficient to generate revolutionary change in the technology, are not flowing to the industry. It is obviously in the interests of exploration groups and therefore the contracting industry, and indeed the community at large, to ensure that geophysics remains at the state of the art. Investment lead times for major developments are of the order of seven to ten years. Isolated injections of capital over two or three years or not enough. The issue here is attracting talented project managers, and hardware and software engineers into the industry. Building and maintaining a critical mass of such people for a period of ten years or more is critical.

Firstly, let me illustrate our community's perception of geophysics with a case history.

Consider Western Mining Corporation's Olympic Dam deposit located on the Stuart Shelf of South Australia. Drilling based on reconnaissance gravity and magnetic surveys discovered the major copper, gold and uranium resource of Olympic Dam under 300m of barren cover. The sand dunes overlying the deposits have been bulldozed to make way for a processing facility and a town of several thousand people. The decision to mine Olympic Dam became an election issue for the then Premier of South Australia. The mine currently contributes approximately $300 million per annum to the economy of South Australia and is likely to contribute even greater revenue for at least the next 30 years.

Who knows that the non-seismic geophysical industry with an annual turnover in Australia of $30 million per annum, that spends an estimated $3 million per year trying to improve gravity and magnetic

Does this family know?

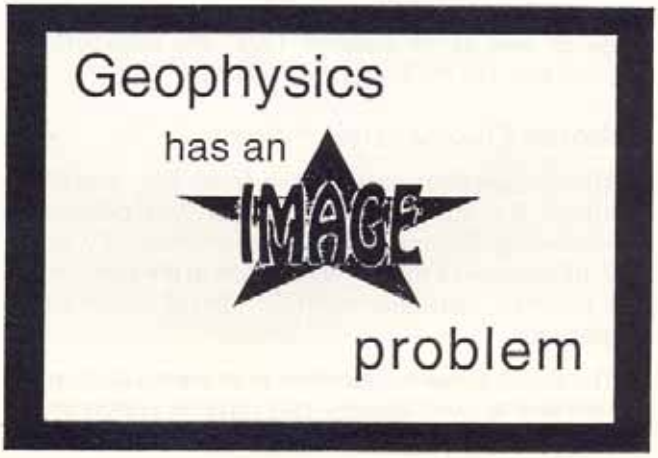
techniques, is directly responsible for turning rocks below the sand dunes into an annual revenue stream of $300 million? Does the talented high school student who can make a significant contribution to geophysics in 20 years know? Does the politician who can legislate for a major exploration initiative know? Does the merchant banker or the stock broker who can raise $5 million for future development know? Do the mums and dads in South Australia know?

The answer is almost nobody knows.

Fellow geophysicists, I suggest to you that geophysics has a serious image problem. Almost no-one outside of your peers, friends and relatives have even heard of geophysics. Furthermore, I suggest to you that the future of the industry will be a lot more robust if the community understood the role geophysics played in their well-being.

R&D Case Histories

Before examining the sources of investment capital for the geophysical industry and why community attitudes are important, it is worth looking at the



commercial environment of some of the major revolutionary developments in the industry. These case histories are taken, in part, from Bates et al (1982).

Digital Acquisition and Processing of Seismic Data

The seismic contractor, GSI Inc., began investing in digital data processing research in 1952. It wasn't until 1958 that digital acquisition and processing was actually offered by GSI to the industry. During this time, GSI relied on financial and consulting support from the client companies, Mobil and Texaco. It is interesting to note that the early results from the system left clients unconvinced and that even by 1965, some seven years after the introduction of the first system, it was not clear to the industry whether the additional cost involved in digital acquisition and processing were justified.

Aeromagnetic System

Although the first aeromagnetic survey was carried out in 1921 (in a balloon) available magnetic field sensors had neither the sensitivity nor stability to be effective. Fluxgate sensors appeared to offer promise and during the 1930's were the focus of most of the development efforts. A revolutionary development in aeromagnetics came with the refinement by Vacquier of fluxgate elements and internal circuitry to the point where changes as small as one gamma could be detected. This breakthrough was funded by Gulf Research and Development Company. The system was adopted by the navy as the basic MAD system for submarine detection in 1942. At the end of the war Gulf licensed the technology to Aero Service and Fairchild Aerial Surveys, airborne geophysical contractors of the day.

INPUT® Airborne Electromagnetic System

Dr Tony Barringer convinced Selco, a major Canadian mining house, to invest in a development team and new building in 1958 to develop a revolutionary new concept in airborne EM. The results of this work were so encouraging that in 1961, Selco provided capital for Barringer to start his own contracting and development business, Barringer Research. Derivatives of Barringer's INPUT ® Airborne EM system, now account for all fixed wing EM surveys carried out in the world. This technology has found 16 major deposits worth in excess of $10 billion. It is interesting to note that when business for Barringer Research was at its peak in 1979, the total annual revenue was $12 million (1993 dollars).

Airborne Fluorsensing System

The concept of using a laser to detect very thin films of oil on the surface of the ocean was originally developed by Barringer and taken on-board by BP in 1987. BP invested a further $70 million in the technology and in 1993 out-sourced it to World Geoscience Corporation.

The developments described here are revolutionary as opposed to evolutionary and have in common the fact that client companies are always involved in funding the development. Contractors played a critical role in the development process.

Sources of Funds

Four basic sources of funding are available for exploration geophysics. These are:

- Contractors.
- Client companies made up of oil and mineral and exploration groups.
- Investors.
- Government.

Airborne geophysics provides a useful context for discussing funding as it is a strategic technology for exploration tenement acquisition, equipment development is expensive and there are a number of emerging technologies such as gradiometry, lasers and multi spectral scanning instruments.

Contractors

In the contracting industry the main source of funds for development comes from cash generated by the business. Historically it has not been possible to generate enough cash from a contracting business to fund revolutionary developments as shown by the case-histories cited above. Contractors do play a key role in nurturing the technology and, where funds are provided either by investors or client companies, in revolutionary developments. World Geoscience Corporation an Airborne Geophysical contractor invested approximately $900,000 on research and development during 1993. Over this period the group acquired approximately 1 million line kilometres of data. For each kilometre flown $0.90 was invested in research and development. This is a significant percentage of the revenue generated by each kilometre of flying and illustrates the difficulty in funding even evolutionary research and development in a highly competitive market place. The other point to note is that the return to contractors for developing new technology is definitely many times less than the return to clients, when research and development allows the client company to discover a major new resource.

Clients

Client companies have historically played a key role in revolutionary developments in geophysical technology. This has been done through either developing the technology in-house and out sourcing to a contractor or jointly developing the technology with a contractor. Client involvement in revolutionary development results from the potentially significant return from investment in strategic technology. An improved awareness of the role played by geophysics in our community, particularly amongst shareholders and stock brokers of exploration companies, would make it far easier for the directors of public companies to justify investment in geophysical research and development.

Investors

The sharemarket and R&D syndicates are potentially important sources of investment capital for R&D within the geophysics industry. It is important to note that unleveraged investment in geophysical research typically gives poor returns e.g., a new deep probing airborne EM system that costs $10 million to develop over a period of five years would have a financing cost of around $40 per kilometre. This is approximately the current rate for existing fixed wing EM systems in Australia. It is unlikely that this project would be a commercial success. Of course there are many ways of leveraging the investment, to provide excellent opportunities for significant returns. However, access to investors' money is hampered very significantly by the lack of knowledge in the community about exploration geophysics.

Government

There are a number of different sources of funding for R&D from government. These include:

- University funding.
- Direct R&D grants to industry.
- Co-operative research centres.
- Contracts for geophysical surveys.

I want to emphasise here the importance of the role government contracts have played in the development of airborne geophysical technology. Figure 1 compares the average annual expenditure on airborne geophysical contracts and research in Canada, with that in Australia, since 1970. The figures have been averaged to a single annual average per decade and illustrate the very high levels of government expenditure in Canada during the decade of the 1970's and to a lesser extent the 1980's. These high levels of expenditure coupled with the fact that the work was budgeted in advance, provided the contracting industry with a large and stable base of work. It is no accident that the base technologies for airborne magnetics, radiometrics and electromagnetics were developed and refined during this period in Canada. (These figures were compiled by Laurie Reid with assistance from the GSC, OGS and MER agencies in Canada; by Ian Hone from AGSO, and Joe Cuccuza from AMIRA).

A further point to note is that the act of collecting a data set, particularly in new geological or operational environments often results in new developments. Government contracts by their nature are commonly in this category. It is of course much easier for State and Federal governments to fund geophysical initiatives with the support of the community at large.

There are many ways in which geophysical fraternity can, both as individuals and organisations let the community at large know of the role exploration geophysics plays in their well being. When we solve the problem of informing the community around us there will be money to solve the technical problems and ensure the health of our industry.

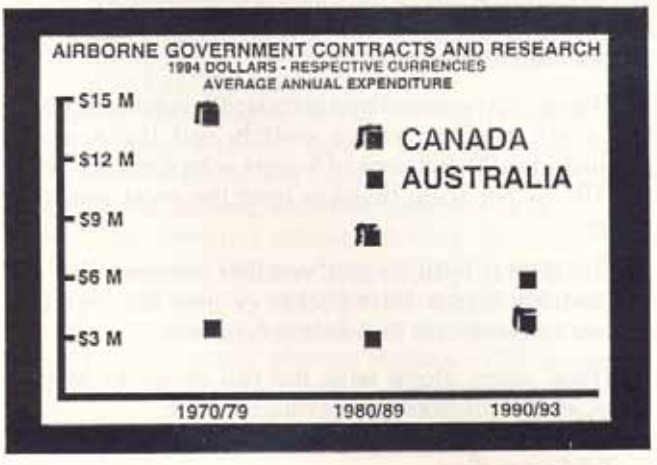


Figure 1. Comparison of average annual expenditure on airborne geophysical contracts and research between Canada and Australia.

References

Research in the 1990's by B.R. Spies and Winterstein, Leading Edge, January 1994.

Geophysics in the Affairs of Man by C.C. Bates, T.F. Gaskell and R.B. Rice, Pergammon Press 1992.

Editors Note:

Don Pridmore's keynote address has stimulated much informal discussion. What can we do to improve the image of geophysics? Preview is interested to hear your viewpoint.

Perhaps you have an R&D story to tell. Is your R&D program as impressive and sustained as WGC or is it quietly languishing for lack of finance? Preview is waiting to hear from you and is happy to promote what geophysics R&D programs there are out there.

WGC airborne EM R&D has resulted in Questem and SALTMAP systems. Shown is one of the airborne EM planes and instrument operator Wayne Peel.

Industry News

Employees Take Over Swedish Geophysical Equipment Company

The Swedish company ABEM Geoscience has been taken over by its employees. The new company name is Mala GeoScience and Olof Forslund is the CEO. Its main line of business will still be the development and production of geophysical measuring equipment.

Mala Geoscience new majority shareholders - the staff.

The takeover was declared on January 1st and since then, the 17 employees have been busy organising their forces for the future. The personnel at Mala GeoScience currently owns 60 percent of the shares. Furthermore, the geoconsultants Conterra AB and Geosigma own 20 percent each of the share portfolio.

The company is located in the Northernmost part of Sweden, not more than 200km from the Artic Circle, where the development of exploration equipment for base metal ores started as early as in the mid-1920s. Since then the company has specialised in the development and manufacturing of a variety of tools for rock characterisation and ore delineation from bore-holes. This summer Mala GeoScience will launch its first GPR, embarking upon a totally new market.

Bore-hole Radar System

Mala GeoScience is highly skilled in the areas of electronics, computers and precision mechanics. The company is currently working on an extensive TQM-programme, in order to additionally increase the level of quality. Mala GeoScience has a broad product programme, which is not confined only to areas of applied geophysics. Besides equipment manufacturing, the company also specialises in custom designed development. The experience and knowledge gained from the high performance requirements of bore-hole operations has been successfully applied to other areas with similar requirements.

New Ground Broken

The Ramac Borehole Pulse Radar System has attracted most attention on the international market. The development of the bore-hole radar system started in 1983, and was ordered by the OECD, who wanted to produce equipment for detecting rock structures.

This system can also be used to investigate sites for the storage of nuclear waste. Other areas of application are determining ore limits and investigating the causes of earthquakes. Engineers at Mala GeoScience travel the world in order to measure bore-holes.

"-Our business concept is actually to sell the equipment. The reason for us working with geotechnical applications in the field, is to break new ground and show customers how to use the borehole radar", states Olof Forslund, who also reveals that they are going to concentrate their efforts on new markets this year. Mala GeoScience has a strong export emphasis (95 percent of its production is exported).

A New Product - GPR

In connection with the European Geophysical Exhibition EAEG, arranged in Vienna in June, Mala GeoScience will present a completely new addition to their product programme - a ground penetrating radar. As yet, Mala GeoScience is still quite secretive about the new product but claims that the radar RAMAC/GPR will be considerably more flexible than its competitors. Of ergonomic design, it will be possible to use in a vehicle or carry it in the field. The market for GPR equipment is about 50 times bigger than the market for bore-hole equipment and with GPR, Mala GeoScience are aiming to increase turn-over considerably with an expected growth of at least ten percent a year.

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JH-8 Susceptibility Meter

The very popular JH-8 Susceptibility Meter manufactured by MALA Geoscience of Sweden is now available through Geoterrex Pty Ltd in Sydney.

The hand-held meter incorporates a clear and easy to read, quick response, direct reading analogue display across the full width of the meter and this feature, above all others, is the preferred display output within the geoscientific community.

This unit is powered by a standard 9-volt battery and has a six position range switch and the scale is graduated in 20 divisions of 5 units with a resolution of 5×10^{-5} SI per scale division over the most sensitive range.

The JH-8 is light weight, weather resistant and fits comfortably into a shirt pocket or into the supplied leather carrying case forwearing on a belt.

These units, along with the full range fo MALA Geoscience equipment, are available from:

Geoterrex Pty Ltd
7-9 George Place
Artarmon NSW 2064
Tel: (02) 418 8077
Fax: (02) 418 8581

Petroconsultants Digimap

Petroconsultants Digimap started life in 1980 as Digimap Geodata Services, primarily to service the computer mapping needs of an associated consultancy company: Flower Doery Buchan (FDB). The client base of Digimap, as it is still commonly known, has remained predominantly oil companies. As more and more of our clients acquired their own in-house mapping capabilities, their need for custom mapping services declined, but at the same time there was an increasing requirement for digital data. Digimap discovered a market niche for which it developed a product which has become one of its best sellers - a digital shotpoint location database for all Australian seismic surveys.

Ironically, the product almost never got off the ground. The first area completed was the Eromanga Basin, at a time when onshore activity was still at a respectable a level. With a sudden drop in onshore exploration, it soon became apparent that the focus had to be shifted offshore if the product were to succeed. The first version of the Barrow Sub-basin shotpoint database, completed in 1986, proved extremely popular, since very little digital location data existed at the time. This enabled work to proceed on other basins, and today Digimap has up-to-date seismic location data for the entire Australian continental shelf and most of the active onshore basins. A cooperative agreement with the Dept. of Mining and Petroleum in Papua New Guinea has led to a complete database for Papua New Guinea.

Digimap started its first overseas venture in 1985 by providing mapping services in Jakarta with P.T. ABM. A major change in the direction of the company occurred in 1988 when Petroconsultants S.A. of Geneva acquired both Digimap and FDB, the latter company becoming known as Petroconsultants Australasia. The outlook of both companies became significantly more international from that point, not only as a result of marketing the Geneva-developed worldwide products (Foreign Scouting Service, Exploration Database, etc), but also as a consequence of an increasing trend to develop local products of a more international appeal.

Digimap's own proprietary seismic scanning software, DIGISCAN, is a perfect example. The company has always had a strong research and programming division, one of its most outstanding achievements being the development of IMPSEIS, a sophisticated seismic inversion program coupled with completely original colour plotting software. The fortuitous acquisition of an optical scanner from Petroconsultants' UK operation intended to be used for scanning well logs, became the impetus to create a system for scanning seismic sections. The technique SQUEEZE enabled horizontally compressed plots to be made with distinct advantages over photographic techniques.

The rapid explosion of the use of workstations for interpretation, however, convinced Digimap to develop the software further to produce digital seismic traces in SEG-Y format reconstructed from the original prints. DIGISCAN and DIGISCAN PLUS (the full waveform version) have certainly made an international impact. Not only have overseas companies sent scanning work to Sydney, but Digimap now has two overseas scanning centres in Jakarta (with Digicon) and Houston (with CGG). Prospects look good to set up several more.

Pursuing the international focus for the future, Digimap's graphical interface, PetroWorld, for Geneva's IRIS21 worldwide database is gaining increasing attention. Petroconsultants Digimap have helped to establish Sydney on the world map!

ASEG-GDF2 - A Data Exchange Standard for all Computer Users

By
David Pratt
ASEG Standards Committee

The ASEG has provided funding to assist with the further development of the ASEG-GDF data exchange standard to bring it into line with current and future industry demands. The new standard known as ASEG-GDF2 does away with the least popular features of the old standard while maintaining upwards compatibility. This ASEG project is designed to re-define and improve the standard plus provide end users with software capable of reading and writing data sets in ASEG-GDF2 format. Graham Pilkington is currently writing code for a pull-down menu driven system that will run on PC's and Unix workstations.

New Concepts for ASEG-GDF2

The new standard embodies the key features of the existing standard but removes the requirement to use 9 track tapes and the International Standard ISO 1001-1979 for 9 track tape labelling. Nearly all users of geophysical data found the tape labels to be superfluous and difficult to use because of the proliferation of short tape files that contained no useful data. In summary the key features of the new proposed standard are:

- Media independence (Exabyte, DAT, CD-ROM, 9 track tape)
- No ISO 1001-1979 tape labels required for tape media
- Unix "tar" format recommended for tape transfers
- Implementation assumes that files are available on disk
- "DEFN" and data record structure conform to existing ASEG-GDF
- Implementation support for existing ASEG-GDF archives.

These concepts have simplified the development, support and implementation issues for the ASEG and geophysical users of the standard.

Reading and Writing of Tapes

A key issue with the new implementation by the ASEG is the removal of direct support for reading and writing of tapes. It is assumed that the user organisation has the ability to read and write tapes with their own utilities or standard system utilities. This assumption conforms with current industry practise for both small and large organisations. We are recommending that tapes (9 track, Exabyte, DAT etc) are written using the Unix "tar" format. Implementations of "tar" are available for all Unix workstations, IBM compatible PC's and VAX systems. This covers the majority of computer environments in our user community. Other exchange formats are possible, but we believe that tapes will be used for archiving and a single tape format is preferred in this instance. By way of example, the "tar" format was used to write aeromagnetic data to Exabyte for the recent South Australian Initiative.

Illustration of ASEG-GDF2 Data Exchange

The importance of the concepts of ASEG-GDF2 are best illustrated by providing a simple example of a file exchange between two different organisations. In general, most line oriented data is stored or is easily exported to an ASCII multi-column file similar to that shown in Fig. 1.

But what do the numbers mean? For this fragment of an aeromagnetic data set, most experienced personnel can decipher approximately 80 percent of the numbers based on the data ranges. However, in this example there are four separate total magnetic fields. Interpretating these fields is guesswork and error prone.

If the file is small, the sending organisation might add some column names to the beginning of the file to make it easy to decipher and a copy of the documentation from the report he wrote. What if the data format was changed during the project? It often happens that the documentation for the important data is lost or incorrect.

If the file is large the manual addition of a header is impractical with a text editor and in many cases the receiving organisation has to strip out the header before processing. By convention, format and descriptive

```
20440  590010627620.80 3110.00 814721.007238150.00 70.0  54935.61  56635.93  55159.801  54987.96
20440  590010627621.00 3111.00 814730.317238141.00 70.0  54940.83  56635.93  55159.841  54992.29
20440  590010627621.20 3112.00 814739.567238131.50 70.0  54945.31  56635.93  55159.891  54996.15
20440  590010627621.40 3113.00 814748.887238122.00 70.0  54949.28  56635.93  55159.931  54999.69
20440  590010627621.60 3114.00 814758.197238113.00 70.0  54952.91  56635.93  55159.981  55002.93
20440  590010627621.80 3115.00 814767.507238103.50 70.0  54956.28  56635.93  55160.021  55005.81
20440  590010627622.00 3116.00 814776.817238094.00 70.0  54959.25  56635.93  55160.071  55008.42
20440  590010627622.20 3117.00 814786.127238085.00 69.8  54961.96  56635.93  55160.111  55010.78
```

Figure 1. Sample multi-column data file (MAG.DAT)

```
Line FltDate  Time     Fid     Easting   Northing  Alt  Mag-raw   Mag-diurn IGRF      *Mag-corr

20440  590010627620.80 3110.00 814721.007238150.00 70.0  54935.61  56635.93  55159.801  54987.96
20440  590010627621.00 3111.00 814730.317238141.00 70.0  54940.83  56635.93  55159.841  54992.29
20440  590010627621.20 3112.00 814739.567238131.50 70.0  54945.31  56635.93  55159.891  54996.15
20440  590010627621.40 3113.00 814748.887238122.00 70.0  54949.28  56635.93  55159.931  54999.69
20440  590010627621.60 3114.00 814758.197238113.00 70.0  54952.91  56635.93  55159.981  55002.93
20440  590010627621.80 3115.00 814767.507238103.50 70.0  54956.28  56635.93  55160.021  55005.81
20440  590010627622.00 3116.00 814776.817238094.00 70.0  54959.25  56635.93  55160.071  55008.42
20440  590010627622.20 3117.00 814786.127238085.00 69.8  54961.96  56635.93  55160.111  55010.78
```

Figure 2. Column identification added to a data file is often impractical in the processing stream.

information is enclosed in a separate file that is normally written to tape prior to the main data set. This file is either printed or viewed in a text editor and control information is prepared for processing of the main data set. An example of part of an accompanying description file is shown in Figure 3.

```
WILD BOAR - WESTERN AUSTRALIA   AIRBORNE GEOPHYSICAL SURVEY

Job number                      1396
Client                          IRON DUKE MINES N.L.
Survey date                     December 1989 to March 1990
Tape Creation date              7-4-90
Central meridian                117 degrees

SURVEY SPECIFICATIONS

Aircraft                - ROCKWELL SHRIKE COMMANDER 500S
Magnetometer            - SCINTREX V201 Split Beam Cesium Vapour
Resolution              - 0.04 nanoTesla
Cycle Rate              - 0.2 seconds
Sample Interval         - 13 metres (average)
Data Acquisition        - 8 Channel WATANABE MC 6700 Chart Recorder
                        - HEWLETT PACKARD 9000 Series Computer
Traverse Line Spacing   - 200 metres for areas 1
Traverse Line Direction - 000-180 degrees for area 1
Tie Line Spacing        - 2000 metres for area 1
Tie Line Direction      - orthogonal to traverse lines
Survey Height           - 60 metres - mean terrain clearance
Navigation              - SYLEDIS UHF radio positioning system

Lines are not separated by an end of file mark. The end of each
tape is indicated by at least one end of file mark. The end of the
final tape is indicated by at least two end of file marks.

Record length   96 bytes
Block size    9600 bytes

RECORD FORMAT

Format  Undefined  Variable

    I5      99999  line
    I3        999  flight
    I6     999999  date
  F8.2      99999  time
  F8.2      99999  fiducial
 F10.2     999999  easting - metres
 F10.2    9999999  northing - metres
  F5.1        999  radar altitude
 F10.2     999999  raw magnetic intensity
 F10.2      99999  diurnal
 F10.2      99999  igrf
    I1  see below  final magnetic intensity flag
 F10.2     999999  final magnetic intensity

NOTES

Final magnetic intensity corrections:
IGRF model 1985 removed - base value 55200 nanotesla
Diurnal correction applied - base value 56640 nanotesla
System parallax of 1.2 fiducials removed

Data used in processing is flagged as follows:

Recovery flag
  0  not used
  1  used
  2  syledis two range solution
  3  syledis three range solution

Final variable flags
  0  not used
  1  used
```

Figure 3 Example of information that might be found in a description file.

The descriptive information shown in Figure 3 is sufficient to decode the data shown in Figure 1 and provides the geophysicist with documentation of the physical significance of each of the channels. In fact this represents the dominant practice within the industry at the present time.

However, without a standard for data exchange the following things can and do go wrong:

- Physical units for channels are undefined
- Tape data structure is undefined or incorrect
- Documentation is only on paper
- Paper documentation gets lost
- Paper documentation does not match the data
- No digital documentation included with data
- Digital documentation does not match the data
- Operator misinterprets channel descriptions and loads wrong data
- Receiving organisation cannot strip header information from data

Convoluted record structure.

ASEG-GDF2 provides a convenient method of providing standard documentation while conforming with current industry practice.

By way of example, the aeromagnetic data discussed above would be exchanged using three files:

- Structured data format definition (DEFN)
- Descriptive information (COMM)
- Geophysical data set (DATA)

- **Data format definitions** provides an automatic procedure for decoding of the geophysical data and allows the DATA records to be automatically separated from the descriptive information (COMM).
- **Descriptive information** is encapsulated in COMM type records that easily separate free form text from the consistently structured DATA records.
- **Geophysical data sets** can be stored in exactly the same blocked structure that is in common use today. The standard allows for one unnamed record type

```
DEFN   ST=RECD,RT=COMM;RT:A4;COMMENTS:A76
DEFN 1 ST=RECD,RT=;FLTLINE:I5;FLIGHT:I3;DATE:I6;TIME:F8.2;FIDUCIAL:F8.2
DEFN 2 ST=RECD,RT=;AMGEAST:F10.2;AMGNORTH:F10.2
DEFN 3 ST=RECD,RT=;ALTITUDE:F5.1;TMAGRAW:F10.2;TMAGDIUR:F10.2;TMAGIGRF:F10.2
DEFN 4 ST=RECD,RT=;FMAGFLAG:I1;TMAGCORR:F10.2;END DEFN
```

Figure 4 Example of ASEG-GDF2 DEFN structure file. (MAG.DFN)

for simple data exchanges such as aeromagnetic data. Where complex data sets are exchanged with more than one type of data, then different record identifications are used.

Figure 4 shows a sample DEFN file.

For the purpose of this example, the sample DEFN file in Figure 4 has been kept simple. However, it is possible to include full descriptions, physical unit definitions and null value assignments for each channel that is described in the DEFN file. The first line of the DEFN file defines the FORTRAN format of the "COMM" comment records. The second line of the DEFN file contains the first of four lines that define a null record type that is identified by "RT=". This allows us to transfer the data without a record type identifier on each line of the main input data file.

The construction of the DEFN and data records conforms to the Syntax outlined in the original ASEG-GDF standard (Dampney et al 1985, Exploration Geophysics 16, p.123-138) except the strict blocking requirements of the 9 track tape labelling convention has been dropped.

To conform to ASEG-GDF2 in this example, the files corresponding to the file fragments illustrated in Figures 1, 4 and 5 would be copied to the output medium as three discrete files:

- MAG.DFN (ASEG-GDF2 DEFN information)
- MAG.COM (Free form description prefixed by COMM identifier)
- MAG.DAT (Geophysical data)

Since the new standard is now media independent, these files could be copied to diskette, CD-ROM, Exabyte, DAT or 9 track magnetic tape. In the case of magnetic tape, the Unix "tar" format is recommended for exchange.

A full description of the ASEG-GDF2 standard will be prepared for release with the software.

For further information please contact

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```
COMMWILD BOAR - WESTERN AUSTRALIA   AIRBORNE GEOPHYSICAL SURVEY
COMM
COMMJob number                       1396
COMMClient                           IRON DUKE MINES N.L.
        .
        .
        .
        .
        .
COMMIGRF model 1985 removed - base value 55200 nanotesla
COMMDiurnal correction applied - base value 56640 nanotesla
COMMSystem parallax of 1.2 fiducials removed
COMM
COMMData used in processing is flagged as follows:
COMM
COMMRecovery flag
COMM  0  not used
COMM  1  used
COMM  2  syledis two range solution
COMM  3  syledis three range solution
COMM
COMMFinal variable flags
COMM  0  not used
COMM  1  used
```

Figure 5 Free form description from Fig. 3 prefixed by COMM record identifier (MAG.COM).

BILL & TED'S EXCELLENT JOINT VENTURE

.... In our last episode, our intrepid heroes, geophysicist Bill Nerdburger and his brother Ted, geologist, had contracted a severe case of hair loss when their joint venture was badly burned by mystical geophysical data tape formats and poor documentation. The JV seemed no closer to excellence or finding the elusive **BIG ONE**. With pith helmets hiding their hirsute hiatus, our boys headed for Perth and the ASEG conference, where in a bar at the Burswood, they finally cornered their old geophysical data nemesis, Ridgy Didg of Ridgy Digital Anything N.L. Little did they know, this meeting was about to change their lives forever. Now read on .....

Weeell! The boys look pretty happy now! Can you believe the change **ASEG-GDF2** has made in Ridgy Didg? Can **ASEG-GDF2** put an end to Bill and Ted's late nights at the office and chronic hair loss problems, deciphering data tapes? Will their hair grow back and can they do away with those stupid hats? Will **ASEG-GDF2** help their JV find excellence and the **BIG ONE** in time for Bill to snatch Best Paper in Adelaide? Will **ASEG-GDF2** help Ted become President of Nerdburger Mining and should we be buying a few Nerdburger shares now? Will **ASEG-GDF2** become a household word in the world of geophysical housekeeping? Stay tuned for the next exciting episode .....

Seismic Window

With

Rob Kirk
BHP Petroleum

Volcanic Extrusives and Intrusives on Seismic

Four examples of seismic expression of extrusives and intrusives on seismic record are submitted for your consideration.

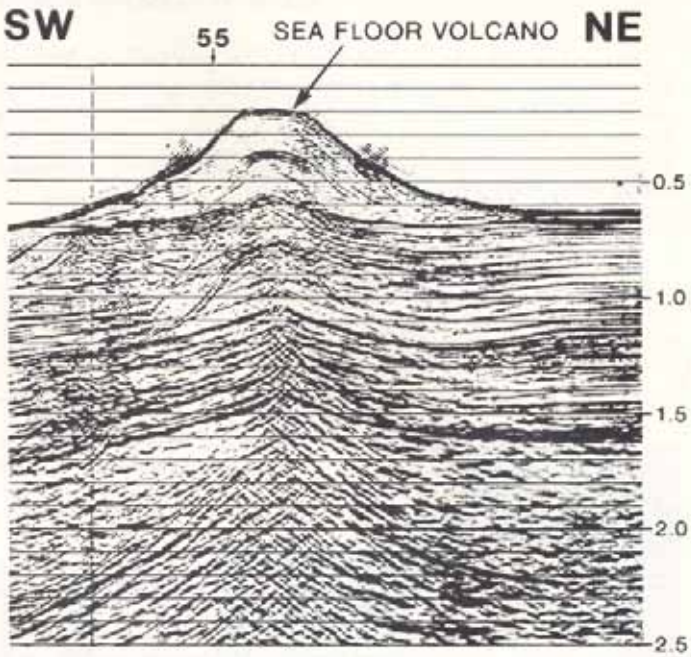


Figure 1. This line shows a volcano extruded out onto the modern Vietnamese sea floor.

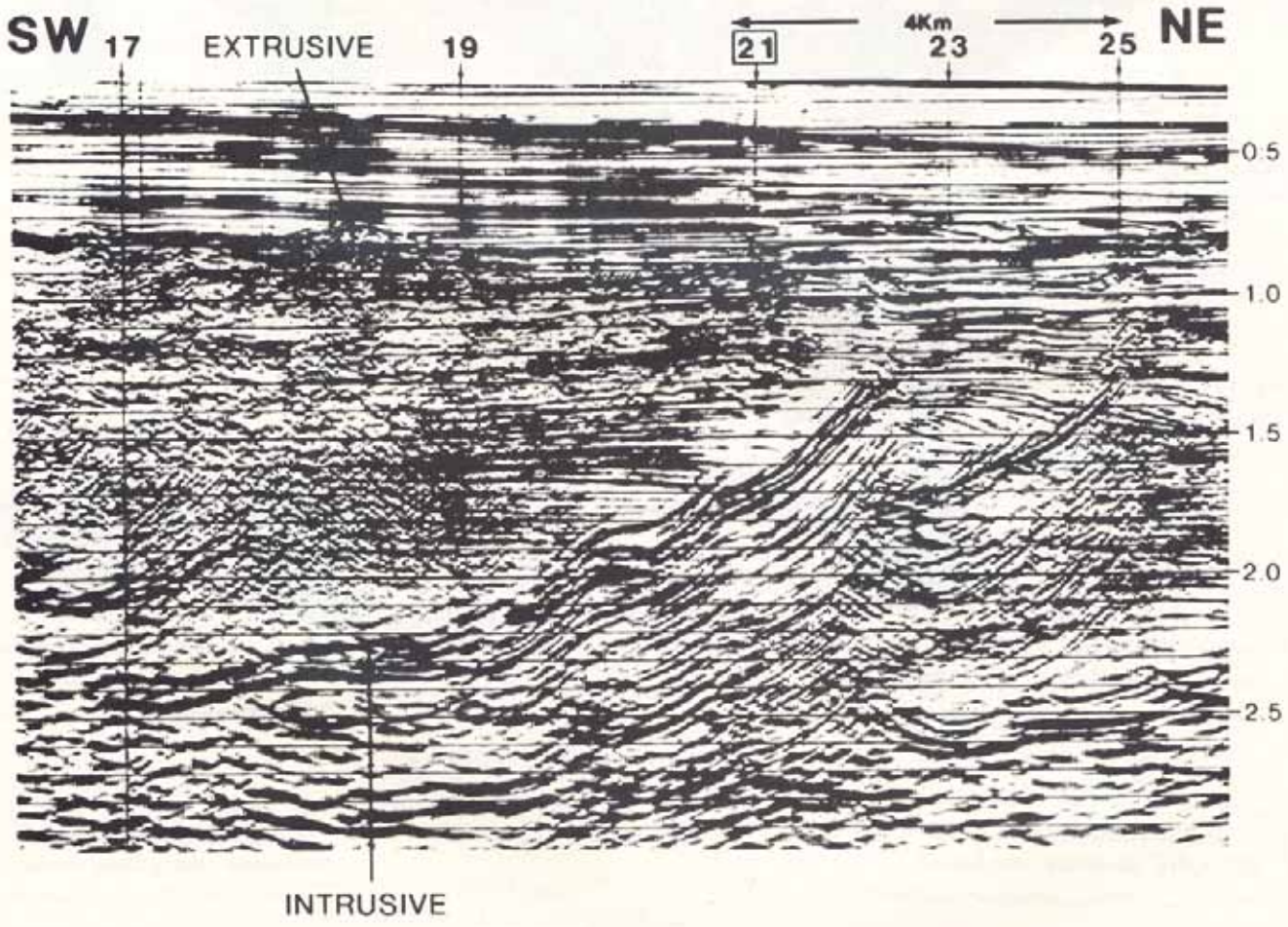


Figure 2. This line shows Tertiary instrusions (and associated noise trains) cross cutting prograding clastics offshore Vietnam. Note also the extrusive mound form in the shallow section.

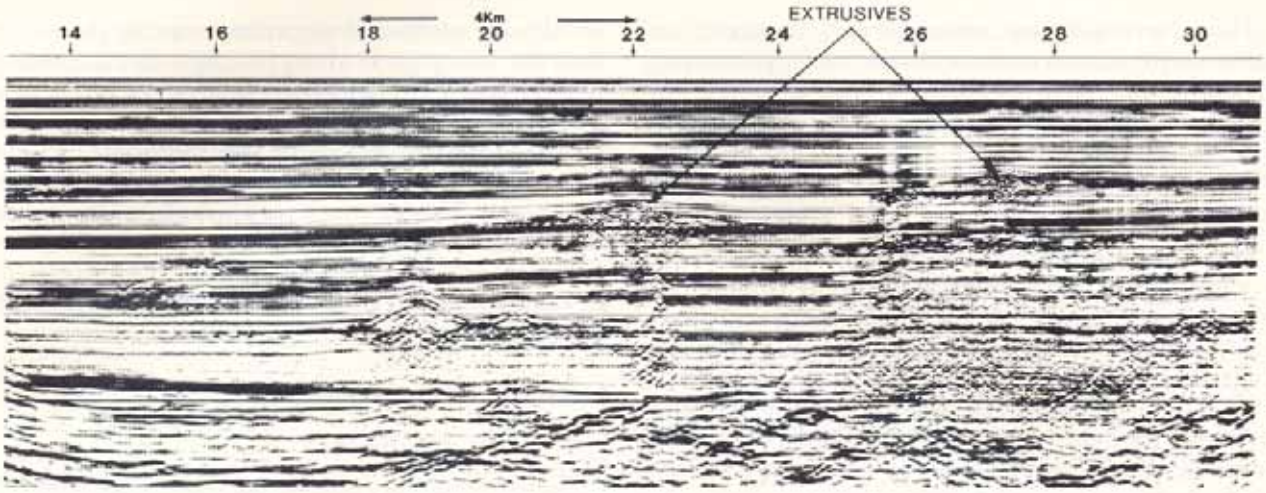


Figure 3. This line shows high frequency detail of extrusive volcanics offshore Vietnam.

Figure 4. This line shows an interesting subtle event A-A'. Part of this reflection cold be interpreted as a flat spot but the correct interpretation is probably an intrusive igneous body.

Next in Seismic Window

Source Rock

ASEG Grahame Sands Award 1994

Stuart Nixon, Richard Kurzeja & David Hayward

Stuart Nixon, Richard Kurzeja and David Hayward, directors of the Perth based software company, Earth Resource Mapping (ERM), are the recipients of the ASEG Grahame Sands award for 1994, in recognition of:-

"Contributions to the development of earth science image processing/data integration and visualization/interpretation software - ER Mapper".

The award, which is given at each ASEG Conference, is for significant contributions to the earth sciences. This is the first occasion that earth science software developers have been recognised for their efforts by the Grahame Sands award.

The ER Mapper software was conceived and developed as a concept on an AMIGA micro-computer, by Stuart Nixon through an AMIRA project, in 1987, which proved the feasibility of the basic concept of a simple image processing system for earth sciences,

L to R: David Hayward, Stuart Nixon and Richard Kurzeja.

particularly the so-called "algorithm" approach. With the formation of Earth Resource Mapping in 1989 in Perth (backed by venture capital from companies such as Sun Microsystems and Hitachi), to commercialise the software on high capacity UNIX workstations, ER Mapper V1.0 was released in 1990. From the outset, software development has been carried out and managed by ERM directors Stuart Nixon, Richard Kurzeja and David Hayward.

They have set new international standards in excellence for earth sciences software development and marketing and have provided a software platform which has application to a whole range of disciplines in the earth sciences and geophysics in the broadest definition of the terms "earth sciences" and "geophysics".

Specifically, from the initial prototype software development in 1988/89 to the current commercial software (version 4.1a), the ER Mapper software has set out to be an industry standard software tool for integration/analysis/interpretation/visualisation of all types of raster and vector data for "geophysical" and earth resource data mapping in any coordinate system and in any data structure, developing imaging software that the industry needed, targeting and responding to the needs of the mining industry (V1.0, June 1990), the oil and gas industry (V3.0, November 1991) and environmental geosciences (V4.0, January 1993).

The commercial ER Mapper software was based initially on Sun UNIX workstations and is now (V4.1+) also operating on Digital, HP and Silicon Graphics UNIX workstations. A PC version operating on Windows NT is to be released in 1994. The rapid growth of the software acceptance has largely been achieved on the Sun platform alone, but with the recent port of the software to these other platforms, phenomenal growth can be expected.

The nomination of the three software developers for the Grahame Sands award cited excellence shown in the following areas:-

1. Technical innovation in the software

Several image processing software innovations designed to de-mystify and make image processing feasible, available and user-friendly to all earth scientists on their desk-top computers have been conceived, often incorporating ideas and advice from industry beta-sites and users. These innovations which have set the standards include:-

- Algorithm pipeline concept - data and processing
- Dynamic compilation
- User code links
- Virtual datasets
- Real world data - byte data and real numbers
- Integration of multiple resolution datasets
- Smooth resampling to display device resolution
- Geo-linked windows
- X-Windows based image processing
- Program forking - multitasking
- Dynamic linking to other commercial software
- Rapid Warping
- Device independent hardcopy software engine

The algorithm concept, as one example of the above innovations, is a notable innovation in image processing whereby the raw dataset is stored once as a binary file and an algorithm which contains all enhancement/processing/windowing details is an ascii processing stream file known as an algorithm file. An infinite number of algorithms can be stored. This idea, like many good ideas, is simple but surprisingly had not been implemented before on large image processing systems. Older systems were thus wasteful in storage, having to store the very large data files (with the enhancements applied) as many times as it was enhanced. The savings in storage made smaller decentralized image processing systems feasible.

2. Technical Excellence in terms of Product Presentation

- User friendliness - ease of use
- Good documentation
- Software stability despite rapid development
- Applications - demonstration/training datasets and manuals

3. Open Standards

- X11 and Unix
- Support for many interchange standards
- 52 raster, 18 vector standards supported and growing
- Open standards booklet published to encourage software linking

4. User Support Initiatives

- On demand continuous updates/bug fixes
- Industry beta-site programs
- E-mail and hardcopy EMU (user group) monthly forum/newsletter

5. Marketing and Business strategies

These include:

- CD Rom promotions (see Preview No. 44, p11)
- CSIRO/ERM joint R&D
- Applications group
- Joint product marketing (eg with Intrepid, ECS, PGW, Hiview)
- Educational licenses in universities

Evidence of the excellence achieved and the widespread earth science industry acceptance of the software is that in just 4 years of commercial operation, ER Mapper has become arguably Australia's most successful earth science export product ever, with currently over 900 software licences operating world-wide. ER Mapper is currently used by approximately 30 mining companies, 40 petroleum companies, 40 Government organisations, 60 universities and 50 software/consultant companies operating in 42 companies throughout the world.

Earth Resource Mapping now has wholly owned subsidiaries in the US and Europe with currently 85 distributor offices world wide. Over 75% of sales are export sales and this figure is growing rapidly.

Due to the innovations introduced by the award recipients, in the ER Mapper software, the learning curve time for an earth science professional or technician to skilfully operate image processing software is now several days rather than weeks or months for the traditional imaging systems. The old "high priest"/centralised approach to image processing has thus been eliminated. Using workstations on networks, a project team can work simultaneously on all or part of data for a project. This promises to revolutionize our work patterns and in particular is an important factor in making geophysical data easily accessible and acceptable to all earth scientists, particularly geologists.

ER Mapper can and is being used for mineral, petroleum, coal, groundwater, engineering, environmental and regional mapping studies using geophysical and other gridded data within our exploration industry. Also it can and is being used for forest, agriculture, oceanographic, meteorological, hydrological, archaeological, topographical, ecological, planetary, defense and remote sensing data analysis, visualization and interpretation.

Most importantly it enables all data from all the above disciplines, whatever the original source, to be fully integrated. This opens up new possibilities for imaginative cross-fertilization and ideas generation amongst the previously isolated earth science disciplines. Tools like ER Mapper will lead to a greater appreciation of each others data by earth science specialists and will help to develop a new breed of broader minded explorationists. ER Mapper is thus rapidly becoming the international earth science and geophysical data system standard for image processing and data integration.

ER Mapper is being used for education purposes in many universities throughout the world. A remote sensing teaching textbook based on ER Mapper is currently being written by William Harbert at the University of Pittsburgh in the US.

In summary the growth of the company set up by Stuart Nixon, Richard Kurzeja and David Hayward: ERM and its product ER Mapper has set new standards internationally, as a role model for development of earth science software products.

These three software developers have taken their own considerable computer programming and commercial skills and have gone out to the exploration and remote sensing industry and provided a data visualization/integration/interpretation tool that the industry has long needed and waited for.

Previous recipients of the Grahame Sands Award have made contributions to specific areas of the earth sciences but it is doubted that any will have as wide an impact as this nomination both technically and commercially.

The ASEG congratulates Stuart Nixon, Richard Kurzeja and David Hayward on the Grahame Sands award and the example they are setting in taking Australian technical innovation to the international earth science community.

Geoff Pettifer and Rod Paterson

Book Review

Gold Metallogeny and Exploration

Edited by R.P.Foster, Chapman and Hall 1993 RRP $67.95

To quote the editor, "this new book represents an attempt to provide a succinct synthesis of all major aspects of gold metallogeny and exploration, ranging from the chemical distribution of gold in the earth's crust, and the hydrothermal chemistry of gold, to Archaean and Phanerozoic lode deposits, epithermal environments, chemical sediments, and placer deposits, and culminates in chapters devoted to geochemical and geophysical exploration and the economics of gold deposits. Each chapter is written by geoscientists who are acknowledged internationally in their respective fields."

By and large the book succeeds, marred only by sloppy proofing and printing errors (As an example the review copy was missing pages 401 to 425, as well as the index). I particularly enjoyed Dick Henley's chapter on Epithermal Gold deposits. Possibly a separate chapter on structure would have been a good idea as structures control the majority of gold deposits, regardless of classification.

The chapter on the geophysical exploration for gold was written by Norm Patterson and the late Phil Hallof. The chapter reflects the authors geographic bias and there is a strong indication that they have little knowledge of the dramatic and revolutionary developments in geophysical exploration that have occurred in Australia in recent years. There is no reference to a number of key papers by authors such as Irvine and Smith (1990), Locke and De Ronde (1987), Allis (1990). There are very few Australian references, and for one of these they misspell the senior authors name (Tennison Woods and Webster 1985).

By far, the most important development in the use of geophysics for gold exploration has been the use of imaging techniques for airborne surveys, yet there is not one mention, or example of this technique, despite the numerous papers published on the topic. Imaged magnetics have proved to be an invaluable tool in mapping regional geology throughout Australia, Canada (Urquhart 1989) and other parts of the world. In Kalgoorlie it has been particularly important in mapping the extent of the Boulder/Lefroy fault. (e.g. Isles, Harman and Cunneen 1988, Spencer, Pridmore and Isles 1989 etc.). The work of Lesley Wyborn and others in mapping potassic alteration using imaged gamma-ray spectrometry at Coronation Hill is a great piece of work that deserves wider publicity.

The use of gravity to detect epithermal alteration (Locke and De Ronde 1987) is also allowed to pass without comment.

Hallof and Patterson recommend the use of airborne magnetics and VLF for regional surveys, followed by CSAMT, EM or IP for detailed surveys. This would certainly be a departure from the normal practice generally followed in this country. Of the seven examples they give, none are from Australia, and none apply to the deeply weathered terrain so familiar to us all.

Recommendation -If you are involved in Gold exploration, this is an important reference and hopefully future editions will correct the deficiencies. If you buy the book, check that you received all the pages and check back copies of "Exploration Geophysics" and other references to fill the gaps in the geophysics section.

David S. Gamble

References:

Allis, R.G. (1990) Geophysical signatures of epithermal systems. *J Geochem. Explor. 36, 339-374*

Irvine, R.J. and Smith, M.J. (1990) Geophysical exploration for epithermal gold deposits. *J Geochem. Explor. 36 375-412*

Isles, D.J. Harman PG and Cuneen JP (1988) Aeromagnetics and the Yilgarn Gold Rush. in *Bicentennial Gold 88*

Locke, C.A. and De Ronde, C.E.J. (1987) Delineation of gold-bearing hydrothermally altered rocks using gravity data - a New Zealand example. *Geoexploration 4, 471-481*

Spencer, G.A, Pridmore, D.F and Isles, D.J (1989) Data Integration of Exploration Data using Colour Space on an Image Processor. *Exploration Geophysics 20, 31-35*

Tennison Woods, K. and Webster, S.S. (1985) Geophysical signature of gold and porphyry copper mineral deposits in the Lachlan Fold Belt, New South Wales. Proc *4th Australian Soc. of Economic Geophysicists Conf., 325-331*

Urquhart, W.E.S (1989) Field Examples of Controls on Magnetite Content *Exploration Geophysics 20, 93-97*

Wyborn, L et al, BMR89 Kakadu - Report Resource Assessment Commission

ASEG Library

The ASEG Library was established in 1993 by the ASEG Federal Executive Committee. It is located upstairs in the library of the Australian Mineral Foundation (AMF), Conyngham Street, Glenside, Adelaide.

Over 500 items were collected in less than one year! They are mostly journals, and we plan to extend this to reports and books.

AMF manages the Library on behalf of the ASEG. ASEG members are welcome to use the Library, but a small fee is charged for borrowing and copying. To borrow an ASEG Library item, simply fax a request to 08-379 4634. The request form is found in the last page of AESIS monthly newsletter or ask Mr Kevin Bond of AMF on 08-379 0444. Current charges for borrowing a book or journal is $4. A photocopy of a journal article is $4 per article plus 25c per page. This covers the copyright fee, postage and handling. When requesting, please add "from the ASEG Library".

Journals

The journals currently held in the ASEG Library are:

Geophysics vol 39 (1974) - vol 58 (1993)

Geophysical Prospecting vol 40 (1992) - vol 42 (1994)

Journal of CSEG (Canadian SEG) vol 7 (1971) - vol 29 (1993)

Butsuri-Tansa (SEG,Japan) vol 37 (1984) - vol 46 (1993)

Acta Geophysica Sinica (Chinese SEG) vol 30 (1987) - vol 36 (1993)

Geophysical Transactions (Hungarian Geophys Soc) vol 30 (1984) - vol 38 (1993)

Journal of Geological Society of India vol 37 (1991) - vol 42 (1993)

Journal of Geodetic Society of Japan vol 22 (1976) - vol 27 (1981)

Journal of Seismological Society of Japan vol 27 (1974) - vol 33 (1980)

The Leading Edge vol 5 (1986) vol 12 (1993)

First Break vol 10 (1992) - vol 12 (1994)

CSEG Recorder vol 18 (1993) vol 19 (1994)

Abstracts of Annual Meeting(Egyptian Geophysical Soc.) 1981 - 1992

Abstracts of Meeting (Geodetic Society of Japan) 1976

Abstracts of Meeting (Japan Seismological Society) 1975 - 1976

Annual Report (Hungarian Geophysical Society) 1984 - 1987

A few odd issues are missing from the above list and a copy of the complete list is available from ASEG in hard copy or as a dBASE IV file at the cost of media and postage.

Copies of contents pages of some of the journals are available from the ASEG for the cost of copying and postage.

Donations -- Donations of books and journals in geophysics are most welcome. All the donations are duly acknowledged on the individual item. Please contact Koya Suto on 03-877 4848.

Geophysics Data Releases

AGSO

Digital Elevation Model From The Granites (NT) Airborne Data

A digital elevation model and contour maps of the Mount Theo and the eastern and southern parts of the Mount Solitaire 1:250 000 Sheet areas from the Granites - Tanami region of the Northern Territory. The DEM combines the latest height data with accurate position information. The basic data were acquired in 1993 on north-south lines flown 90m above the ground and spaced 500m apart.

GPS recorded differentially using two GPS receivers was sampled every 350m (5s).

The same elevation data were calculated every 70m (ls) and the final grid has a 105m (3.5") cell size. Maps at 1:250 000 scale cost $40 for a dyeline or $120 for a transparency and the digital point located and gridded data may be purchased for $1000.

Geophysical Education Package

A set of twelve 35-mm slides in colour and/or black and white have been released to show key geophysical data sets over the Australian continent. The set comprises the following images:

1. Magnetic Anomaly Map of Australia (1993).
2. Magnetic Anomaly Map - Ebagoola 1: 250 000 Sheet area. Coloured image.
3. Magnetic Anomaly Map - Ebagoola 1:250 000 Sheet area - greyscale image.
4. Gravity anomaly map of the Australian region. This image combines Seasat data over the oceans with the Australian land data to produce an image covering 0-60^{0}S x 100-160^{0}E.
5. Gravity anomaly map of Australia (1992). The coloured image was compiled from approximately 600 000 gravity values obtained over the whole continent.
6. Gravity anomaly map of Australia (1992). Same as (5) except using a greyscale imaging technique.

6. Gravity anomaly map of Australia (1992). Same as (5) except using a greyscale imaging technique.

7. Earth's Geomagnetic Field - Total Field (1990). Shows the Total Magnetic Intensity over the whole Earth.

8. Earth's Geomagnetic Field - Declination (1990) shows the declination of the Earth's magnetic field at epoch 1990.

9. Geomagnetic Field in the Australian Region - Declination (1990). Shows the declination of the geomagnetic field in the Australian region, as well as the rate of change of declination.

10. Geomagnetic Field in the Australian Region (1990). Shows six components of the geomagnetic field in the Australian region -F (total magnetic intensity), H (horizontal intensity), I (inclination-dip), X, Y & Z (north, east and vertical intensities), as well as the rate of change of these components.

11. Earthquake Epicentre Map of Australia 1856-1992. Shows all known earthquakes with magnitudes of 4 or greater that are known to have taken place in the Australian region.

12. Earthquake Hazard Map of Australia - 1991. Shows the expected ground acceleration over the Australian continent for 500 year return period.

The complete set of slides can be ordered for $50 - including postage.

For further information contact :
AGSO Sales Centre
GPO Box 378
CANBERRA ACT 2602
AUSTRALIA
Telephone: (06) 249 9519
Facsimile: (06) 249 9982

NT Data Release

The Minister for Mines and Energy Shane Stone recently announced the public release of new data from airborne magnetic and radiometric surveys by the Northern Territory Government.

The data, available from the Northern Territory Department of Mines and Energy is from surveys in the Groote Eylandt, Roper River and Helen Springs/Beetaloo areas, and where carried out by World Geoscience Corporation Ltd.

The aerial surveys provide basic geophysical data which give an indication of the sub-surface geology and thus help to identify possible mineral deposits. Traditional owners have been supplied with copies of contour maps and profile samples which will provide valuable information about the potential in these areas, and illustrate the likely benefits from possible future development.

It is hoped that the information will provide an incentive for traditional owners and explorers to get together and negotiate to their mutual benefit.

With the completion of these surveys, the NT Department of Mines and Energy Geological Survey has provided high quality airborne geophysical data coverage over approximately one quarter of the land portion of the Northern Territory.

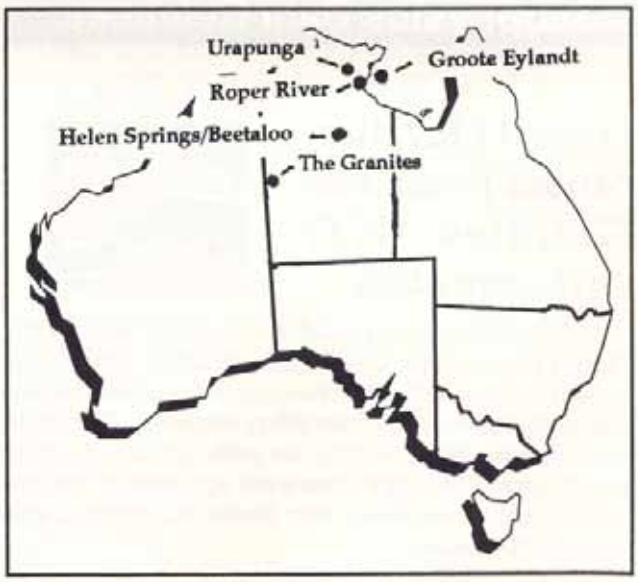
Digital data as well as contour maps and profiles are available on 122 mapsheets and part-mapsheets of scale 1:100,000. All surveys have been flown with a flightline spacing of 500 metres, at an altitude of 100 metres above ground, with only the Granites/Tanami surveys at 90 metres above ground.

In a number of cases, the Northern Territory Geological Survey data has been merged with existing company data, to reduce acquisition costs and optimise coverage.

A new survey, the "Urapunga" survey, has just started, and will cover at least 8 mapsheets at scale 1:100,000 in the Mount Marumba/Urapunga region. Upon completion, practically all of Arnhem land will have high quality data coverage, and the same quality data will also be available over the northern part of the McArthur Basin.

The NT Department of Mines and Energy expects that the high quality data will provide a stimulus for companies to continue forward exploration as well as being a valuable tool for new investors to make informed decisions on the resource potential of the area.

For further information contact:
Vera Porcelli
Department of Mines and Energy
Tel: (089) 89 5286
Fax: (089) 89 5289



Publicise your Data Releases in ASEG Preview
Contact: Geoff Pettifer;
Tel: (03) 412 7840; Fax: (03) 412 7803;
e-mail: grp@mines.vic.gov.au

Membership

New Members

We welcome the following new members to the Society. Their details need to be added to the relevant State Branch database:

Western Australia

Risto PIETILA
Outokumpu Western Australia P/L
1st Floor, Burswood Court
141 Burswood Road
Burswood WA 6100

Bruce HARLEY
156 Empire Avenue
Wembley Downs WA 6000

South Australia

John TESSELAAR
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Andrew CRADDOCK
49 Wattlebury Road
Lower Mitcham SA 5062

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4/4 Cambridge Terrace
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David MILLER
4 Selway Street
Oaklands Park SA 5046

Anna ORANSKAIA
29/201 Anzac Highway
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Queensland

Mark PENNISI
6 Kinbrace Street
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New South Wales

Gela ARUAI
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Ian CAMPBELL
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27 Merriwa Street
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Overseas

Jayson MEYERS
Box 414 - Geology
Uni - NCD
Papua New Guinea

Obituary

Bruce Harley

There will be many Australian geophysicists and geologists very saddened to hear that Bruce Harley has died of cancer after a valiant fight of several months.

Bruce had worked for Billiton Australia since 1980 out of a number of regional offices including Orange, Cairns, Darwin and Perth. At each of these places Bruce, his wife Judy and their 3 children made many friends who will sorely miss him.

After three years in the Australian Navy, he graduated from U.N.S.W. and taught for a few years at Shore and Knox Colleges in Sydney. He later completed an M.Sc at Macquarie University, prior to joining Billiton. Possibly as a result of his time in the Navy, he was an excellent organiser of field work run with an almost military precision.

Bruce brought enthusiasm not only to this geophysical work, but also to his life. He was known as a keen and active sportsman, and led a very happy family life. The sympathy of all Bruce's colleagues and acquaintances around Australia and elsewhere go to Judy, Emma, Sophie and Edward.

Nigel Hungerford

Change of Address

The following changes need to be made to the relevant State Branch database:

New South Wales

Christopher KERNICK
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Stanmore NSW 2048
To: 61 Monteith Street
Turramurra NSW 2074

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Scone NSW 2337
To: Senior Common Room
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University of Sydney 2006

Tully RICHARDS
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Orange NSW 2800

Richard STUKLIS
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Bob COPPIN
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To: 40 Westall Street
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Bob GRAEBNER
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USA
To: P.O. Box 679008-371
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Resignations

Jamie BURGESS
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Edwardstown SA 5039

Andrew McMECHAN
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Balgowlah NSW 2093

Where Are They?

Does anyone know the new address for the following members?

Richard BEARE
Last known address:
Santos Limited
21st Fl, 215 Adelaide Street
Brisbane Qld 4000

Paul FARRELL
Last known address:
PM Farrell & Assoc International P/L
PO Box 197
Sufers Paradise Qld 4217
Bruce FINLAYSON
Last known address:
23 Finlayson Street
Netherby SA 5062

Jaroslaw KICINSKI
Last known address:
7 Cygnet Court
Yangebup WA 6164

Calender of Events

July 8-10 1994

SEG/Chinese Society of Petroleum Geophysicists Int Meeting,
Harbin, Heilongjiang Province PRC
For further details:
T.K. Chao
Exxon Exploration
Box 4778
Houston Tx 77210-4778
USA
Fax: 713-775 7761

July 24-27 1994

EAEG/SEG Summer Research Workshop on Construction of 3D Macro Velocity-Depth Models.,
Congress Centre
Leeuwenhorst in Noordwijkerhout
The Netherlands
For further details:
EAEG Business Office
P.O. Box 298
3700 AG Zeist
The Netherlands
Ph: +31 3404
Fax: +31 3404 62640

August 1-4 1994

Special ASEG Symposium and Field Demostrations Geophysics of the Flying Doctor Deposit,
Broken Hill, NSW
For further details:
Dr E.D. Tyne
Geoterrex Pty Ltd
Ph: (02) 418 8077
Fax: (02) 418 8581 or
Dr J.R. Bishop
Mitre Geophysics Pty Ltd
Ph: (002) 25 4556
Fax: (002) 25 4553

August 14-17 1994

West Australian Basins Symposium
PESA (WA) Branch
For further details:
Jim Durrant
Ph: (09) 299 7175

August 21-24 1994

1994 AAPG International Conference & Exhibition South East Asian Basins: Oil & Gas for the 21st Century.
For further details:
AAPG Conventions Dept
P.O. Box 979
Tulsa OK 74101-0979
USA
Fax: 1-918-584 2274

September 11-15 1994

1st Int'l Airborne Remote Sensing Conference & Exhibition, Strasbourg, France
For further details:
Ph: 313-994 1200 (x 3234)

September 12-17 1994

6th Int'l Symposium on Seismic Reflection Probing of the Continents and their Margins, Budapest Hungary
For further details:
Ph: 303-273 8422

September 20-22 1994

2nd Int'l Science Technical Conference on Marine and Airborne Gravimetry, St Petersburg, Russia
For further details:
Fax: 7-812-312 4128

September 26-30 1994

Geoscience Australia - 1994 & Beyond
12th Australian Geological Convention
Geological Society of Australia
For further details:
The Secretary
12AGG
P.O. Box 119
Cannington WA 6107

October 23-27 1994

SEG 64th Meeting Los Angeles, California, USA
For further details:
SEG
Box 702740
Tulsa, OK 74170-2740
USA
Ph: +918-493 3516
Fax: +918-493 2704

November 21-25 1994

IAH/IEA
Water Down Under 1994
Adelaide SA
For further details:
Congress Manager
Ph: (06) 270 6530