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Preview

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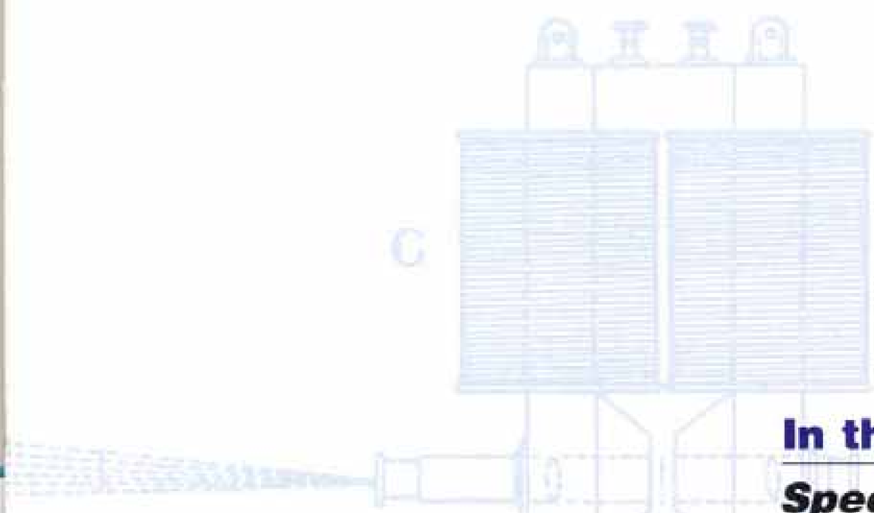
Issue No. 51

I.G.E.S.



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Printed by Jenkin Buxton Printers

Editor's Desk

Our Jubilee Issue has passed not without a few editing and printing gremlins, which humble editors and remind them of their humanity and Murphy's Law. Nevertheless, production of Preview is a stimulating, task for both contributors and at times, tired editor. We trust though the overall context and relevance of Preview is to your liking and worth the effort.

Working towards a more sustainable Preview production and standard we now have, with the ASEG Executive blessing, the makings of a Preview Editorial Board consisting of:

Editor: Geoff Pettifer, Geological Survey of Vic.

Associate Editor (Petroleum): Rob Kirk, BHPP.

Associate Editor (Minerals): Stephen Mudge, RGC

Associate Editor (Environmental, Engineering and Groundwater): Derecke Palmer, University of NSW.

Associate Editor (Academia): to be confirmed.

Business Manager (Advertising & Corporate Sponsors): Andrew Sutherland, Schlumberger

We hope in this way to have regular contributions/ columns (eg like Seismic Window) to cater for all interests. We are also interested in State Branch representatives on the Editorial Board, to scout for news and articles from each state. Any volunteers?

Sadly we farewell Greg Turner as he moves to the west and new adventures in WMC. Greg has been a tower of strength in Preview production. We wish Greg well and thank him for his contribution to ASEG Life. Andrew Sutherland is assuming Greg's mantle. Welcome Andrew!

Despite our best efforts and reduced cost of colour, there is no colour feature this issue and possibly for October. Please consider our offer of the previous Preview Editorial and if interested in sponsoring a colour article with all its attendant benefits, please contact Andrew Sutherland or myself.

Finally, enjoy this issue - two illuminating articles, the first of two on the IGES story with Ken McCracken; and an informative tutorial on Australian Geodetic Coordinate Systems by John Manning and Jim Steed of AUSLIG. Plus SIROTEM, marine shallow reflection in Scandinavia, magnetics non uniqueness and a view on promoting the geosciences make for varied and informative reading. Thankyou to all contributors.

Geoff Pettifer, Editor

Vice President's View

Computing technology has moved into the 90's at a rapid rate and the seismic exploration industry has developed accordingly.

Having been associated with the seismic industry since 1981, I have witnessed the development of acquisition and processing techniques on a world scale and have seen this industry mature in Australia throughout the 80's.

Today Australia acquires and deals with as much 3D seismic data as any other location in the world, relative to the size of our petroleum industry in the global picture. The techniques used to acquire 2D and 3D seismic data in Australia include the latest available anywhere in the world. This is due to the Australian based companies understanding the merit of using such techniques (particularly 3D seismic in exploration), for gaining maximum information to help unravel the complex geological regimes we have in most of the prospective basins around the continent. It is also due to the seismic contractors developing and providing this technology in Australia.

During the past four years some of the largest 3D seismic surveys shot anywhere in the world have been carried out over the Northwest Shelf and Gippsland Basin. This work has substantially contributed to the continued exploration success in these areas and probably just as importantly, has provided employment and exposure for Australian geophysicists.

Australia has seen the import of some of the most advanced computing technology in the world (supercomputers and desktop work stations) as a direct consequence of the seismic exploration industry. I believe this has not only benefited the geophysicists who are lucky enough to use such technology for seismic processing or interpretation, but Australia in general.

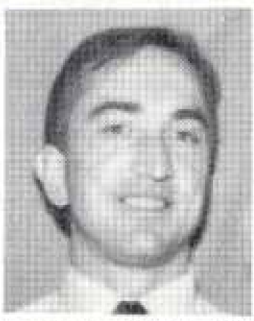
The seismic industry in Australia has grown up rapidly in the 80's and stands tall today with expertise and techniques equal to any other exploration industry or location in the world.

I believe seismic geophysics will continue to be associated with the leading edge of computing technology into the next century and will continue to develop and produce applications and techniques that will reduce the risk in oil and gas exploration. Judging from what has occurred during the last decade and where we are today, Australia's seismic industry will be associated with and benefit from such developments well into the next decade.

The Australian geophysical community and particularly the seismic community should be proud of the work and very high standards that have been achieved and I believe Australian geophysicists are and will continue to contribute much to future developments in the seismic technique.

Rob Singh, Second Vice President

Executive Brief



Just the one Executive meeting since the last edition of Preview. Below is a summary of the main discussion items.

- Lindsay Thomas presented a draft 1994 budget for comment. This is the first complete budget since the Executive's move to Melbourne, an indication of the learning curve required to get a true idea of the income and expenditure for a "typical" year and to have experienced at least one Conference. It is intended that a budget and appropriate documentation on handover to the next Executive will greatly reduce this learning curve.
- Seven new member applications, including one for corporate membership, were received.
- Arrangements for the Adelaide Conference were progressing well. Sponsors are sought.
- Hugh Rutter will be representing the ASEG at the October SEG Conference in Los Angeles. This is a great opportunity to have some input to the SEG and make people more aware of the activities (publishing in particular) and even the existence of the ASEG. Membership numbers allow us three section representatives on the SEG Council and other ASEG members who may be attending the Conference are being approached.

Greg Turner has resigned from the Executive to take up a position with Western Mining. Greg and Vicki are off to the sun, sand and, er, more sand of Kalgoorlie, WA. The Executive Committee thanks Greg for his considerable effort and commitment over the last two and a half years and wishes him all the best with his new career. Greg has made a significant contribution as ASEG Business Manager, bringing in new advertisers and sponsors, and, through the introduction of colour spreads in particular, helping to make Preview a high quality publication.

Andrew Sutherland is the new ASEG Business Manager and all inquiries regarding advertising in Preview and Exploration Geophysics should be directed to him. Andrew will be assisted by the Secretariat, Janine Cross.

It follows that we are now short one position on the Executive Committee. If any Melbourne-based member is prepared to invest around 8 to 10 hours per month of their time in the service of Australian geophysics, please contact any member of the Executive Committee, a few of whom are listed on page 4.

Brenton Oke, Secretary

ASEG 11th Geophysical Conference And Exhibition

The ASEG 11th Geophysical Conference and Exhibition will be held in Adelaide, South Australia from the 3rd to 6th of September 1995. The conference will be held at the Convention Centre, with the exhibition in the adjoining Exhibition Hall.

The theme of the 1995 conference is

INCREASING THE RESOURCE

REDUCING THE RISK

The theme was a popular choice as all of us are in this business to satisfy both these criteria, irrespective if, as a geophysicist, you herald from minerals, petroleum, academia, or the emerging field of the environment. All facets of our daily work are concerned with INCREASING THE RESOURCE, by maximising our business opportunities ie exploring for and finding that ore body/oil field, better quantifying and exploiting that resource, defining environmental issues and aiding in their solution, the better training of graduates, and providing a fertile background for research.

Also, and equally important, our careers are geared to quantifying risk, and minimising it. It is only possible to minimise risk, be it technical, managerial or commercial, if the risk is understood. Clearly this defines the second theme of REDUCING THE RISK.

The call for papers has been distributed, and we hope for an enthusiastic response.

The last conference in Perth was recognised as a world class minerals geophysics conference, and it is our intention to continue this tradition. We hope to match the calibre of the minerals papers with the petroleum section. To implement this we propose a special session dealing with successful hydrocarbon exploration/development in SA/NT (see insert opposite), in addition to the general petroleum geophysical papers. This petroleum forum follows the format of the successful Mt Isa Symposium and the Geophysical Signatures of WA Mineral Deposits Symposium, from the last two ASEG conferences.

There will also be a series of high calibre pre- and post conference workshops, and high profile key-note speakers.

There will be more detail on these and other matters in the following issues of Preview.

We hope that the conference will be as successful as the previous conferences, and we wish to invite one and all to participate in this prestigious geophysical event.

Craig Gumley And David Tucker
Co-Chairmen
ASEG 11th Conference Committee

Special Session on Geophysics in Successful Hydrocarbon Exploration and Development in South Australia and the Northern Territory

A north-south transect through the centre of the Australian continent reveals a fabulous variety of proven petroliferous basins. Basin ages include Precambrian, Palaeozoic, Mesozoic and Cenozoic. Tectonic settings include active margin, intracratonic and passive margin, and the exploration stages of these basins range from mature production licences to unexplored basins. A Special Session on "Geophysics in Successful Hydrocarbon Exploration and Development in South Australia and the Northern Territory" at the ASEG 11th Geophysical Conference and Exhibition aims to act as a focus for case study papers which will illustrate the successful application of petroleum geophysical techniques throughout this continental transect.

Papers covering both the range of current petroleum geophysical techniques, and the geographic/geologic variety of the Australian continental transect are sought.

Papers addressing the following topics will be particularly welcome:

3D seismic acquisition, processing and interpretation, 4D developmental monitoring, tomography, shear wave applications, multiple attenuation, DHIs, AVO, VSP, depth conversion and migration, novel seismic acquisition, processing and interpretation techniques, traditional geophysical log evaluation, modern logging tools such as the detailed electrical and sonic hole imagers, deviated well geosteering, fracture detection, and modern electrical/electromagnetic and aeromagnetic methods in hydrocarbon exploration.

Papers should detail applications of petroleum geophysical techniques in SA and NT basins such as the:

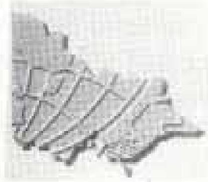
Vulcan, Bonaparte, McArthur, Georgina, Amadeus, Officer, Cooper-Eromanga, Otway and Bight.

It is anticipated that most papers will be case studies, as these will be of the greatest interest to the wider geophysical community, and that papers will fit the "Success" theme, be it defined economically or technically.

Papers for the Special Session will be considered along with the normal conference papers, so submit your synopses marked "Special Session on Geophysics in Successful Hydrocarbon Exploration and Development in South Australia and the Northern Territory" in triplicate by 1 November 1994. If you have any enquiries about the Special Session, please contact Richard Hillis, Department of Geology and Geophysics, University of Adelaide, SA 5005 (Fax: 08 303 4347; Tel: 08 303 5377).

ASEG Branch News

Victoria



The Victoria Branch is now back to something like normal operations with regular meetings scheduled for the Kelvin Club (normally on the 3rd Tuesday of each month - subject to confirmation by newsletter).

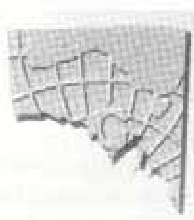
Our first speaker for 1994 was John Peacock from Geoterrex in Sydney. John was able to avoid the temptation to sell any of his high quality services or advanced survey equipment. Instead he spoke as an enthusiast for the emerging (or dominant) role for GPS in survey control. Apart from basic hardware options John was able to educate us all concerning the benefits of alternative software for data reduction and error estimates.

Providing a bonus for the period Alastair Brown was the guest of honour for a joint ASEG and GSA meeting conducted at Melbourne University. Alastair spoke on the concepts and advantages of 3-D seismic interpretation. He indicated that 3-D data are now obtained as a matter of routine in all significant mature fields with costs comparable to the drilling of a single well. Alastair was questioned enthusiastically on price comparisons and cost benefit analyses as well as possible extensions to hard rock exploration.

As a reminder for companies and students I would advise all interested parties that postgraduate projects for 1995 are now being compiled for circulation in VIEPS (Latrobe, Melbourne, Monash Universities). Companies may wish to offer good Hons/MSc projects (hopefully with some financial support) and benefit from data and access to prospective employees.

Jim Cull, President

South Australia



As predicted in the last issue of Preview, the SA Branch has been a hive of activity. In the past month or so we have been privileged to have two highly regarded international speakers. on the 28th June, Tom Davis from the Colorado School of Mines (CSM) gave a presentation on Advances in 3-D Seismic Technology for Horizontal Drilling Applications. Specifically, he presented some results of work being done at the CSM involving 3 Dimensional and 3 Component seismic. They have been having considerable success using this technology to delineate subsurface fracture patterns in their study area and hence improving the success rate of horizontal wells. Thankyou Tom for a most interesting and informative presentation. The 2nd of the international identities was Bill Galloway from the University of Texas at Austin on the 27th July. A large gathering of some 45-50 (including some PESA members) were present to hear Bill outline some unconventional theories on the geological properties of Submarine Canyons. Submarine Canyons are generally large geological features that make the Grand Canyon look small! A highlight was Bill making the geophysicists amongst us feel comfortable with geological concepts by showing a selection of 'creatively interpreted' seismic sections to illustrate his theories. Thankyou to Bill and the National Centre for Petroleum Geology and Geophysics for organising Bill's presentation.

Our latest venue for meetings appears to be an improvement on venues used in the recent past; hopefully this will continue to be the case.There are meetings and annual events planned right up until Christmas so the 1/2 year ahead looks like being as busy as the past few months. The next meeting is the much awaited Nostalgia evening in late August. Flyers will be sent out shortly with all the relevant details.

On a more negative note, the annual Students Barbecue outlined in the last issue of Preview appears in doubt due to a lack of funds. The SA Branch committee was disappointed that our application to the federal ASEG Promotions Committee for funding assistance was rejected. Promoting Geophysics to students who are considering geophysics as a career is a sound means of ensuring a viable geophysics industry and hence a viable ASEG. What better way could Promotions Committee funds be used?

Grant Asser, Secretary

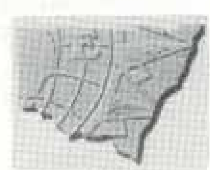
ACT

The ACT Branch of ASEG has still been relatively inactive over the last few months, due either to work commitments of the members of the executive to organise meetings, or the persistant string of sub-zero evening temperatures in the Canberra region which may have driven the executive into hibernation for the winter.

An AGM is planned in the next few weeks (depending on whether temperatures warm up) and another meeting is planned on the 5th October with the guest speaker being Dr Alex Mendecki of ISSI with a seminar on mine seismology and rock mechanics in deep South African gold mines. The seminar will be highly relevant in light of the recent Moura coalmine disaster.

Kevin Wake-Dyster, Secretary

New South Wales



Following the very memorable end of year dinner in 1993, ASEG NSW decided on a change of pace, and doubled the fun with a winter solstice celebration in July. The occassion was organised to perfection by our past president Nigel Jones, it was a sellout night, and everybody enjoyed the evening. Nigel Brown won the prize for the competition concerning the name of the restaurant, the Strilytzia, thereby also ensuring that any comments would be repeatable.

The August meeting was a standing room only affair with an address by Dave Robson, the new Chief Geophysicist at the NSW Geological Survey, on his first hundred days and Discovery 2000. It was likely that the budget of $40 million over 6 years was a factor in the sighting of certain members for the first time in ages!

Derecke Palmer, President

Preview Deadlines

Issue	Deadline
October 1994	September 30 1994
December 1994	November 25 1994
February 1995	January 27 1995
April 1995	March 31 1995
June 1995	May 26 1995

Preview - Next Issue

- *Mentor: Robert Sheriff*
- *Imperial Geophysical Experimental Survey Story Continues - Technical Aspects*
- *Seismic Window - Source Rock*
- *New Mineral Geophysics Column*
- *1994 Membership Listing Booklet*

ASEG People Profile

Lindsay Ingall Honorary Member

Lindsay graduated with a B.Sc. degree in Geology and Physics from Sydney University in 1947. He was keen to get into operational geophysics, joined the Zinc Corporation in Broken Hill and spent 18 months working with the Oscar Weiss South African team which was carrying out regional magnetic, gravity and electrical surveys for the Broken Hill mining companies.

Lindsay developed a desire for more action and joined the BMR late in 1949 with the objective of getting down to the Sub-Antarctic. Before this happed he was assigned to help Ted McCarthy with the pendulum gravity survey of Australia using the Cambridge pendulums. The survey took 18 months and on completion Lindsay set off in February 1952 for a 12 month stay on Heard Island. The work involved operating the magnetic and seismological observatories. High velocity winds and blizzards often made life difficult.

Shortly after returning to Australia in 1953, Lindsay decided to go to Canada and he joined the Canadian Gulf Oil Company in 1954. He carried out seismic and gravity surveys across Canada from Quebec to the Northwest Territories. The most challenging time was spent in the Canadian Arctic, where Lindsay pioneered geophysical exploration for his company. Two seasons of helicopter gravity were followed by a season of seismic.

Eventually Lindsay was promoted to field supervisor, found the action dull and returned to Australia in 1962. He formed a company called Wongela Geophysical which is still active. Wongela is highly experienced in gravity exploration for oil, coal, oil shale and base metals. It is also responsible for a large proportion of the regional helicopter gravity coverage of Australia. This work was done for the BMR and the yearly contract was won 9 times between 1964 and 1974.

Lindsay was always keen on helicopters and he teamed up with a pilot and engineer to set up a helicopter company in 1963. The principals purchased a small Hughes helicopter and took it to the South Simpson desert to fulfil a helicopter gravity contract for the French Petroleum Company of Australia.

More helicopters were purchased, the company expanded and a good time was had by all, even with the occasional unplanned landing.

Lindsay carried out overseas assistance work for ADAB in Thailand in 1977 and the Asian Development Bank in South Korea and Sri Lanka in 1979-1980.

Lindsay ws on the original committee set up to establish the ASEG in 1971 and was President in 1971/72 and 1978/79. He was made an Honorary Member in 1988 and is currently Chairman of the Honours and Awards Committee.

In 1981 the AIG was formed and Lindsay was on the original committee. He was President in 1989/90 and is currently Treasurer.

The Imperial Geophysical Experimental Survey - Revisited

Ken McCracken
Jellore Technologies Mittagong

Introduction

Exploration geophysics started in Australia in 1929 with the conduct of the "Imperial Geophysical Experimental Survey" (IGES), that cost $10 million over two years, in 1994 buying power. For a long time after, the report of the Survey ("The Principles and Practice of Geophysical Prospecting", by A.B. Broughton Edge and T.H. Laby) was a definitive text book on exploration geophysics.

Having been asked to prepare an article on the IGES, I found out that there are 4 metres of archival material on the IGES in Canberra. I therefore spent a very happy day in the archives, learning much more about the who, how, what, and why of the survey. Much of this is, I suspect, unknown to the present generation of Australian Geophysicists.

The first article, then, is about the genesis of the IGES. The next article will be the survey program itself, and how it compares to present day practice.

The Beginnings

The early 1920's were a time of success in geophysical prospecting. The discovery of the Boliden ore bodies in Sweden using electrical methods, and major discoveries of oil in Texas using gravity gradiometers, generated great commercial interest. As a result, a number of geophysical companies were established, principally in Germany, France, and the US.

Starting about 1923-4, the agents of those companies made repeated representation to the Federal and State governments that their instruments/services should be immediately used in Australia. Sir Humphry Applebee of "Yes Minister" would have admired the obfuscation that followed. The main burden of the replies was simple - the methods have not been proven in Australia, and we are very suspicious.

The correspondence involved even the Prime Minister of the day, Stanley Bruce, and he referred it to his son-in-law, who happened to be in charge of establishing the newly created CSIR - the fore-runner of CSIRO of today.

Among the technical people, of course, there was considerable interest. Thus the archival material contains a copy of a lecture on "Scientific Prospecting" by Mr William Aplin given in Mt Morgan in May, 1926. Those with a knowledge of the history of our industry, will recall that the Mt Morgan gold mine had been the creation of a mining entrepreneur, William Knox D'Arcy. Moving to London in the 1890's, D'Arcy became a major player in the Anglo-Persian Oil Company - later to become British Petroleum. By the 1920's, Anglo-Persian was actively experimenting with geophysics - and their associates at Mt Morgan and elsewhere in Australia were clearly aware of this. Their influence continued strongly throughout the planning period for the IGES.

In the 1920's, the British and Australian governments had mutually complementary problems. Britain had too many people; Australia not enough. Two boards were set up - the "Overseas Settlements Committee" (British) and the "Development and Migration Commission" (Australia). The chairman of the latter was one of the most famous Australian mining technocrats of all time - Herbert W Gipps.

In 1907, he was the mining engineer who built and commissioned the first flotation plant at Broken Hill that turned millions of tonnes of worthless mullock into a high grade Zn resource. Here was a man of science, practical, successful, and with the ear of both industry and governments.

Gipps was travelling to London in 1926 on Development and Migration business. He was briefed by CSIR regarding the "geophysical problem". Gipps consulted influential people who gave support to the concept of an experimental geophysical survey - the chairman of Anglo-Persian who volunteered their assistance; several chairmen of important Australian mines; and a pre-eminent academic geologist and antarctic explorer; Sir Edgeworth David. Also, Gipps saw a draft copy of a "feasibility study" of geophysics in Australia, prepared by A.S. Fitzpatrick at the request of CSIR. The case was technically sound, and supported by influential people.

I.G.E.S.
Fig. 104. Torsion balance in the field showing metal hut

The torsion balance was the main gravity instrument

And so, on 15th January 1927, Gipps wrote from the "Otranto, at sea between London and Gibraltar", proposing an experimental survey to be funded 50/50 by Australia and Britain. He indicated that the PM of Australia had agreed to find £25,000. Gipps further stated "I will make myself personally responsible for the efficient conduct of the (survey), and will not allow it to proceed any further than is wise".

By May 1927 the IGES had been initiated. Each government contributed £16,000, yielding a total purchasing power equivalent to A$10 million today. For those days - that was big money. It shows what having a PM's son-in-law; the leading technocrat of the day; and a few mining company heavies can do for you when the political environment is favourable.

Planning The Survey

A planning committee met in London six times in April and May, 1927, and rapidly agreed on the scope of the experimental program, and it's management. It was decided that gravity gradiometry, magnetics, electrical and EM methods, and seismic would be the technical areas of interest.

Reading the record it is clear that there were no Australian candidates for the senior positions. Sir Edgeworth David of the University of Sydney suggested that A.B. Broughton-Edge, who had achieved some success in electrical geophysics in Rhodesia, should address the committee regarding his work. Clearly he made a good impression; within 6 weeks he had been offered the position of Director of Survey.

The Fitzpatrick feasibility study had clearly recognised the manner in which the conductive overburden would compromise the high frequency EM of the 1920's. Resistivities of several ohm metres were mentioned; the need for long skin depths was correctly identified. The committee therefore recognised the need for "a very good EM research man", and approached McGill University (Montreal).

The professor of the time volunteered to come himself. He was well known as a psychotic - some would say unstable - and the committee deftly avoided the problem by replying that "a 65 year old could not be expected to work in the high temperatures of the Australian deserts". He therefore nominated E S Beiler, who became Deputy Director of the Survey.

The full staff of the Survey are listed below. Note the names - two (J. Rayner and N. Fisher) became Directors of the BMR - one (L.A. Richardson) established Australia's first, and very successful geophysical contracting company, and one (J.L. Pawsey) became the "father" of Australian radar and radioastronomy. It was a very competent and influential group of people.

One year after his arrival in Australia, the Deputy Director of the Survey, Dr E S Beiler, died suddenly in Western Australia. This created a major staffing problem, that was solved by the old expedient of dragooning a member of the Executive Committee to do the job. The lucky volunteer was the Professor of Physics at the University of Melbourne, Prof. T. H. Laby.

IMPERIAL GEOPHYSICAL EXPERIMENTAL SURVEY

Director A. B. Broughton Edge, B.Sc., A.R.S.M., M.Inst.M.M.
Deputy-Director E. S. Bieler[a], M.Sc., Ph.D. (Cantab.).
Field Secretary W. H. Scott[b], later M. A. Elliott[c].

ELECTRICAL SECTIONS

No. 1

Leader J. C. Ferguson, B.Sc.
Field Assistants L. A. Richardson, Assoc.I.S.
R. F. Thyer[d].

No. 2

Leader S. H. Shaw, B.Sc., A.R.S.M., Assoc.Inst.M.M.
Field Assistants I. W. Morley[e], B.M.E., B.Met.E., Assoc.Inst.M.M.
J. R. Harper[f], B.E.E.

GRAVIMETRIC SECTION

Leader N. B. Lewis, B.Sc., D.Phil. (Oxon.).
Field Assistants A. J. Moore, B.C.E.
E. L. Blazey, B.E.E.

SEISMIC SECTION

Leader R. L. Aston[g], B.Sc., B.E., M.Sc. (Cantab.), A.M.I.E. (Aust.).
Field Assistants[h] N. H. Hill[i], B.Sc.

Consultant Seismic Section E. H. Booth, M.C., B.Sc., F.Inst.P.

ATTACHED TO SURVEY

J. McG. Bruckshaw[k], M.Sc. For the Department of Scientific and Industrial Research, London.
J. M. Rayner[l], B.Sc. For the Department of Mines, New South Wales.

TEMPORARY ASSISTANTS (one month or less)

E. W. Gregory, B.Sc., J. L. Pawsey, B.Sc., N. H. Fisher, D. M. Sutherland.

[a] Died in Australia 25. 7. 29. [b] Resigned 16. 10. 29. [c] Appointed 30. 9. 29.
[d] Appointed 17. 6. 29. [e] Served 14. 1. 29 until 31. 3. 29 and 1. 6. 29 until 15. 2. 30.
[f] Appointed 30. 10. 29. [g] Appointed 16. 1. 29. [h] Assistants provided by other sections as required.
[i] Served 27. 1. 29 until 8. 3. 29. [k] Attached 1. 1. 29. [l] Attached 21. 1. 29.

Staff of the Imperial Geophysical Experimental Survey

He went on to be co-editor of the final report, and his physics, and teaching skills are clearly evident in the result.

Finally, to indicate the differences between then and now, I quote from the description of the electrical survey team as requested by the Director of the Survey.

"The following is the full establishment - one well trained field geologist, with a knowledge of mining engineering and physics; he must also have equally good hearing in both ears; an intelligent youth as an assistant to move about the small metallic rods connected with the field telephone; three surveyors; three boys for driving in wooden pegs, and one good motor mechanic to run the dynamo and look after the electrical cable".

Next Issue

.... The IGES story continues with technical details of the survey, in the language of today.....

SA ASEG Student Night

Life as a Geophysicist

On the 11th May 1994 the ASEG SA branch and the Student Geoscience Society at Flinders University presented a student information evening at the School of Earth Sciences, Flinders University. The aim of the evening was to give students a feel for the work and lifestyle of a professional geophysicist, and to promote geophysics as a viable career choice to University students from earth science and/or maths/physics disciplines.

Wendy Watkins (SANTOS), Craig Gumley (SANTOS) and Terry Crabb (MESA) revealed, to an attentive audience, their views on choosing geophysics as a career direction, their experience in the industry, and the applicability of their University education. The speakers represented varying levels of experience, from recent graduate through to 10 and 20 plus years respectively.

Thirty Adelaide University students and ASEG members took advantages of a bus laid on between the Adelaide and Flinders campuses. About 80 students and 15 ASEG members in all attended the enlightening presentations, and then enjoyed an informal but energetic discussion over a drink and BBQ dinner.

Our thanks to MESA for sponsoring this very successful evening which we hope will benefit academia and industry alike. We believe such events further the society's aims of promoting geophysics. Thanks also to the honours geophysics students at Flinders University, especially Geraldine Teakle and Sam Bierbaum, for arranging the drinks and BBQ. We hope to find the funds to repeat the event in future years.

Kim Chatfield & Richard Hillis
Student Liaison, ASEG SA Branch

Viewpoint

The Invisible Geosciences!

Derecke Palmer
University of New SouthWales

A recurring theme at the recent ASEG Conference & Exhibition in Perth (see Preview No 50, p 41) was the low visibility and poor image of the earth sciences in general, and of geophysics in particular. I believe that our profession, along with other earth scientists must draw a very clear distinction with the earth resource industries and then market the unique features of the earth sciences.

The approach adopted by the mining industry has been to sell itself. AMIC, for example, has tried a little emotional blackmail with the "exploding house" TV advertisement, which, although quite factual, seems to be strong on the negatives of paranoia, self pity, and "the world owes the mining industry a living" approach. In addition, their School Links Program was essentially an "us and them" approach, whereby students were encouraged to develop school projects involving nearby mines, so that they became empathetic with the mining cause. I also have difficulty with this approach, because selling mining with a hole in the ground is similar to selling farming with a school project at an abattoir!

Other mining based groups have instituted essay competitions with topics which are heavily biased towards the party line, with topics such as "Why mining is essential to Australia." This approach is preaching to the converted, it is pushing a narrow theme, it appeals to a literate minority, and it has about as much media impact as the telephone directory.

> *......selling mining with a hole in the ground is similar to selling farming with an abattoir.....*

Furthermore, the mining industry has won very little public support (at least on the east coast!) with its perceived intransigence over the recent Mabo legislation.

I am left with an image which is strong on the negatives and the hard sell, and which definitely does not create any nice warm feelings! Although the mining industry has an excellent record on environmental issues, contribution to the nation's economy, etc it would appear that the message is not getting through and that the current approach has been less than efficacious. This situation has a direct impact on the geoscientific professions, because we are associated with that industry, and because it drives talented students away from university courses and from our professions. Our industry has a very dim future unless we can obtain our fair share talented graduates on a regular basis.

The first step is the recognition that students, like the rest of the public, are consumers, and simply must be approached from a marketing perspective. This means that we must discover their concerns and interests and address them. In particular, we must pay some attention to the widespread concerns about the environment, global warming, the ozone layer, etc, and be strong on the positives. Emotional blackmail results in students voting with their feet!

The second step recognises the fact that most geoscientists came into the profession through indirect means. It is amazing that a substantial proportion of our members went to university to become chemists, physicists, engineers, and other professions, and simply took first year geology as a fourth subject. It is especially difficult to change this pattern and obtain any commitment by new students to the earth sciences prior to undertaking first year geology because of peer, teacher, parental and community attitudes, and any attempt only turns them away. Furthermore, few high school students have had much exposure to geology, and they are not as comfortable with geology as with the traditional subjects.

Accordingly, the approach might be to promote first year geology as a subject which has relevance to many professions. Just as the vast majority of first year university students in maths, physics and chemistry do not become members of those professions, so first year geology could be promoted as a basic prerequisite for a wide range of professions including environmental studies, geography, land use planning, the biological sciences, surveying, mining, petroleum and civil engineering, architecture, agriculture, investment analysis, risk assessment, tourism, as well as geology, geochemistry and geophysics. How many mining companies would prefer to employ accountants or computer programmers who have a little understanding of the earth sciences through having completed first year geology?

One year of the earth sciences at the undergraduate level will do more to produce a balanced perspective than any other approach, and a fee paying student, whether for one or more years, is a very cost effective method of marketing the earth sciences! Accordingly, we need to ensure that suitable advertisements are included in every careers feature in the newspapers. These usually occur around mid-year.

However, it is critical to make the first year courses enjoyable, and to try to communicate some of the enthusiasm that most earth scientists have for their profession. To some extent this would promote geology as an attractive lifestyle subject. Rather than yesterday's approach of requiring students to recognise twenty minerals, fifteen rocks and a dozen fossils, which are forgotten within a short time of completing the appropriate examination, the emphasis should be on the big picture of plate tectonics, mid ocean ridges, the major processes at work in Australia, and other similar exciting concepts which will give them a new/perspective of the earth. The theme might be **"See the World with Geology!"** If nothing else, they should become geologically literate tourists. However, it could also encourage many to stay on for a second year, in anticipation of another great year of learning about the Earth! The aim is to make them geologically aware rather than geologically competent, which takes almost as much time in field experience as the full undergraduate course.

We need a smart bumper sticker. Are there any improvements on "Geoscientists See The World!" This can be conveniently corrupted at a later date to "Geoscientists See (Save) The World! or even "Geophysicists See (Shake) The World!" (At least refraction seismologists do!)

We need more brochures which are oriented towards a tourist - Sunday drive market, such as the flora and fauna brochures that are widely available. How many coach tours which do the daily trip to the Blue Mountains have any idea of the geological setting of

......We need a small bumper sticker. Any improvements on .... "Geoscientists See the World!"......

some of the most spectacular scenery around Sydney? We need more members of our profession to be available for any activity which presents our science. While careers nights are the most obvious, there are many others. Last year, I ran an eight week after school course called "Let's Rock!" for gifted and talented primary school pupils. The emphasis was on the enjoyment of geology, and their response was great!

We need more topical teaching material that communicates the excitement and the technology of our profession. The gravity and aeromagnetic images of Australia, recently released by AGSO, are stunning. A suitable brochure explaining their geological significance for high school students, geographers, soil scientists, school teachers, etc by either Dave Tucker or Peter Gunn, would make the package a must for almost every school in the country!

In summary, our approach should be to emphasise the positives, to make a clear differentiation between the earth sciences and mining, to promote the life style idealistic aspects, and most importantly, to ensure that the students enjoy the subject! It would result in increased numbers of university student who eventually realised that the "rape and pillage" image of the mining industry is a caricature, and that the earth sciences and mining are everything positive that the hard sell has only had limited success in spreading! Most importantly, it would ensure a healthy future for our profession and our industry.

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Preview Tutorial Series

Geodetic Coordinate Systems In Australia

John Manning
Manager

Jim Steed
Project Manager

Geodesy
Australian Surveying and Land Information Group (AUSLIG)

Introduction

Geophysical and geological fieldwork in Australia usually requires a geographic infrastructure for the collation and best use of the data. Geophysicists may have come across potentially confusing acronyms and names in relation to positioning and mapping, including: Clarke spheroid, ANG, AGD, WGS84, AMG, UTM and AHD. What do they all mean? In addition Australia is currently working to introduce a new geodetic reference frame which is directly compatible with satellite positioning. To provide readers with a background to this change, a brief explanation and history of co-ordinate systems in Australia is presented, together with definitions, and a description of the steps currently being taken to make the integration of geographic data across Australia simpler and more effective.

In the past and today, large sums of money were and are being spent to collect geographically related data across Australia; which was recorded in a variety of ways. However modern computer techniques have now made it possible to efficiently collect large volumes of data quickly. This information can, however be worthless if it cannot be correctly archived, related in position to earlier data, and cross referenced for future use.

Geographical co-ordinate systems are fundamentally used to pinpoint the location of data, making it possible to compare data collected independently or at different epochs. Unfortunately there have been many different reference systems used in the past for recording geographically related data, making the final integration a difficult task; and the individual data sets less usable.

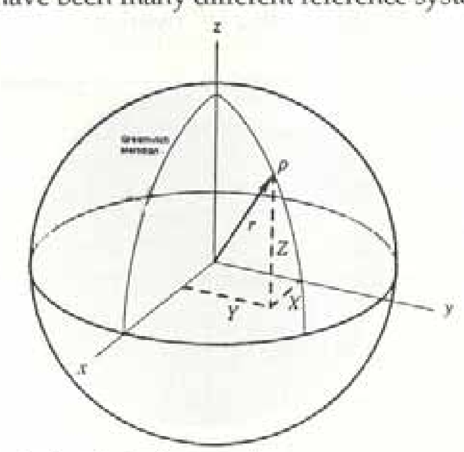

Figure 1 - Earth-centred reference system

Explanation of terms

Reference System

Most space-based positioning techniques provide coordinates in terms of an earth-centred reference system. This is a 3-dimensional Cartesian co-ordinate system which may be used to uniquely identify any location relative to the earth's centre of mass, as shown in Figure 1. The accuracy with which such a reference system can be defined has improved remarkably in recent years, and although refinement continues, any further development is unlikely to affect the average user.

- The origin is the earth's centre of mass.
- The positive arm of the Z axis passes along the instantaneous axis of rotation of the earth, towards the northern hemisphere.
- The positive arm of the X axis passes through the Greenwich meridian and is at right angles to the Z axis
- The positive arm of the Y axis is at right angles to both the Z and X axes so that they form a right handed system.
- Rotations about the axes are defined as positive if they are anti-clockwise when viewed from the positive end of the axis, looking towards the origin.
- X Y and Z do not correspond to latitude, longitude and height.

Ellipsoid

The earth's shape is best represented by an equipotential surface known as the geoid. However this surface is not regular and is best represented by an ellipsoid (also referred to as a spheroid). An ellipsoid is a 3-dimensional figure, formed by rotating an ellipse, which closely represents the shape of the earth. Its size and shape is usually defined by the semi major axis (the a radius), and the semi-minor axis (the b radius) as shown in Figure 2. The flattening (f) is the relationship between the semi-major and semi-minor axes of the ellipsoid:

$$b/a = 1 - f \qquad (1)$$

$$b = a(1-f) \qquad (2)$$

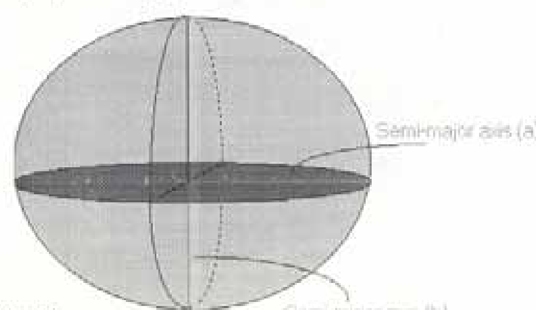

Figure 2 - Ellipsoid

Geodetic Datums

An ellipsoid may be chosen to best fit the whole earth, or only a region of it. The set of parameters that describe the relationship between a particular ellipsoid and a global geodetic reference system is called a geodetic datum (Figure 3).

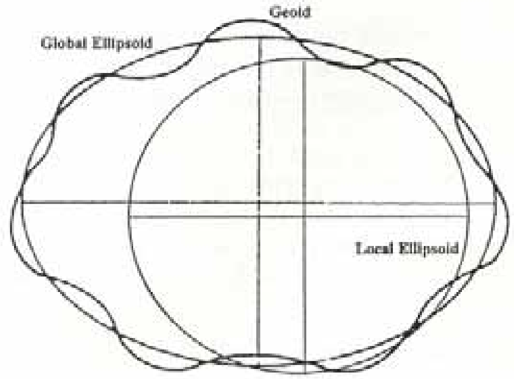

Figure 3 - Relationship between local and global datums

A geodetic datum is usually defined by a set of at least three parameters:

- The ellipsoid semi-major axis
- The ellipsoid flattening
- The offset of the local ellipsoid origin, with respect to the earth's centre, in terms of the X, Y and Z axes.

  This is usually achieved with:

- The position of an origin station, and an orientation (azimuth and deflections of the vertical), or
- The position of a number of origin stations.
- Ideally the centre of the ellipsoid should coincide with the centre of the earth's mass and the axis of the ellipsoid should be parallel with the conventional terrestrial reference system (CTRS). However, in the past, this was rarely achieved or even intended. Datums were usually chosen to provide a best geometric fit to the area of interest, meaning that the centre of the ellipsoid did not coincide with the earth's centre.

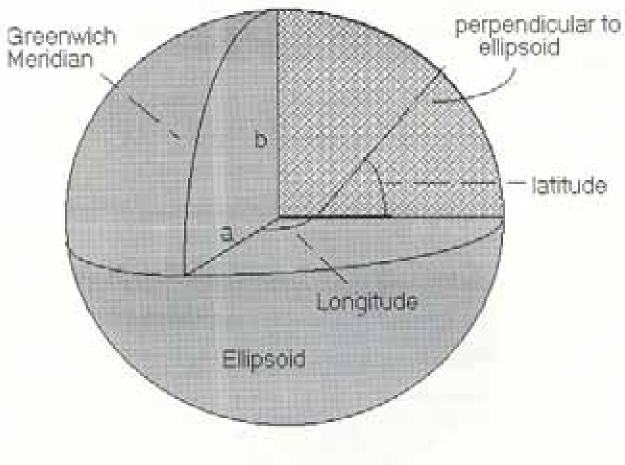

Figure 4 - Geographical Coordinates

Geographical Co-ordinates

Once a datum has been established positions may be expressed in terms of latitude, longitude and ellipsoidal height with respect to the chosen ellipsoid (Figure 4). It is therefore possible for a position on the earth's surface to have different geographic coordinates (latitude, longitude and ellipsoidal height) depending on which datum is being used.

Where available, Cartesian coordinates for a reference system (X Y Z) may be converted to latitude, longitude and ellipsoidal height. This conversion is a simple mathematical process and can be found in standard Geodesy textbooks such as Geophysical Geodesy by Kurt Lambeck. Note that the height is relative to the ellipsoid and may differ from the conventionally adopted mean sea level height by many metres (see the later section on heights).

Grid Coordinates

Working with latitudes and longitudes on an ellipsoid is sometimes too complex, so these positions are often converted to grid coordinates (eastings and northings). These grid coordinates are a 2-dimensional projection of latitude and longitude onto a flat surface. There is is a relatively simple mathematical conversion between latitudes and longitudes and eastings and northings; it does not involve a change of datums.

There are many types of projections, each with its own advantages and disadvantages, but one commonly used in Australia is the Transverse Mercator projection, as illustrated in Figure 5.

This projection is obtained by mathematically fitting a tangential cylinder about the ellipsoid and projecting each position, as seen from the centre of the ellipsoid, onto the cylinder, which can then be opened into a flat surface. To minimise distortions these projections are divided into zones, each zone centred on the meridian which is in contact with the cylinder. Therefore to uniquely define a position, it is imperative that the zone number is supplied with grid coordinates.

When this projection is used with internationally adopted zone designations and other parameters, it is known as the Universal Transverse Mercator projection (UTM). The Universal Transverse Mercator projection has the following characteristics:

- Zones are 6^0 wide, with a $½^0$ overlap.

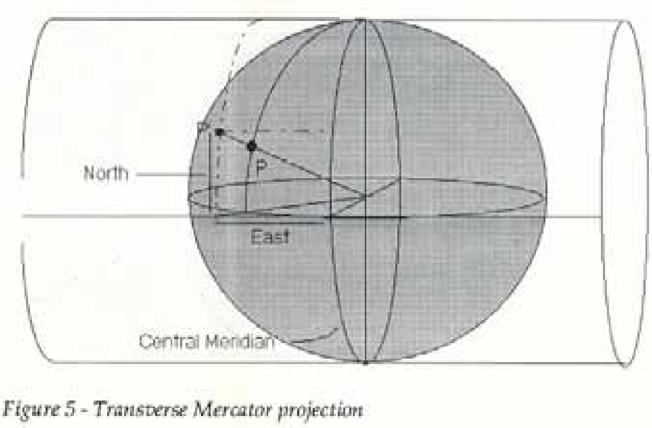

Figure 5 - Transverse Mercator projection

- Coordinates are in metres, north and east of the origin (or false origin).
- A central meridian scale factor of 0.9996 is used to minimise the distortion at the zone edges.
- The origin for each zone is the intersection of the equator and the central meridian.
- In the southern hemisphere a false origin is used so that all coordinates are positive. This false origin is 10,000,000 metres south, and 500,000 metres west, of the zone origin.

The central north-south grid line of each zone (the central meridian) has an easting value of 500,000 metres and plots on the projection as a straight line, while other north-south grid lines plot as lines which converge towards the pole. Lines of constant latitude plot as curved lines bending about the central meridian.

Latitudes and longitudes are converted to UTM grid coordinates (and reverse) using Redfearn's formulae and the adopted ellipsoid parameters.

Summary of relationships

A position may be represented as Cartesian coordinates (X Y Z) which are relative to a 3-dimensional reference system. Once a suitable ellipsoid has been chosen and positioned relative to the reference system (a datum), these coordinates may be converted to latitude, longitude and ellipsoidal height. These geographical coordinates may in turn be converted to grid coordinates (easting, northing and zone) on a chosen projection. If different datums or projections are used, different geographic and grid coordinates will be obtained for the same site.

Coordinate systems used in Australia

Clarke 1858 ellipsoid

In Australia prior to 1966, there were some twenty different datums using four different ellipsoids.The ellipsoid used for most national mapping coverage was the Clarke 1858 ellipsoid, which is described by the semi-major axis and the flattening:

semi-major axis (a) = 20 926 348 Clarke feet

Flattening (f) = 1/294.26

A Clarke foot is known to be 0.3047 9726 5425 metres, hence the semi-major axis converts to 6 378 293.645 metres. However most surveys were computed from baselines measured in British feet, where a British foot of 1926 is 0.3047 9947. This means that latitudes and longitudes computed from these baselines are actually in terms of an ellipsoid described by:

semi-major axis (a) = 20 926 348 British feet

= 6 975 449.333 yards

= 6 378 339.78 metres

Flattening (f) = 1/294.26

Although the Clarke 1858 ellipsoid was used, the different origins used meant that there were actually a number of different datums. The most important origins used include:

Sydney Observatory:-
S33°51'41.10" E151°12'17.85"

Perth Observatory 1899: -
S31°57'09.63" E115°50'26.10"

Darwin Origin Pillar: -
S12°28'08.452" E130°50'19.802"

A comparison of coordinates, based on the Sydney and Perth origins would show on average a difference of about 10 seconds in longitude (about 300 metres). This is mainly due to the difference between the deflection of the vertical at these two sites.

Some 1:250,000 scale maps were based only on astronomical observations with an accuracy of the order of 100 metres or more, or by a mixture of astro and conventional surveying. A comparison of map coordinates based on different origins of this kind could give differences of hundreds of metres due to errors from: the astronomical observation, the deflections of the vertical, the surveying techniques used to transfer the astronomic position and the map compilation process.

The Australian National Grid

When latitudes and longitudes in terms of the Clarke 1858 ellipsoid were converted to Transverse Mercator grid coordinates they were known as Australian National Grid coordinates (ANG). The parameters used with the ANG were:

Ellipsoid	=	Clarke 1858
Central scale factor	=	1.0 exactly
False Easting	=	400 000 yards
False Northing	=	4 915 813.467 yards
Zone Width	=	5 degrees

Initial Central meridian = 116 degrees East longitude.

With these parameters the ANG northing became negative in Tasmania. Therefore, to maintain positive coordinates, 1,000,000 yards was usually added to the ANG northings in the Tasmanian region.

Because they are a direct conversion of the Clarke 1858 latitudes and longitudes, these grid coordinates have the same problems caused by the different origins used. These ANG coordinates are often referred to as Clarke coordinates because of the ellipsoid used.

The Australian Geodetic Datum

The Australian Geodetic Datum (AGD) was developed as a unique datum for Australia. It was proclaimed in the Australian Commonwealth Gazette of 6 October 1966 and included the parameters of the local ellipsoid known as the Australian National Spheroid (ANS) and the position of the origin point, Johnston Geodetic Station :

Latitude S 25°56′ 54.5515″

Longitude E133° 12′ 30.0771″

Ellipsoidal height 571.2 metres

Australian National Spheroid

Semi-major axis (a) 6 378 160.0 metres

Flattening (f) 1/298.25

Australian Geodetic Datum 1966

The adjustment of the Australian geodetic survey network was completed in March 1966 using the Australian Geodetic Datum.

The set of geographic coordinates (latitudes and longitudes) produced by this adjustment was known as the Australian Geodetic Datum 1966 co-ordinate set (AGD66) and was rapidly adopted by state and federal authorities.

The grid coordinates derived from a Universal Transverse Mercator projection of the AGD66 coordinates, therefore using the Australian National Spheroid, is known as the Australian Map Grid 1966 (AMG66) co-ordinate set.

Australian Geodetic Datum 1984

In 1982 a new national adjustment, referred to as the Geodetic Model of Australia 1982 (GMA82), was performed using all the data previously included in the 1966 adjustment, as well as additional, modern conventional and space-based observations. The datum used for this readjustment was identical to that used in 1966, but because of the improved observations and adjustment techniques these two co-ordinate sets differ by about 2 metres in south east Australia, and up to about 5 metres in the north west. This difference is not regular and it is not able to be modelled over the whole of Australia. The difference between AGD66 and AGD84 was not noticeable on maps at 1:250,000 and 1:100,000 scale which continued to be based on the AGD66 coordinate set.

The latitudes and longitudes resulting from this adjustment were accepted by the National Mapping Council (NMC) in 1984 and are now known as the Australian Geodetic Datum 1984 co-ordinate set (AGD84). When converted to Universal Transverse Mercator grid co-ordinates, projected from the Australian National Spheroid, the coordinate set is known as the Australian Map Grid 1984 (AMG84).

Western Australia, South Australia and Queensland mapping authorities chose to immediately adopt AGD84, while the other states continued to use AGD66. This has resulted in a mixture of coordinate sets with relatively small, but potentially confusing differences.

The World Geodetic System

From time to time the International Association of Geodesy adopts a geocentric reference system which is a best fit for the whole earth, based on the latest information. The reference system adopted in 1980 is known as the Geodetic Reference System 1980 (GRS80) and was used by the US Defense Mapping Agency (DMA) as the basis for the World Geodetic System 1984 (WGS84). It is this system that is used for positions from the Global Positioning System (GPS). Because WGS84 is earth-centred, and AGD is offset from the earth's centre of mass, positions in these two systems differ by about 200 metres and about 5 seconds of latitude and longitude.

Previous versions of global reference systems (WGS72) were used in the early days of GPS, and the Transit Doppler positioning system which was in use prior to GPS used still other global reference systems (e.g. NWL9D and NSWC9Z2). Although slightly different, these systems all differ from the AGD by about 200 metres.

Transformation between co-ordinate systems

By the late 1980s GPS was becoming a popular means of positioning for both experts and non-experts. Although many GPS receievers and software give the option to convert the WGS84 positions to a local datum, some users are not aware of the need to do so, or are confused by the various methods available.

Geophysicists using data acquired using GPS positioning may wish to consider requesting both WGS84 and AMG coordinates in their digital located data files from contractors.

It should be noted that a transformation is required to move from one datum to another (e.g. WGS84 to AGD84). Changing from one coordinate type to another on the same datum (e.g. AGD66 to AMG66) is a mathematical conversion, not a transformation.

There are three common methods of transforming between co-ordinate systems:

- Apply a "block shift" in latitude longitude and height, or easting and northing, determined from one or more sites which have coordinates in both systems. This block shift may be determined from a single common site, or be interpolated from a number of common sites. The accuracy of this method is dependant on the accuracy of the coordinates in both systems and how representative they. This method is the best available when dealing with pre-1966 coordinates. It is also frequently used with the AGD66 co-ordinate set, when working over large areas.
- Molodensky's formulae were publshed by the US DMA in its report on the World Geodetic System 1984. These formulae are effectively a form of origin shift which also incorporates the differences in the two ellipsoids used. Included in DMA's report are parameters for use with the Molodensky formulae to transform from AGD66 and AGD84 to WGS84. However because these parameters are based on a average shift derived from Transit Doppler positions, the resulting transformation has an accuracy of about 5 metres horizontally and 10 to 20 metres vertically.
- Provided the two co-ordinate systems each have a consistent scale, orientation and origin

(homogeneous), sites which have positions known in both systems can be used to compute parameters for a 3-dimensional similarity transformation (three origin shifts, three rotations and a scale change). Such parameters are available to transform between AGD84 and WGS84 across Australia (the Higgins parameters of 1987) and also between AGD66 and WGS84 within NSW. Coordinates transformed with these parameters have an estimated accuracy of a couple of metres.

The Australian Height Datum (1971)

On 5 May 1971 the Division of National carried out a simultaneous adjustment of 97,230 kilometres of two-way optical levelling throughout Australia. Mean sea level for the period 1966-1969 from thirty tide gauges around the Australian continent was held fixed at zero height and the resulting computed surface, with minor modifications in two metropolitan areas, was termed the Australian Height Datum (AHD). At its 29th meeting in May 1971 the National Mapping Council adopted the AHD as the datum to which all vertical control for mapping was to be referred. This height datum continues to be used as the reference for all heights in Australia

Heighting by GPS

Mean sea level, on which the AHD is based, is a very close approximation of the equipotential surface known as the geoid. However this surface differs substantially from the WGS84 ellipsoid to which GPS heights refer (from -35 metres in south west Australia to +70 metres in northern Queensland). The difference between these two surfaces is known as the geoid-ellipsoid separation or N value, and is relative to a specific ellipsoid. Extreme care must be taken to ensure that the N value used is in terms of the correct datum.

$$H = h - N \qquad (3)$$

Where H = height above the geoid (the MSL or AHD value)

h = height above the ellipsoid (the height obtained from GPS)

N = Geoid-ellipsoid separation (N value)

More accurate results can be obtained from GPS by using differential techniques. Equation (3) then becomes:

$$\text{Diff } H = \text{diff } h - \text{diff } N \qquad (4)$$

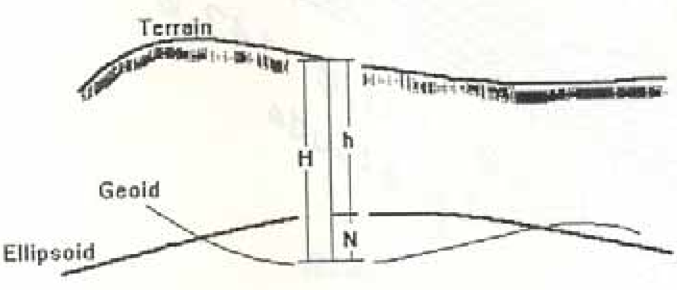

Figure 6 - The geoid-ellipsoid separation

If the geoid is above the ellipsoid, N is positive. If the geoid is below the ellipsoid, N is negative

There are a number of ways of determining the N value:

(1) Use astro-geodetic observations. This method is slow and expensive and is no longer used.

(2) Compare AHD and ellipsoidal heights at surrounding sites and then interpolate. This needs good absolute ellipsoidal heights and well determined MSL values and assumes that both are error free.

(3) Compute from a global geopotential model (e.g. OSU91). A geopotential model is a set of coefficients used with spherical harmonics to represent the geoid surface over the entire earth. They are generally derived from terrestrial gravity and satellite altimeter data and are available in some GPS software packages. They have an absolute accuracy of the order of a metre.

(4) Compute using a global geopotential model, refined with local gravity observations. This requires sophisticated software and observed local gravity data. The absolute accuracy may be well under 1 metre and the relative accuracy may be of the order of a few parts per million (mm per kilometre).

(5) Interpolate from a grid of N values generated by any of the above methods. This is fast and can be automated. The accuracy depends on the grid size and the nature of the geoid in the area.

AUSLIG has computed a grid of accurate N values for the Australian region, using method (4) above. This grid, which is known AUSGEOID93 (see Figure 7), is the second in a series of national geoids. Others will be produced as improved data and models become available. AUSLIG has also developed an interpolation software package known as Winter, for use with the AUSGEOID93 data set.

AUSGEOID93 consists of a 10′ by 10′ grid (approximately 20 km) of geoid ellipsoid separations in terms of the WGS84 ellipsoid. These values, which are suitable for use with the Global Positioning System (GPS), were computed using:

- The OSU91 global geopotential coefficients, produced by Professor Richard Rapp, Ohio State University, USA.
- The 1980 Australian Gravity data base from the Australian Geological Survey Organisation.
- Techniques and software developed by Dr A.H.W. Kearsley, Associate Professor University of NSW. This software was converted and enhanced by AUSLIG, to run on a Personal Computer.

The major advantage of the AUSGEOID93 data lies in its relative accuracy which has been estimated as between 2 and 5 parts per million (2-5 mm per km) by Dr Kearsley in 1988. Subsequent tests have supported this estimate. In fact using these N values in conjunction with GPS observations has frequently achieved 3rd order optical levelling results at a fraction of the cost and time. GPS results stored as latitude longitude and ellipsoidal height may be reduced to the AHD using AUSGEOID93 or its future upgrades.

The Geocentric Datum of Australia

Space Geodesy methods have developed significantly in the last twenty five years using reference points external to the terrestrial system. Before these space geodesy techniques were available, reference frames were defined by regional geodetic systems of continental or national coverage whose origins did not necessarily coincide with each other or the centre of mass of the earth.

The reference frame used for satellite systems is earth centred and to optimise the potential benefits, most users needs to work in the same (geocentric) system. A geocentric datum uses the geocentre, the earth's centre of mass, as the origin of the reference frame together with appropriate scale and orientation parameters. In Australia the Australian National Spheroid was selected as a local best fit geometric figure across Australia and was not specifically related to the centre of mass or consequently directly compatible with the dynamic reference frame of artificial satellites.

In October 1984 the National Mapping Council, recognising the need for Australia to eventually convert to a geocentric datum, resolved to adopt the AGD84 co-ordinate set as the first step in that process. It noted that a universal reference figure for the earth had not yet emerged and again the Australian National Spheroid was used as the reference ellipsoid to establish the AGD84 co-ordinate set as the new basis for the geodetic infrastructure of Australia. Some states moved to the new co-ordinate set whilst others remained on AGD66.

In 1987 the Intergovernmental Committee on Surveying and Mapping had recognised the increasing use being made of satellite positioning systems and the ongoing development of global reference frames. It recommended that Australia adopt a Geocentric datum for surveying and mapping by the year 2000 and resolved that members could use their discretion in the timing of the conversion process.

In 1991 the Intergovernmental Committee on Surveying and Mapping (as successor to the National Mapping Council) set up a Geodesy working group. One of the problems to be addressed was the diverging use of datums and different co-ordinate sets being used across Australia AGD66, AGD84, WGS72, WGS84. At the time NSW were also requiring to move from AGD66 to a new coordinate system more accurate than AGD84.

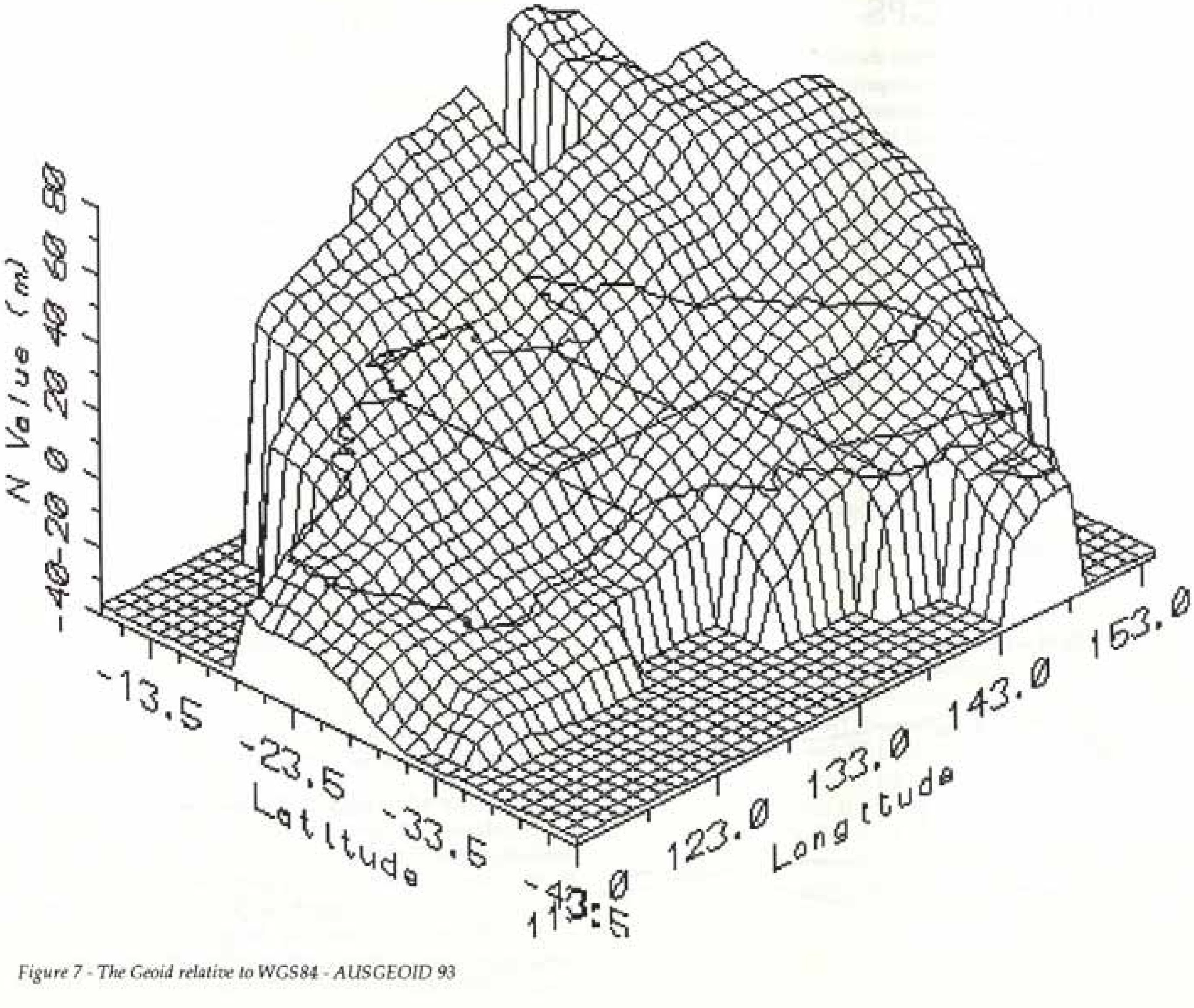

Figure 7 - The Geoid relative to WGS84 - AUSGEOID 93

The Global use of Geocentric Coordinates

The arguments for and against the adoption of a geocentric datum for national applications have been documented by Karl Breteger in the Australian Surveyor in 1991 but the world is seen to be inevitably moving to geocentric datums.

A global geocentric datum is already supported by a growing number of world wide organisations. America, Europe and some Asian countries have already moved to a geocentric datum. The UN Regional Cartographic Conference for the Asia -Pacific has passed a resolution for all countries in the region to use a geocentric datum for surveying and mapping This will eventually provide a world wide benefit by having the same reference system for all geographic information applications.

In 1990 the International Surveying body, FIG, recommended that its members promote and support the adoption and use of a global geocentric reference system proposed by the International Association of Geodesy (ITRF). In 1991 the fifty six member maritime nations of the International Hydrographic Organisation resolved that all future navigation charts would be based on the world geodetic system, and the Hydrographer RAN is progressively converting all paper and electronic charts in Australian waters to the WGS84 datum. The Australian Defence mapping agency RASVY, is also now converting all topographic information to a geocentric datum in line with an overall decision by Department of Defence. The International aviation organisation ICAO have now decided that all aviation charts will be in terms of a geocentric datum from 1997.

The introduction and application of the national geocentric datum to state land information administration is the responsibility of the individual state agencies.

The Australian Fiducial Network

The Australian Fiducial Network (AFN) of permanent, on line, GPS stations (Figure 8) is being established by the Australian Surveying and Land Information Group (AUSLIG). It will provide the national framework and the link to global reference

Figure 8 - The Australian Fiducial Network (AFN): permanent, on-line regional GPS station

frames. Each station will consists of a Rogue GPS receiver observing 30 second epoch data for precision Geodesy and a second receiver which gathers one second data for national integrity monitoring purposes. The network has been extended to a regional network to meet integrity monitoring requirements of other federal departments.

From a geodetic network viewpoint, the AFN has been densified within Australia with the GPS survey of a nominal 500 Km network, the Australian National Network (ANN), by the Intergovernmental Committee on Surveying and Mapping. This network includes connections to the array of high precision tides gauges operated by the National Tidal Facility to investigate sea level rise.

The AFN and ANN geodetic positions are currently being computed in the ITRF92 system. These coordinates will be within one metre of the WGS84 positions and will be known as the Geocentric Datum of Australia (GDA). The UTM projection of these coordinates will be known as the Map Grid of Australia coordinate set (MGA). The reference for heights will not change - it will remain as the Australian Height Datum. Fixed values of these sites will be used by state jurisdictions when they needed to enhance and readjust their networks using GPS. This will ultimately bring all state and federal networks on to the one datum to provide the maximum benefit to the Australian geographic information user community.

This co-ordinated dataset will then be held fixed for non scientific applications whilst the scientific movement of the Australian Plate will be monitored by periodic recomputation of the position of the AFN sites. The Australian plate can be expected to generally move about 2 metres in 20 years with little internal differential movement.

Real time differential GPS systems (DGPS) are available for navigation applications, and for accurate survey purposes GPS is used in a differential mode with post processing. For both these applications the correct coordinates of the base station and the reference frame in use needs to be known for computation of the unknown positions. Data from the AFN permanent receivers or from ANN sites will enable computations to be undertaken directly in terms of the Geocentric Datum of Australia

Current status of the AFN

The Antarctic sites in the regional network were set up last summer with permanent GPS trackers at Davis, Mawson and Casey together with the Macquarie Island. Data from these sites is trickled back to Canberra every 15 minutes by satellite. The Darwin AFN is now operational from a site at Manton Dam and data is also available from other sites at Ceduna, Karratha and Alice Springs. Cocos, Townsville and Wellington NZ will come on line in the near future. AUSLIG is discussing the future of civilian access to data from GPS trackers owned and operated by the USA at Tidbinbilla and Yaragadee W.A. and the possibility of replacing them with Australian units. An Australian receiver has been installed at Mt Pleasant in Hobart which will replace the current American owned GPS at that site, after a suitable change over period.

GPS observational data from all these sites can be obtained from AUSLIG for post processing, together with data from an integrity base station operating at The AUSLIG building in Canberra. Martin Hendy is the prime contact (telephone 06-2014346). Prior notice for data from these sites would be helpful in the present testing phase. GPS data from selected sites will be also be made available to the International scientific community principally through the IGS network.

Summary

Australia has used a number of different datums and coordinate sets:

- Pre-1966: the Clarke 1858 ellipsoid with a variety of origins, which as UTM grid coordinates were known as the Australian National Grid (ANG).
- 1966: The Australian Geodetic Datum adopted and the AGD66 geographic and AMG66 UTM coordinates used.
- 1971: Australian Height Datum (AHD) instituted.
- 1984: The AGD84 geographic and AMG84 UTM coordinates adopted by some authorities.
- Late 1980s: GPS becomes popular and positions in terms of WGS84 become available.

Australia is moving to a geocentric datum compatible with GPS and it is anticipated that the Intergovernmental committee on Surveying and Mapping will release geocentric coordinates of the national GPS sites later in 1994. These will be held as fixed values for general usage; whilst the movement of the continent will be monitored by permanent GPS receivers located at the Australian Fiducial network sites. The new geocentric coordinates of the Australian National Network will vary from the AGD values currently in use by about 200 metres

The AFN and the national integrity monitoring network will provide the national basis for legal traceability in Australia without the need to pursue legal responsibility into international law.

Information, software, formulae and references on co-ordinate systems, transformations, GPS and the AFN are available as a free service from the AUSLIG computer Bulletin Board System, which may be accessed using a PC and modem (06-2014375, 06-2014378).

AUSLIG

Non-uniqueness And Next Generation Magnetics

Phil Schmidt and Dave Clark
CSIRO Division of Exploration & Mining

In principle, non-uniqueness problems in the magnetic method can be overcome through using differential vector magnetometers (DVM, see cover of Preview No. 47) in conjunction with active source magnetics (ASM). The interpretation of magnetic surveys is often compromised by the intrinsic ambiguity in the geologic, geometric and magnetic nature of the target. Complicating factors include magnetic remanence, demagnetisation and anisotropy of susceptibility. The inherent non-uniqueness of target geometry for potential fields can lead to misinterpretation of shape, size, dip and depth. Anomalies of no economic interest are often drilled because their signatures resemble those of prospective bodies. When testing magnetic anomalies, incorrectly interpreted geometry leads to missed targets. This incurs excessive drilling costs and delays exploration programs. An even more serious consequence of misinterpreted target geometry is the potentially economic orebody that is missed altogether.

There are several types of ambiguity that cause difficulties for exploration using magnetics:

Geologic Ambiguity

Targets of quite different geological nature may produce similar magnetic anomalies because of the lack of one-to-one correspondence between magnetic properties and lithologies, the complicated effects on magnetisation of metamorphism, hydrothermal alteration and deformation, and the fact that different geological features may have similar geometric form. As an example the magnetic signatures of a buried pipe-like massive sulphide orebody and an intrusive plug of similar geometry may be indistinguishable (Figure 1). If the sulphide orebodies which constitute the exploration targets in the area contain monoclinic pyrrhotite, their magnetisation is likely to be dominated by remanence, rather than induced magnetisation. On the other hand, the magnetisation of most magnetite-bearing intrusives is predominantly induced. If the nature of the magnetisation can be determined remotely, before drilling, the prospectivity of the anomalies can be ranked and drilling priorities decided.

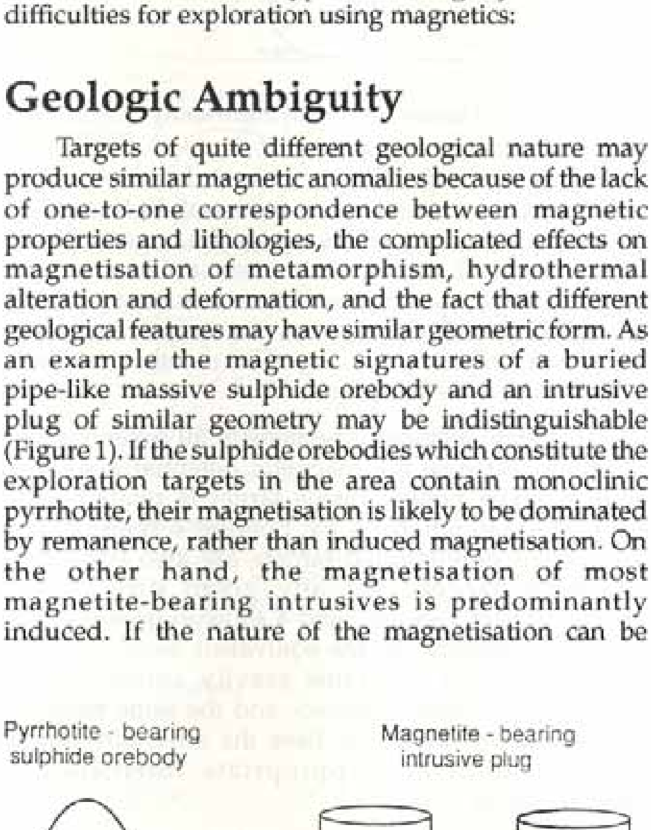

Figure 1 Geological Ambiguity

An example of more subtle geologic ambiguity concerns intrusive suites of different ages, which record different directions of remanent magnetisation, as shown in Figure 1. If mineralisation is associated with a particular suite of intrusions, determination of remanence directions prior to drilling would discriminate prospective intrusives from targets of little interest.

Equivalent Sheets

Geometric ambiguity pertains to all potential field methods. However one source of geometric ambiguity, which is unique to the magnetic method, arises because the magnetic anomaly depends the direction of magnetisation. There is no comparable effect in gravity anomalies, because density is a scalar property, unlike magnetisation which is a vector. The presence of remanent magnetisation or strong susceptibility anisotropy can produce magnetisations that are quite oblique to the present field.

As an illustration, Figure 2 shows equivalent magnetic targets that are not equivalent gravitational targets. It is easy to see that the dip-parallel component of magnetisation produces a pole distribution on the upper surface of the sheet that is independent of dip. The poles of opposite sign at the other end of the sheet are so remote that they make negligible contribution to the anomaly. The anomaly due to the dip-parallel component of magnetisation is therefore independent of dip. It can be shown that the component of magnetisation across the sheet also produces an anomaly independent of dip. Thus the dip of the sheet is uninterpretable, unless the magnetisation direction is known.

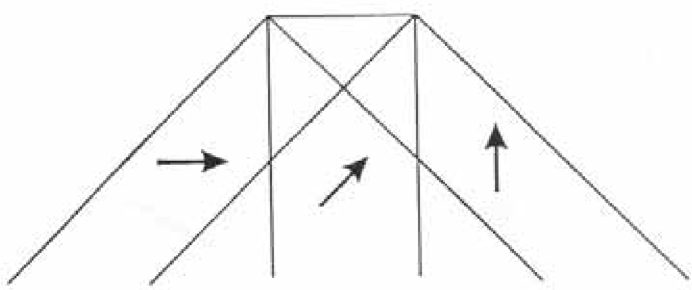

Figure 2 Equivalent Sheets - Dip Indeterminacy

Wrongly assuming magnetisation parallel to the present field can lead to drilling down-dip, causing the target to be missed or drill intersections to be target to be missed or drill intersections to be misinterpreted. Interpreted geological structure based on magnetic modelling can be seriously misled by this dip indeterminacy. For instance, a conformable body may be mistakenly interpreted as cross- cutting.

There are two solutions to the problem of dip indeterminacy that can be applied prior to drilling, as well as during the drilling program. Both methods involve separating the contributions of induced and remanent magnetisation to the observed anomaly. The first method involves remote determination of magnetisation direction, which allows the dip to be modelled uniquely. An alternative method involves direct mapping of the distribution of magnetic material by determining the induced response to active source magnetics (such as a superconducting magnetic source), thereby eliminating the effect of remanence.

Equivalent Spheres and Equivalent Ellipsoids

The simplest type of geometric ambiguity in potential field interpretation concerns concentric spheres, which produce anomalies identical to that of a point target located at their centre (Figure 3). The anomaly due to a spherical target is equivalent to that of a point dipole, with the same magnetic moment, at the centre. It is less well known that equivalent spheres are a special case of a more general set of equivalent targets - confocal ellipsoids. Clark et al (Exploration Geophysics, v.17, 1986, pp.189-200) have presented the mathematics of the ellipsoid model, from which it is clear that confocal ellipsoids of the same moment are equivalent targets.

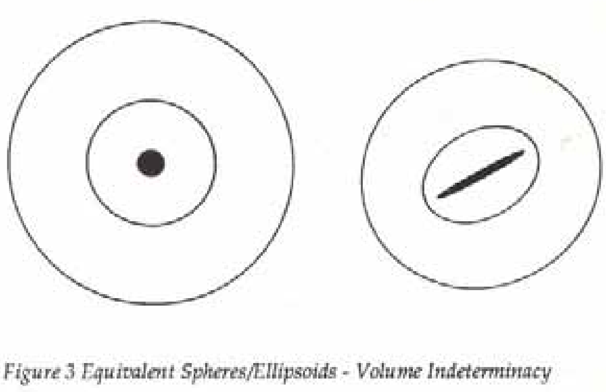

Figure 3 Equivalent Spheres/Ellipsoids - Volume Indeterminacy

In the case of compact targets, the direction of magnetisation and the depth to centre are in principle determinable from the anomaly form. In this context, compact targets include reasonably equidimensional (quasi-spherical) bodies and also elongated bodies with long axes smaller than the depth. However, the volume and depth to top of such targets is uninterpretable from conventional magnetic surveys, unless the magnetisation intensity is known or assumed. Targetting of deep compact bodies from the surface is difficult and initial holes often miss the causative body.

Remote determination of the contributions of induced and remanent magnetisation to the observed anomaly at a point on the surface has a side-benefit of providing a direct indication of direction to centre of the target. Several such vectors serve to locate the centre of the target accurately. Mapping of the distribution of magnetic material using an active inhomogeneous artificial field to excite portions of the target differentially can also discriminate between large, relatively weakly magnetised, targets and smaller, more magnetic targets, which are indistinguishable using conventional magnetics.

Equivalent Lenses

Perhaps the most pernicious type of ambiguity in conventional magnetic interpretation is the equivalence of deep compact targets and shallower, broader targets (Figure 4).

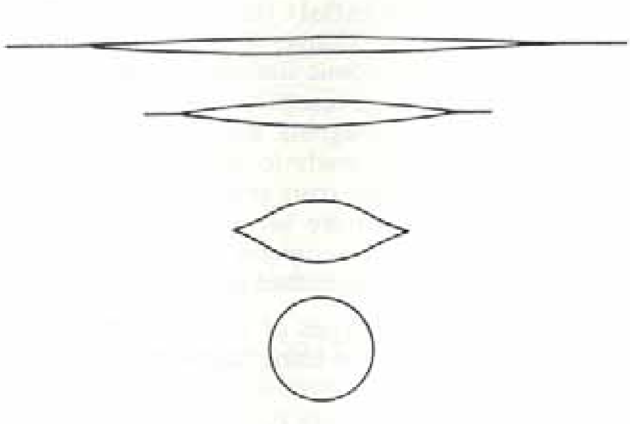

Figure 4 Equivalent Lenses - Depth/Width Indeterminacy

The compact target may correspond to a magnetic orebody (e.g. an Elura-type massive sulphide deposit), whereas the broad, shallow equivalent target is often a laterite layer of no economic interest. Conversely, in other geological settings, a shallow lens may represent a stratiform orebody, whereas the deeper equivalent target may represent an intrusion or other magnetic feature within the basement.

Geometric ambiguity pertains to all potential field methods. Because the magnetic potential associated with a given homogeneous target is related to its gravitational potential by Poisson's relationship, equivalent gravitational targets are also equivalent magnetic targets, for any given direction of magnetisation. Figures 3 and 4 show examples of this type of ambiguity. All the equivalent targets in these figures produce the same gravity anomalies, for appropriate density contrasts, and the same magnetic anomalies, provided they have the same direction of magnetisation and appropriate intensities of magnetisation.

Ways to Solve the Problem

One approach to solving some of these problems has been to measure the magnetic properties of samples in the laboratory, and while this approach may still be appropriate in many cases, it is often possible only after some drilling has been carried out, and can be time consuming. The most definitive discriminator of shallow broad targets from deep compact targets involves application of an active source (inhomogeneous time-varying field) to allow mapping of the lateral and vertical distribution of magnetic material. Determination of in situ magnetic properties and apparent vectors-to-target, based on analysis of responses to natural time-varying fields, also has application to this problem, as a deep target will yield consistent properties and coherent vectors, whereas a heterogeneous shallow target will produce an incoherent pattern of vectors and variable properties. Contributions of remanent and induced magnetisation can be distinguished by using time varying fields so information on magnetic properties and target geometry can be be obtained prior to drilling (Fig. 5).

In another recent development it is now feasible to deploy high temperature ultra-sensitive SQuID (superconducting quantum interference device) sensors in the field. High-temperature SQuID sensors use liquid nitrogen instead of expensive and difficult to handle liquid helium, and offer an order of magnitude increase in sensitivity over conventional magnetometers (Caesium vapour, proton or fluxgates). The challenge is to enable this new technology for adverse field conditions to solve one of the outstanding problems of magnetic interpretation in Australia. This approach will benefit the exploration industry by providing a time saving and cost effective means of constraining magnetic interpretation in the field. Immediate differentiation between extensive shallow bodies and compact deep bodies will allow a survey team to decide on the spot if further work is justifiable.

A proposal to perform field trials to implement and test these ideas is being developed by CSIRO and AMIRA. The project will be managed by AMIRA through CRC AMET under the supervision of Dr Phil Schmidt, and will run for 3 years.

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A pre-circulation meeting to discuss the project in detail was held on the 1st September, 1994 at the CRC AMET Macquarie University. Those who are interested in following up the outcome of the meeting should contact Joe Cucuzza at AMIRA.

Joe Cucuzza Phone : 03-4394604
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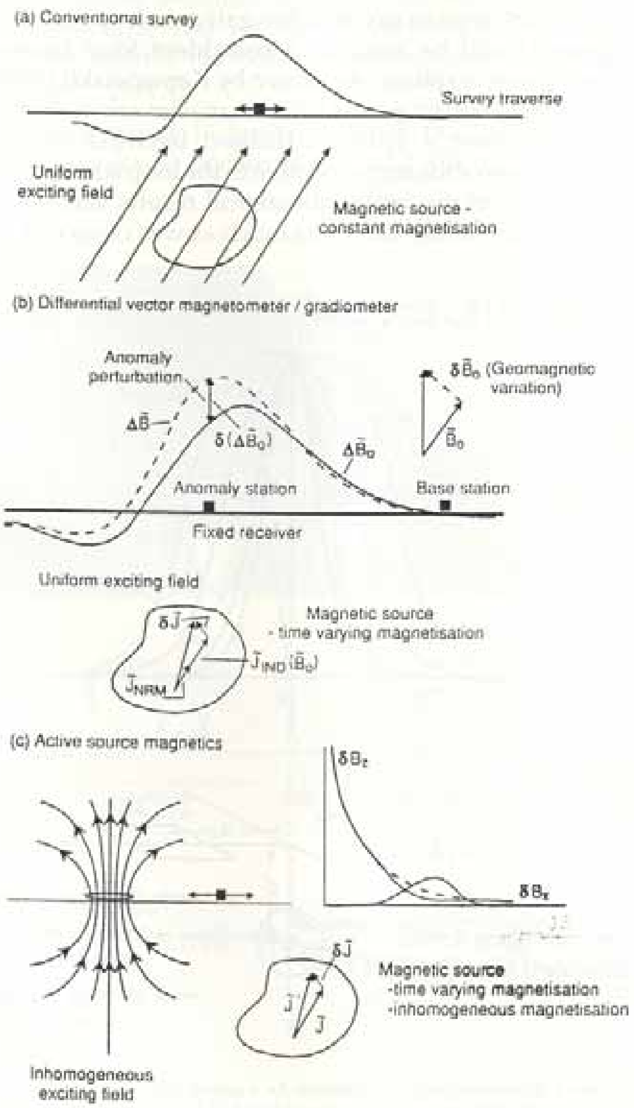

Figure 5 Conventional And Alternative Magnetics

CSIRO AUSTRALIA

AMIRA

Can SIROTEM detect small shallow conductive targets?

Comments on "SIROTEM Detects Conductive Fluid Filled Plastic Drum", October 1993 Preview No. 46 (p22)

by R. Henderson and M. Russell

Henderson and Russell claim to have detected a 20 litre salt-water filled drum using the SIROTEM system. To evaluate this claim we invoke a sphere model to obtain an estimate of the target time constant. Given that the drum volume is 20 litres we use a sphere radius of the order of 0.2m. Given the salt water conductivity to be about 6 S/m, (Emerson, D.W. et at, 1992), we calculate the time constant of the target to be of the order of

$$\tau = \frac{\mu_o \sigma a^2}{\pi^2} = 3x10^{-8} sec{=}0.03 microsec$$

Eddy current response from such a target would not be detectable by SIROTEM if the target were sitting on the Tx/Rx coil.

Since galvanic current response will be zero when the combined Tx/Rx coil is located directly over the target we surmise that the measured response is either an artifact arising from burial of the drum (unlikely, in view of response out to half a millisecond) or response from adjacent metal (much more likely, for the same reason).

It is stated by the authors that SIROTEM was able to detect this target (which it could not) because it employed a combined Tx/Rx coil configuration rather than the offset configuration used by the Geonics EM47. SIROTEM were able to use the combined coil configuration for this experiment only because their gates (as reported in the note) started at 245μsec. We invite them to attempt this configuration with first gate location at 7μsec. They will be dismayed by what they learn about transmitter turn-off decay characteristics, the effects of finite receiver bandwith, etc. They will indeed find that operation at a distance of 12.5m is difficult enough.

For metallic drum detection a gate start-time of the order of 100μsec is quite adequate. The new Geonics EM61 metal detector, which employs superimposed Tx/Rx coils only 1m in diameter, thus facilitating very rapid surveys, is becoming commonly used in North America for buried metal detection and mapping.

J. Duncan McNeill, Geonics Limited

Emerson, D.W., Reid, J.E., Clark, D.A., Hallett, M.S.C. & Manning, P.B. (1992). The Geophysical Responses of Buried Drums - Field Tests in Weathered Hawkesbury Sandstone, Sydney Basin, N.S.W., Exploration Geophysics 23, 589-617.

Author's reply to comments on "SIROTEM detects conductive fluid filled plastic drum"

by J Duncan McNeill

McNeill bases his contention that the SIROTEM measurements could not be picking up a drum full of salt water on the calculation of the time constant for this target. We agree that the time constant is as stated and it suggests the possibility of some other cause such as adjacent metal.

When we first observed a measurable response and notices how small it was (a peak value of only 1 microvolt/amp) we did take extra care to ensure that there was no metal in the vicinity. There was a thin metal sheet nearby that had been used in some other experiments previously, but this was removed to a distance of more than 30m. The best way to be certain that there was no metal effect would be to conduct a detailed magnetometer survey over the site.

It is not true to say that the galvanic response (see Figure 1) will be zero for a coincident loop located directly over a sphere. As shown by Kamenetskii (1976) the coincident loop produces a maximum response directly over a sphere. Indeed because of the shallowness of the target relative to the loop size and the distance from the centre, theoretical results verify that the anomaly width can be as much as was observed.

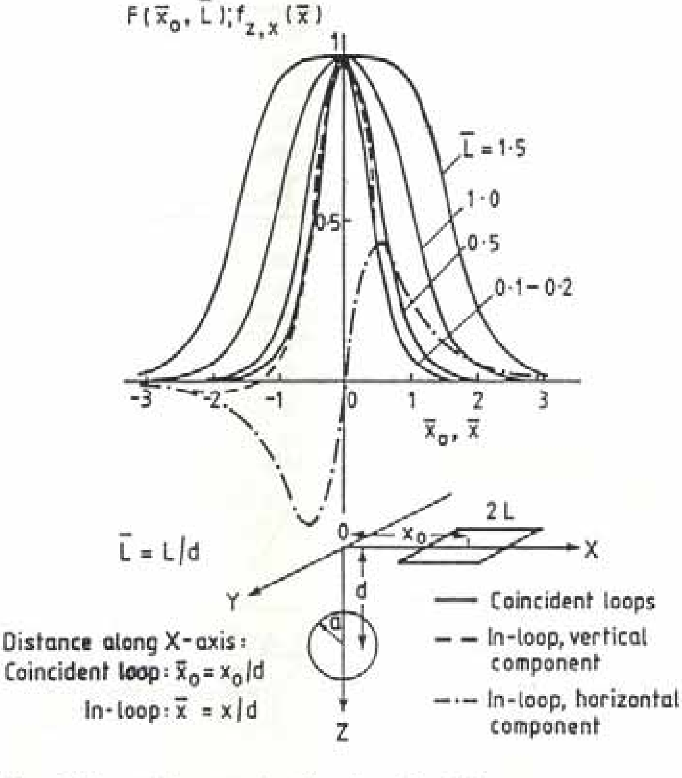

Figure 1. Geometric response functions for a sphere (after Kamenetskii 1976), from: Manual for SIROTEM Field Procedures and Data Interpretation by Buselli, et al., 1985)

Given that we are confident that we have detected an anomaly, and yet it has such a small time constant, may suggest that it is due to some other response than simple galvanic conduction. Certainly there was a very strong magnetic field cutting the target, given the 5.5amps on the loop and its effective area of $50m^2$. We hope to conduct some futher tests in this regard.

With regard to the actual measurement times, we must remember once again that SIROTEM timings are taken from the top of the ramp and in these measurements the set of timings that were used were not the earliest that are now possible. McNeill invites us "to attempt this configuration with first gate location at 7 microsec". We have indeed developed a fast turn-off transmitter since these measurements were made and a fourth set of timings are now available to commence measuring at 8 microseconds from the top of the ramp. We therefore look forward to reporting in the near future, on even more definitive measurements on plastic drums full of contaminants. The importance of being able to detect such contamination targets using TEM, when they are not able to be detected by magnetics, cannot be over emphasised.

Reference

Kamenetskii, F.M., Ed., 1976. Handbook of applied methods of transient processes in ore geophysics. Leningrad, Nedra, 127p.

Sweden to Denmark Bridge - Seismic Survey

New ABEM Terraloc Mark 6 Seismograph employed.

On 27 June 1999, a bridge will link together Sweden and Denmark. A permanent connection across Oresund, one of the world's busiest seaways, has been discussed for more than 100 years and this will be the day it become a reality. The project is estimated to cost twelve billion Swedish kronor (1.15 billion Pounds Sterling). The 16.5 km long bridge will link both countries with a four-lane motorway and twin-track railway (Figure 1).

Governments in both countries have signed an agreement for its construction. And yet the rigorous environmental enquiry is still to come in Sweden. It is still not definite that the bridge project will proceed.

The massive project represents a major challenge. Both environmental and technical demands are very substantial indeed.At the same time, there is little timeavailable and that puts vast demands on the contractors involved. Accurate surveys are vital to ensure that the construction meets both the expected and unexpected. In this context, the advanced portable seismograph ABEM Terraloc Mark 6 plays an essential role. The Oresund Consortium responsible for project planning, building and operation of the Oresund link

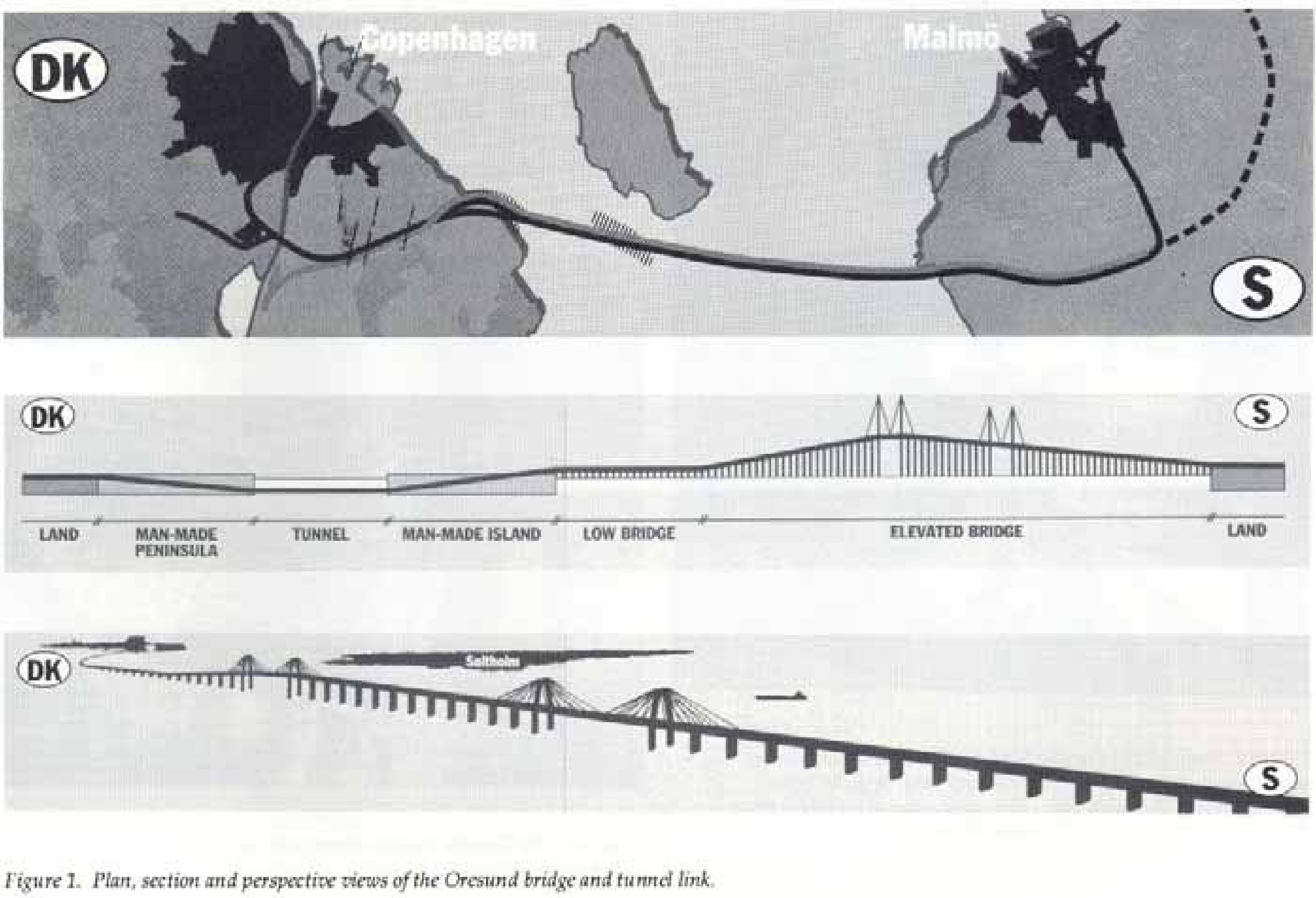

Figure 1. Plan, section and perspective views of the Oresund bridge and tunnel link.

has commissioned a highly detailed survey of the geology of the sound.

Geological Conditions

In very simple terms the conditions can be described as a shallow water strait where rather thin Quaternary deposits overlay Tertiary limestone dominated bedrock of Danian age.

The water depth seldom exceeds 10 metres and the depth is commonly around 4-6 metres. The limestone dominated bedrock often outcrops at sea bottom. The bottom topography is rather even with two main channels carrying most of the boat traffic in the strait of Oresund.

The Quarternary deposits are 2 to 6 metres in thickness and mainly consist of clay till, sometimes enriched in stones and boulders in the lower part. In places there are thin sandy sediments of marine and glaciofluvial origin on top of the till. In some areas thin, sandy sediments occur beneath the till.

The transition to the Tertiary limestone bedrock is seldom well defined due to glacial tectonic activity which has mixed soil and rock fragments into a transitional deposit that can have significant thickness. The challenge for investigators is to define this transitional layer.

Figure 2. Four ABEM Terraloc Mark 6 seismographs have been connected in series and fitted into a survey vessel to facilitate the investigation of the seabed before the construction of the bridge between Sweden and Denmark. Ole Christian Pedersen and Peter Deisz of Geomap AS are the operators

The limestone bedrock is divided into two main units, the so called "Copenhagen Limestone" overlaying the "Bryozoan limestone". The upper unit is very stratified with considerable depositional and physical differences. The thickness is normally 10-20 metres. The lower unit is a denser deposit, in general more homogenous, than the upper unit.

Aims of the Investigation

"It's absolutely essential for the safety of the bridging project that all variations in seabed conditions are defined," says Chartered Engineer Aage Hansen, Head of Geophysics in the Oresund Consortium.

"Load-bearing capacity and deformations at depths of 100 metres are aspects which affect the detailed planning of the bridge project."

The connection between both countries will consist of an elevated section over the Swedish Flint and Trindel channels, a lower section, and a tunnel section under the Danish Drogden channel. Headroom above the Flint channel has to be more than 50 metres with a unobstructed span of at least 300 metres. There must be at least 10 metres of clearance in the Drogden. There is obviously financial benefit in defining the link's optimum route accurately. Given the timing, delays cannot be accepted but at the same time, for example, shortening the tunnel by a metre, could save substantial funds. Fast and accurate mapping is required.

Investigation Details

The Oresund Consortium has given Denmark's Geotechnical Institute (DGI) the assignment to provide accurate surveys of ground conditions where the bridge and tunnel will be constructed. In the first phase, now under way, seismic, geotectonic and hydrographic measurements are being conducted in the projected tunnel site. DGI has also called in its Norwegian counterpart, The Norwegian Geotechnical Institute (NGI) which in turn has involved the Norwegian geophysics companyGeomap A/S for the seismic survey work. In a short while, barely 4 weeks, more than 10 km of seismic profiles have already been recorded.

Figure 3. The Terraloc Mark 6 seismograph has 21 bits resolution, IFP amplifiers and 24-48 channels.

"In other assignments 24 to 48 channel hydrophone recordings are used. But with preliminary investigations in Oresund, 96 channels are used in order to map all the relevant geological structures quickly enough. That's why it's the first time we've connected up four ABEM Terraloc Mark 6 units in series (see Figure 2)," says geophysicist Ole Christian Pedersen of Geomap A/S.

"With the dynamics range and capacity for fast readings that we've obtained from the Terraloc system, we have been able to cope with an enormous amount of information that is needed for a thorough analysis. In all, we have taken over 50,000 measurements from our survey vessel. We use a 475 metre long seabed cable, fitted with 96 hydrophones. n

The position of all hydrophones is determined after each movement of the cable. This is important as the water currents in Oresund are strong and can easily disturb the cable from its intended location.

ABEM Terraloc Mark 6 (Figure 3) operates with 21 bit resolution, 126 dB dynamic range and 25 microsecond sampling. This enabled the location and extent of weak zones and the distribution and extent of sediment and limestone to be measured with greater precision than has previously been possible.

Bengt Sjogren, brought in as an independent seismic expert with more than 35 years' experience in interpreting seismic measurements is delighted with the data received (Figure 4). The quality and capacity of the Mark 6 is appreciably higher than data he has seen from other equipment.

For more information, contact:

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7-9 George Place
ATARMON, N.S.W. 2084
Tel: (02) 418 8077

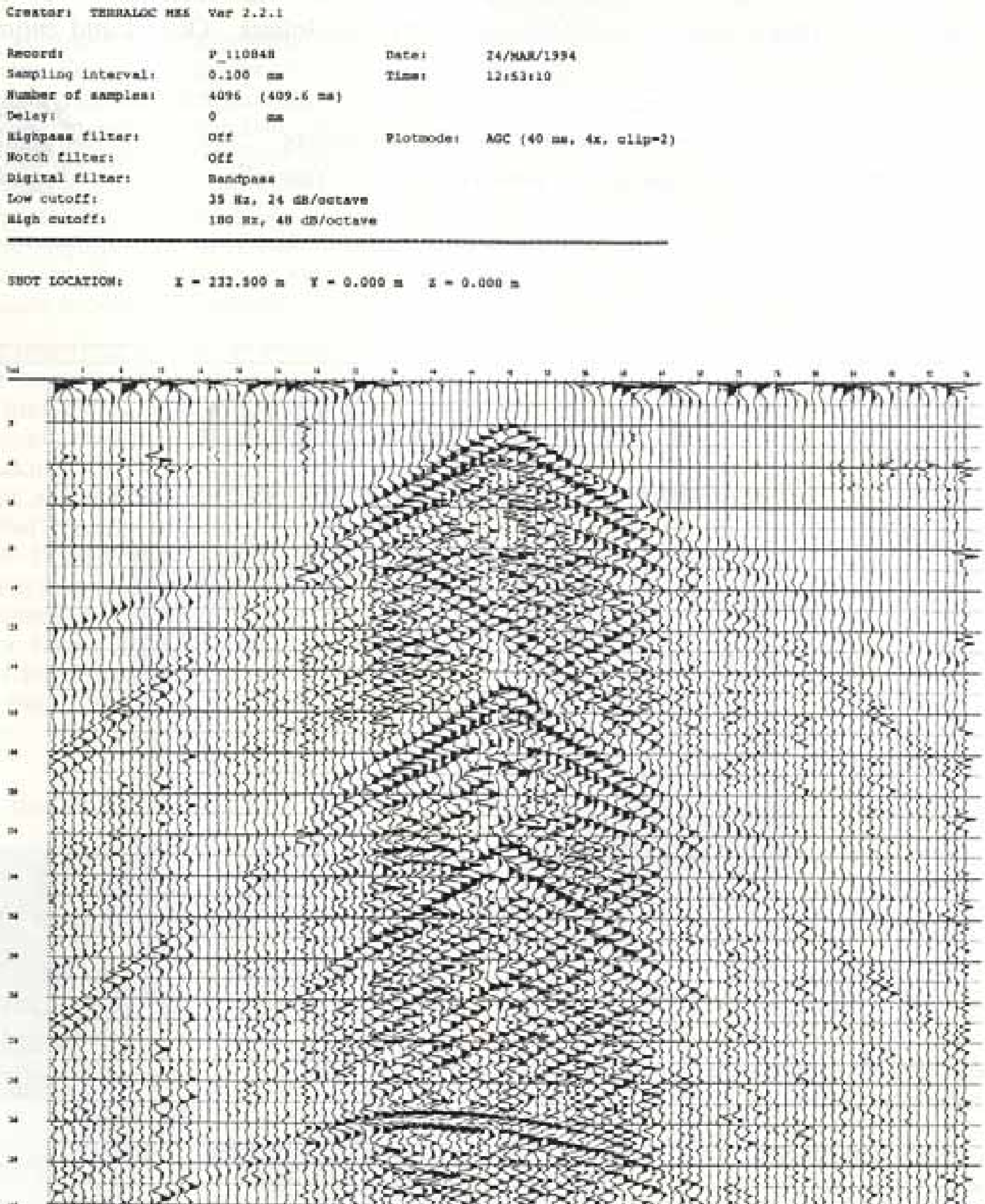


Figure 4. A sample 96 channel (409.6 ms length) field record from the Oresund investigation

ASEG Corporate Sponsor Profile

Zonge Engineering & Research Organization, Inc

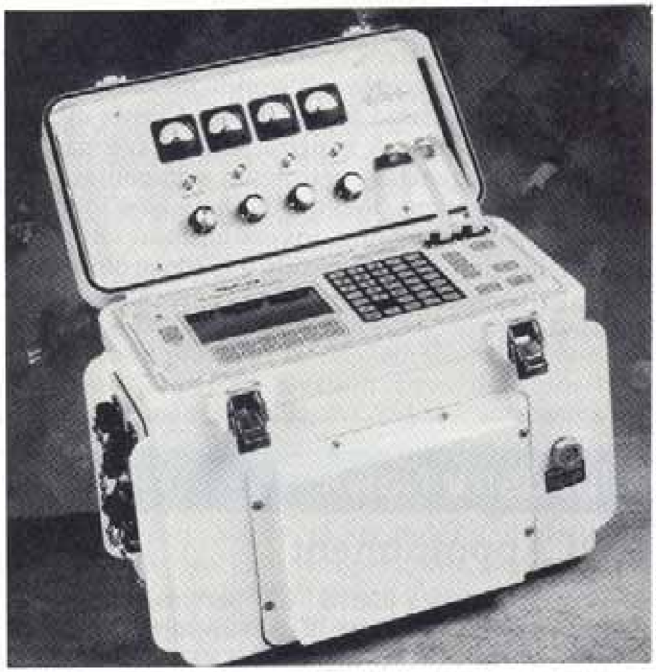
Zonge Engineering and Research Organization, Inc. is a privately owned corporation specializing in electrical geophysical methods. The company was founded in 1972 by Dr Kenneth L. Zonge, who is still the owner and president. He started the company to apply his doctoral research in mineral discrimination (complex resistivity) to field exploration. As a result, the company has always been field oriented. Zonge's field crews quickly gained a worldwide reputation for quality research data in both time and frequency domain IP techniques, complex resistivity, and the innovative Controlled Source Audio-frequency Magneto Telluric (CSAMT) method. Zonge expanded in 1984 by establishing an office in Adelaide, Australia to better meet the needs of its Australian and Pacific Rim clients.

As both an equipment manufacturer and a field services contractor, Zonge is a leader in the electrical geophysical industry. Its field crews are supported by a design and manufacturing division that can build and modify equipment to meet special client needs as they arise. The equipment design and manufacturing process is "supported" by constant input from its field crews using the equipment in a wide variety of environments, ranging from frozen regions in northern Alaska and Canada to outback Australia.

Zonge Engineering began manufacturing a complete line of instrumentation in 1978. The introduction of the GDP-12 Receiver System led the way in multi-channel, multi-purpose, portable field equipment, making CSAMT a commercially viable geophysical tool, and further improving the efficiency of the surveys that Zonge already ran. Though many of the original GDP-12 systems are still in operation today, Zonge has always actively developed its integrated geophysical systems, taking advantage of advances in microprocessor technology, as they have become available. This led directly to the development and production of the GDP-16 in 1987, followed by the GDP-32 in 1993.

The introduction of the 16 channel, 386 processor based GDP-32 receiver has been a major recent innovation at Zonge Engineering. Not only is the GDP-32 receiver smaller, faster, and more versatile than the eight channel GDP-16, and can run all of the methods that the old receiver system could, (resistivity/IP, CSAMT, and TEM), but can run the new AMT and MT programs without configuration changes or modification. Additionally, by installing one board, it is capable of running NanoTEM (as can the GDP-16).


Zonge crew collecting CSAMT data in Indonesia


Zonge's new GDP-32 geophysical receiver.

The addition of Natural Source AMT/MT to the product line makes this technique available to its client base for the first time. Historically natural source techniques have been expensive and too slow to run to be practical for routine use. By taking advantage of the speed of the GDP-32, and the resulting improvement in data analysis, it is now possible to cut down acquisition time drastically, nearly to that of a CSAMT survey.

Zonge Engineering has continued to expand both in equipment capabilities and in field services. Zonge has become active (primarily through its mining clients) in the steadily growing environmental field, using high resolution CSAMT and very shallow, fast turn-off TEM techniques (NanoTEM) to map structure and locate contaminated plumes.

Zonge also offers full data processing services for all of the types of data collected with their receivers. The Adelaide office handles the final data processing for data taken in and around Australia, including full colour inversions of CSAMT, AMT and TEM data sets. Additionally, their field crews are capable of producing near final quality plots in the field for initial interpretation.

In 1994, in addition to its Tucson, Arizona and Adelaide, Australia offices, Zonge has offices in Reno, Nevada, Hermosillo, Mexico and a seasonal office in Fairbanks, Alaska. From an original staff of four working out of Tucson, the company has grown to more than sixty employees worldwide, operating 12 field crews with thirteen staff geophysicists and four design engineers. Zonge continues to expand staff, equipment design, and the application of technology to ground geophysics used in daily operations. To date, there are more than 200 systems in use worldwide, including at least 15 systems based in Australia. Clients include universities, research centres, utility companies, government agencies, petroleum companies, and mining organizations. Recently, we have been involved more in environmental investigations and civil engineering problems. Currently the Zonge office in Australia has three crews operating in Australia and one in Indonesia.

Zonge Australia has worked hard to establish its reputation and intends to uphold this by continuing to expand the services that it offers through a blend of service reliability, technological advances and professionalism. Part of this commitment is improving crew safety by equipping crews with upgraded field communications, training, and other safety equipment. This policy, combined with the fact that all of its crews are experienced, trained professionals, continues to strengthen its position in the geophysical industry.

Industry News

ADI Appointment

Tim Pippett has joined ADI Services in Sydney, Australia as the manager of its sub-surface imaging branch.

As such Tim will be responsible for the geophysical activities of the company with special emphasis on ordnance detection using high resolution magnetics and ground penetrating radar.

Tim Pippett has 20 years of relevant geophysical experience in the consulting, contracting and instrument manufacturing business.

Encom Move office

As from Monday 1st August, Encom Technology Pty Ltd has relocated their Sydney office to:

Level 2, 118 Alfred Street
MILSONS POINT NSW 2061
(Postal address, telephone & fax numbers remain unchanged).

ISS Australia Appointment

Dr Tony Siggins has joined ISS Pacific as Research Manager. Tony has left the CSIRO Division of Exploration and Mining after a long career in experimental geophysics. ISS Pacific is a new Joint Venture company combining ISSI from South Africa, Mindata Australia Pty Ltd and Desmond Fitzgerald & Associates Pty Ltd from Australia.

ISS Pacific manufactures and markets real time micro-seismic monitoring equipment. With an established monitoring program an ISS seismic monitoring system can allow for the detection of and the assessment of the potential for rock mass instability. This assessment can be a chieved quickly as the system works in real time. The recent Mount Isa Mines installation above the 3000 orebody has demonstrated the systems suitability in Australian conditions. Seminars in Melbourne, Newcastle and Kalgoorlie during September and October are planned. If interested, contact Tony Siggins on (03) 593 1077 or Fax: (03) 592 4142.

Digital Exploration Relocated to QCAT Complex

Following less than eighteen months of full scale operations the first major extension at the Queensland Centre for Advanced Technologies (QCAT) was officially opened on the 20 July 1994 by the Premier of Queensland, Hon Wayne Goss.

QCAT is a joint venture between CSIRO and the Queensland Government and is fast becoming a major national and international focus for research and development for the minerals, energy and manufacturing industries.

The development by CSIRO of the new wing at QCAT has made possible the attraction to the site of a leading edge mineral and petroleum exploration company, Digital Exploration Ltd (a DIGICON company). Digital Exploration Ltd is a company at the forefront of petroleum and mineral exploration techniques and brings a new dimension to the capacity of the Centre to meet the needs of industry.

Without the initiative of CSIRO and Digital this capacity would almost certainly have been lost to an overseas location. As a result of the unique business agreement between CSIRO and Digital the Centre now boasts the most powerful and technically advanced intensive computing facility in the Asia Pacific Region.

Digital took the decision to locate at QCAT on strictly commercial grounds but the quality of the new facility at QCAT and the potential to establish closer links with the CSIRO activities at the Centre were also important factors in the company's decision. Under the terms of the agreement with CSIRO, Digital will lease space in the new $1.8 million wing of the QCAT complex and will have access to substantially upgraded convex computers at the site.

With the upgrading of the Convex super computing facilities, which is a key element of the CSIRO/Digital agreement, Queensland now has a frontline mineral and petroleum exploration capacity unmatched in the Asia Pacific Region.

The decision by Digital Exploration Ltd to locate at the Queensland Centre for Advanced Technologies is a major milestone in the development of the Centre.

Geophysical Data Releases

Murloocoppie-Wintinna (SA) Airborne Geophysical Data

The Murloocoppie and Wintinna airborne geophysical data sets have now been amalgamated and released as one data set.

AGSO has reprocessed magnetic data from the 1991 survey of the eastern one third of the Murloocoppie 1:250 000 Sheet area. These data and gamma-ray spectrometric data from this survey have been merged with the data from the 1992 survey of the eastern two-thirds of the Murloocoppie and the entire Wintinna 1:250 000 Sheet areas. The individual data-sets were previously released in June/July 1992 and August 1993.

The new merged digital (point-located and gridded) data are now available. Also released are 1:250 000 scale flight path, total magnetic intensity contours and gamma-ray spectrometric (total-count) contours.

For better definition of small, low amplitude magnetic anomalies in the northern portion of the Wintinna sheet area, new 1:100 000 scale magnetic contour maps have been generated using a grid cell size of 50 metres and a contour interval of 1 nT. Previously released 1:100 000 magnetic contour maps of this area were generated using a grid cell size of 90 metres and contour interval of 5 nT or greater.

Prices for standard Mapping Accord Products apply.

Duketon (WA) Airborne Geophysical Data

The Airborne Geophysical data for the Duketon 1:250 000 Sheet area, Eastern Goldfield, Western Australia.

The Australian Geological Survey Organisation and the Department of Minerals and Energy, WA, contracted World Geoscience Corporation to survey the Duketon 1: 250 000 Sheet area, as part of the National Geoscience Mapping Accord (NGMA). The survey was carried out in February and March 1994. Magnetic and gamma-ray spectrometric data sets were recorded on flight lines flown east-west and 400 metres apart. The nominal ground clearance was 80 metres.

These new generation data are intended to provide the strategic framework for future exploration in Western Australia and to assist the State and Commonwealth Governments and the wider community in developing strategies for resource development and environmental management.

Ballarat Digital Elevation Model

A digital elevation model for the entire Ballarat 1:250 000 Sheet area is now available. The model combines the latest elevation data with accurate positional information acquired during AGSO's 1992 Ballarat survey and the 1989/90 Ararat survey undertaken jointly by AGSO and the Geological Survey of Victoria.

The data have been processed to an 80 m (3.0") grid cell size.

The Ballarat survey was flown at 400 m spacing and the Ararat survey at 200 m.

For the Ararat survey the navigation data for the aircraft were provided by electronic navigation beacons. The aircraft's ground clearance was provided by radar altimeter and the basic height information was provided by a barometric altimeter, both sampled every second. A digital elevation model for Ararat was supplied by the contractor.

For the Ballarat survey, the navigation data for the aircraft were provided by satellite Global Positioning System. The GPS system provided position information relative to the WGS84 reference ellipsoid. As well as latitude/longitude information the GPS navigation system also provided the height of the aircraft above the ellipsoid. These GPS height data were sampled every 350 m (5 seconds) and recorded internally in two GPS receivers, one recording the navigation data in the aircraft and the second recording data at a known location. The data were post-processed to the final accuracy of the horizontal positioning data by a factor of at least 10.

The point located and gridded data cost $1000. The contour maps cost $40.

Index of Airborne Geophysical Surveys

An index of Australian (AGSO/BMR and State Government) airborne geophysical surveys carried out from 1951 through June 1994, is being released in both hardcopy and digital format.

The hardcopy version (published as an AGSO record) contains a summary of the major attributes of all surveys.

The digital version consists of AEROMAP, a Windows 3.1 program which allows the user to selectively access a database of information for each survey. This is achieved by interactively querying a map of Australia upon which the polygonal boundaries of individual surveys are plotted. Aeromap was developed in-house, and requires no software other

than Windows 3.1 installed on a PC. It is supplied on a single 3.5 inch high-density floppy disk.

NT Data Release

Airborne magnetic and radiometric data from the Groote Eylandt, Roper River and Helen Springs/Beetaloo areas surveys carried out by World Geoscience Corporation Ltd., (see Preview No 50, p56) covers a combined total of 14 1:100 000 mapsheets.

The surveys were flown at a ground clearance of 100 metres, with a flightline spacing of 500 metres and a tieline spacing of 5000 metres. Flightline direction was East-West, tieline direction North-South.

Sample interval for the magnetometer was 0.1 sec, for the spectrometer (with 33 lt crystals) 1 sec, translating to approximately 6 m and 60 m respectively.

Data from the surveys are available on EXABYTE tape and as a variety of maps and profiles on plain and transparent paper from the Geoscience Resource Section of the Northern Territory Geological Survey, Department of Mines and Energy.

Cooperation with industry, as illustrated by the combination of government and company data in the Helen Springs/Beetaloo survey, underlines the NT Government's determination to avoid unnecessary duplication of effort, and its commitment to maximising the use of existing information.

High quality airborne geophysical data are now available over approximately one quarter of the land portion of the Northern Territory.

For further information contact:
Geoscience Resource Section of DME
Tel: (089) 89 5202
Fax: (089) 89 6824

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

RGC Exploration Pty Ltd
PO Box 322
Victoria Park WA 6100

South Australia

David INKSTER
PO Box 196
Meadows SA 5201

Troy MACKLIN
52 Kelly Road
Modbury SA 5092

Sally SUTHERLAND
8 Eton Street
Colonel Light Gardens SA 5041

Stephen TOMLIN
Santos Ltd
GPO Box 2319
Adelaide SA 5001

Queensland

Katherine EDWARDS
Physics Department
University of Queensland
St Lucia Qld 4072

New South Wales

Simon STEWART
Geo Instruments Pty Ltd
348 Rocky Point Road
Ramsgate NSW 2219

Benjamin BELL
80 Ellesmere Street
Panania NSW 2213

Change of Address

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

ACT

Jacques SAYERS
From: Water Research Laboratory
University of NSW
King Street
Manly Vale NSW 2093
To: AGSO
Geophysicist,Marine
Geoscience &Petroleum
Geology Program
PO Box 378
Canberra ACT 2601

Cvetan SINADINOVSKI
From: Flinders University
Earth Sciences Geophysics
GPO Box 2100
Adelaide SA 5001
To: Aust. Seismological Centre
AGSO
GPO Box 378
Canberra ACT 2601

Queensland

Andy TUDOR
From: PO Box 118
Lampang 52000
Thailand
To: PO Box 272
Burpengary Qld 4505

Wendy WATKINS
From: 45 Railway Tce
Warradale SA 5046
To: C/- Santos Ltd
GPO Box 1010
Brisbane Qld 4001

Peter WHITING
From: 68 Dollis Way
Kingsley WA 6026
To: 5 Lalina Street
Middle Park Qld 4074

Nigel FISHER
From: Digital Exploration Ltd
54-56 Brookes Street
Bowen Hills Qld 4006
To: Digital Exploration Ltd
PO Box 984
Kenmore Qld 4069

Digital Exploration Limited
From 54-56 Brookes Street
Bowen Hills Qld 4006
To: PO Box 984
Kenmore Qld 4069

Geoffrey HINES
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Bowen Hills Qld 4006
To: Digital Exploration
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Stephen JESTICO
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Bowen Hills Qld 4006
To: Digital Exploration
PO Box 984
Kenmore Qld 4069

Mark TAYLOR
From: 54-56 Brooks Street
Bowen Hills Qld 4006
To: Digital Exploration
PO Box 984
Kenmore Qld 4069

Dave DEKKER
From: 21 Steelcon Parade
Mount Isa Qld 4825
To: 38 Abau Street
Mount Isa Qld 4825

Northern Territory

Justin ANNING
From: Sasco House
8 Cavenagh Street
Darwin NT 0801
To: Power & Water Authority
GPO Box 1096
Darwin NT 0801

South Australia

Julie WIBERS
From: Western Mining Corp
Kambalda Nickel Operations
Kambalda WA 6442
To: Olympic Dam Operations
PO Box 150
Roxby Downs SA 5725

New South Wales

William ASHBY
From: Ampolex Limited
GPO Box L902
Perth WA 6001
To: Ampolex Limited
PO Box A323
Sydney NSW 2000

Guy DUNCAN
From: PO Box 4379
University of Melbourne
To: PO Box 95
Jesmond NSW 2299

Western Australia

Stephen MUDGE
From: RGC Exploration Pty Ltd
PO Box 285
Belmont WA 6104
To: RGC Exploration Pty Ltd
PO Box 322
Victoria Park WA 6100

Victoria

Gary GIBSON
From: Seismology Research Centre
RMIT University
Plenty Road
Bundoora Vic 3083
To: Seismology Research Centre
RMIT University
PO Box 71
Bundoora Vic 3083

Koya SUTO
From: Pacific Oil & Gas
826 Whitehorse Road
Box Hill Vic 3128
To: 36 Boyd Street
Blackburn South Vic 3130

Richard BEARE
From: Santos Limited
215 Adelaide Street
Brisbane Qld 4000
To: Landmark Graphics
Level 4, Suite 9
14 Queens Road
South Melbourne Vic 3205

Overseas

Bryce KELLY
From: 94 Mill Hill Road
Bondi Junction NSW 2093
To: 412 - 27th Streen
San Francisco
California, 94131
USA

Robert PICKERING
From: Bridge Oil Ltd
263 Elizabeth Street
Sydney NSW 2001
To: PO Box 862
Brooks Alberta
Canada T1R-1B7

Nick HALL
From: 3 Frimlay Road
Robertsham
South Africa
To: 17 Westminster Drive
Craighall Park 2196
Johannesburg
South Africa

R.H.N. STEED
From: Developments Australia
GPO Box 5222 BB
Melbourne Vic 3001
To: C/- Petrocorp Exploration Ltd
Private Bag 2056
New Plymouth
New Zealand

Where Are They?

Does anyone know the new address for the following members?

Niels STIENSTRA
Last known address:
4/607 Park Street
Brunswick Vic 3056

Samantha SCHELLAARO
Last known address:
23 Danby Street
Torrensville SA 5031

Kevin FLEMING
Last known address:
6/116 Shirley Road
Crows Nest NSW 2065

Paul FARRELL
Last known address:
PM Farrell & Assoc International P/L
PO Box 197
Surfers Paradise Qld 4217

Phillip BROWN
Last known address:
PO Box 340
Wentworthville NSW 2145

Christiaan BUECHNER
Last known address:
6/42 Bay Road
Waverton NSW 2060

Michael GILES
Last known address:
Western Geophysical
4th Floor, 170 Burswood Road
East Victoria Park WA 6100

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

Fernando DELLA-PASQUA
Last known address:
University of Tasmania
Department of Geology
GPO Box 252C
Hobart TAS 7001

Warwick GREVILLE
Last known address:
Halliburton Geophysical Services
PO Box 466
West Perth Wa 6005

Anthony GRIFFITHS
Last known address:
Halliburton Energy Services
1st Floor, 34 Colin Street
West Perth WA 6005

Calender of Events

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

September 3-6 1995

ASEG 11th Geophysical Conference & Exhibition
For Conference details see page 7.

March 25-29 1996

8th Australasian Remote Sensing Conference
National Convention Centre, Canberra
For further details:
ACTS
GPO Box 2200
Canberra ACT 2601
Ph: (06) 257 3299
Fax: (06) 257 3256