Australian
Society of
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Geophysicists
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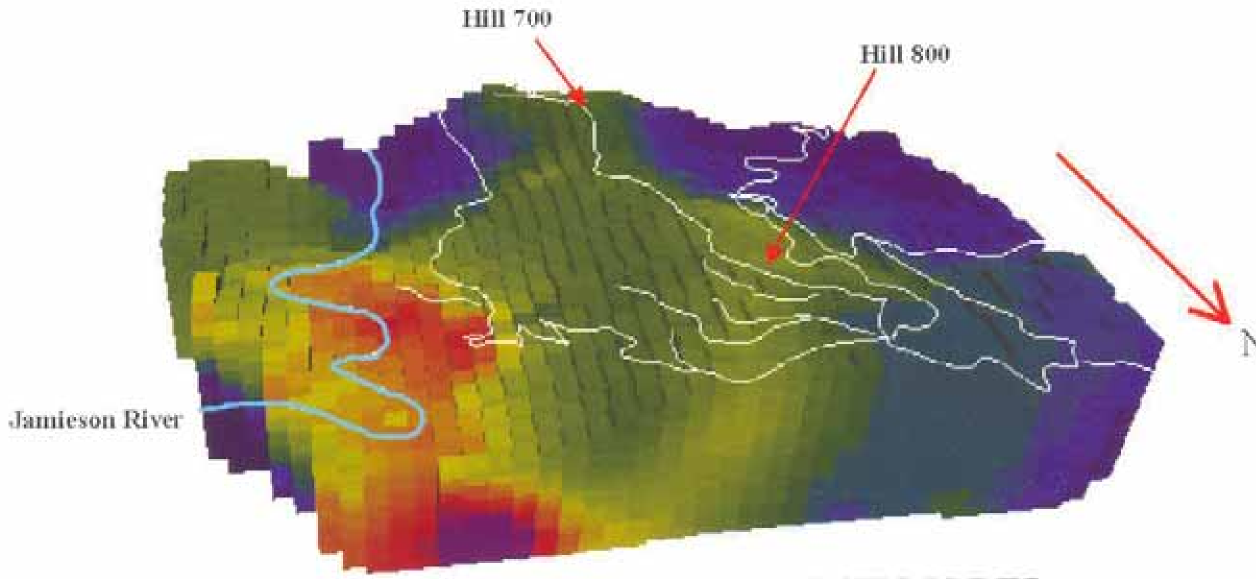
Preview

April/May 1999

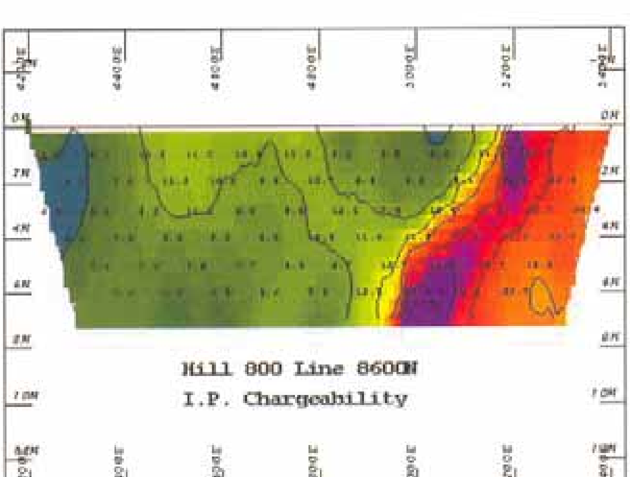
Issue No. 79

Special Feature:

3 Dimensional Treatment of Inverted Induced Polarisation Data 9-14



I.P. CHARGEABILITY BLOCK MODEL



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Editor's Desk

Since taking over as Preview Editor I have notice that my file of material relating to edition of Preview is generally growing thinner. Nearly all correspondence and material is sent to me electronically and I am becoming more comfortable with only ever seeing a document on the screen before being published. It is thus timely to review suitable formats for material and I intend to make a comprehensive list available on our web site. There will also be a revised template for Exploration Geophysics papers.

Before my youngest son was able to read he used to become annoyed when his older brother would prefer to read rather than play. On one occasion he climbed on his brother's bunk and tore the book out his hands and looked at it scornfully. 'It's just words' he declared, unable to understand what all the fuss was about.

Just words are just fine. If you are sending 'just words' then plain text or MSWord files are all that are required. Please no macros or letterheads and don't spend a lot of time formatting unless it is important. If you have any equations or symbols then send a hardcopy which can be used for checking. Do use a spell checker.

Graphics are normally more problematical. Without doubt the greatest problem occurs with embedded graphics. Apart from being an inefficient format for graphics they require unpacking and re-organising. Embedded graphs, which may themselves be embedded in a spreadsheet simply compound problems. Better to send separate graphic files.

The last etiquette that I would request relates to file size. If your document or image is large (greater than 1 MB say) please contact me beforehand to discuss the best method to exchange the file. There are many ISP 's out there that will dump large attachments without notifying the sender or the receiver.

President's Piece

Hello all good members,

This is the last President's piece you shall read from me. Before we all celebrate (!), I'd like to reflect on the actions of the Brisbane Federal Executive over the last three years and ponder where too now for the ASEG.

One of the Brisbane Executive's main aims has been to improve communication between it and your representatives in the state branches, so that a broad, educated foundation is laid for effective decision making. We have established a large number of semi-formal committees, with the benefit being that the Society is in a position to consider and act, instead of reacting. Communication also lessens the bugbear of parochialism - while those with something to say are heard, speakers are more aware of the broader impact of any request on the society.

The Brisbane Executive has sought to raise the society's awareness of its financial status, in conjunction with obtaining agreement on realistic financial goals to ensure the society meets obligations to all its members. ASEG publications, in particular Exploration Geophysics will undergo significant changes this year, driven by facing up to reality.

How have "we" done? By we, I mean not only the Federal Executive but also those in state branches, Standing Committees and the plethora of informal committees. Demands on peoples' time with the setting of ASEG guidelines have been quite onerous recently - with the expectation being that the future will be much easier. (Trust me!). Only time will tell, but for now I cannot express too many thanks to all those involved - in particular, to members of the present and past Executives. It will be interesting to see how it all pans out.

All the best to the ASEG Executive, as it now moves to Sydney for three years, then on to Perth. I foresee the Society continuing to improve in a number of areas - including achieving regular publications at a reduced cost; an increase in continuing education opportunities; an increase in student members and fostering of research. A number of the current Executive will still be involved with the Sydney Executive this year, either formally or informally. Look out for the Executive to incorporate more people from interstate, participating in decision making and meetings by means of the telephone and email.

Finally, I say it has been great fun working with the Society - "So Long, And Thanks for All the Fish'.

PS My recent "offer" of a bottle of free Grange Hermitage has brought some reaction - people actually read the column! Look in the last (Preview 78) editor's column for how we will make amends.

Noll Moriarty
President

1999 Corporate Plus Members

Geoterrex Dighem Pty Ltd
MIM Exploration Ltd
Mincom Pty Ltd
Oil Company of Australia Ltd
Velseis Pty Ltd
Veritas DGC

1999 Corporate Members

Aerodata Holdings Limited
Anglo America Corporation
Ashton Mining Limited
Australian Geophysical Surveys Pty Ltd
BHP World Minerals
Boral Energy Resources Limited
Earth Resource Mapping
ECS International Pty Ltd
Geo Instruments Pty Ltd
Geosoft Australia Pty Ltd
Haines Surveys Pty Ltd
Kevron Geophysics Pty Ltd
Maytex Pty Ltd
Normandy Exploration
Pasminco Exploration
PGS Australia
Primary Industry & Resources South Australia
Quantec Consulting
Rio Tinto Exploration
Schlumberger Australia Pty Ltd
Scintrex Pty Ltd
Terracorp Pty Ltd
Tesla-10 Pty Ltd
West Australian Petroleum Pty Ltd
Western Geophysical / Baker Hughes
Woodside Offshore Petroleum Pty Ltd
Zonge Engineering & Research Organisation

ERRATA

PREVIEW 78

Three student abstracts used in the CRC index were accidentally omitted. They will be published in a future edition.

The front cover has a spelling error to test observant readers.

PREVIEW 77

Peter Watson can be contacted via georisk@tpgi.com.au. Peter is an independent exploration advisor.

Executive Brief

Since this is the final Executive Brief that I will compose, I would like to take this opportunity to acknowledge Noll Moriaty's enthusiasm and commitment to his role as President over the past year. As reported last Preview, Noll was the main driver in developing a business plan for he society. Noll was also instrumental in setting up guidelines for the financial activities of the Society at both Federal and State levels. The plan and financial guidelines have received a great deal of positive feedback from the state branches and in the words of Kevin Wake-Dyster (ACT Branch President), "the plan(s) provide guidelines for growth of the Society, and hopefully in the longer term, a very solid base for geophysics in Australia". Thanks, Noll!

To ensure a fair representation of the states on Executive matters, the Federal Executive has established several informal sub-committees (such as Web-Site, Publicity, Membership committees) to augment the current formal subcommittees (such as the Publications and Conference Advisory committees). Volunteers from all states were sought and the response was tremendous. These subcommittees will also provide continuity through the changeover of the Federal Executive to Sydney.

I also extend thanks to the Secretariat, Glenn Loughrey at Dellaraine Association Management Services. He took on a difficult job and we have emerged with a solid database and sorted through many outstanding requests Glenn will remain the Secretariat for the new Sydney Executive.

Conferences

The final report from the Hobart conference is almost complete and indications are that the conference will provide a surplus of $80,000-$90,000. As detailed the Business Plan (see the ASEG Web page) this surplus is essential to balance expenditures on other activities of the society, particularly Publications.

Membership

Five resignations were received during March. Almost half our members have not yet paid their dues for 1999. These members should have received a final reminder notice and will not be sent any publications until their membership is renewed. The following figures show the break up of financial and non-financial members at March 1999 (non-financial numbers shown in brackets).

All Categories	771	(609)	
Active		528	(350)
Associates		185	(163)
Corporate Plus	3	(4)	
Corporate		16	(9)
Honorary		14	
Students		23	(83)
Life Members		2	

Financial Status

The financial status of the society at March 1999 is as follows:

Premium business account	= $74,794.66
Term Deposit (CBA Commercial Bill)	= $100,000
Cash Management (Sands 0079 1475)	= $10,267.61
Term Deposit (Sands 5008 4219)	= $40,000
Current Liabilities	= $10,922.81
Net Cash:	**~ $164,000**
Trust Monies:	~ $50,000

Robyn Scott
ASEG Hon. Secretary

Personality Profiles

MIKE SMITH

ASEG PRESIDENT

Mike Smith has worked as Chief Geophysicist or Exploration Manager for public companies throughout Australia and the Western Pacific region as well as in Europe and South America. He has over 25 years experience in exploration for a wide range of commodities and deposit styles. He is a Registered Professional Geoscientist in the fields of Mineral Exploration and Geophysics.

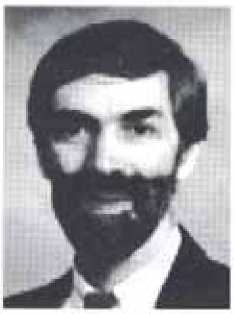
Mike holds a B.Sc. (Hons 1) and and M.Sc. from Sydney University and gained initial geophysical experience at the Bureau of Mineral Resources. He spent 14 years with Exxon Minerals Company based in Sydney, Perth, New York and Madrid with responsibilities for the design, implementation and interpretation of ground and airborne surveys in many countries. In August 1985 Mike joined Austpac Gold NL as Exploration Manager of the company's gold exploration programs in PNG, Solomon Islands, Vanuatu, Fiji and New Zealand, later expanding these activities to Japan, the Philippines and Bolivia. In March 1996 he joined Geo Instruments as Manager for Marketing and Sales of helicopter-borne electromagnetic, magnetic and radiometric surveys.

Mike served three terms as President of the Australian Institute of Geoscientists (AIG), two terms as Vice-President and is currently a Councillor. He is a former Vice President and Treasurer of ASEG and has served on many conference and symposium organising committees of AIG and ASEG.

An ongoing interest in sport and local sports administration led to the election as inaugural President of the Manly Warringah Baseball Umpires Association where he is about to commence his third term. He commenced playing baseball at Sydney University and has been an umpire for 9 years, and is accredited at Level 1 by the NSW Baseball Umpires Association. Why this interest? Mike says, "Umpiring is about decision making. You make 200 to 300 decisions per game with less than 10 seconds each time to vocalise and signal your judgement and you have to get it right every time. Continued training is a key element. Teamwork with fellow umpires and intelligent control of players and managers are others. The umpire's view of the game is the best in the house and it is a pleasure to watch athletes execute the skilful plays required of baseball". Mike continued playing baseball until this year when persistent messages from his knees ("Play golf, play golf") were finally heeded.

BRIAN SPIES

1ST VICE-PRESIDENT



Brian has had an exciting and varied career in exploration geophysics. First exposed to geophysics in high school, he discovered that the combination of geology and physics offered the optimum balance of fieldwork and science, and pursued appropriate courses at university (UNSW). His early career with the Bureau of Mineral Resources (1971-1979) included pioneering work on the transient electromagnetic (TEM) method in Australia and culminated in exchange visits to the USSR and a Ph.D. from Macquarie University.

In 1980 Brian moved to the USA, where he worked in mineral exploration in Colorado and California and was a visiting assistant professor at the University of California at Berkeley. He joined Arco Oil and Gas' research centre in Texas in 1984 and expanded his interests to seismology and petroleum reservoir characterisation. In 1989 Brian received ARCO's highest technical award for developing a TEM system for pipeline corrosion detection.

Brian moved to Schlumberger-Doll Research in Connecticut in 1990, where he led development of deep-probing electromagnetic borehole techniques for reservoir imaging and worked on reservoir monitoring with permanently-emplaced sensors. In 1996 Brian returned to Australia to assume the position of Director of the Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET).

Brian is an energetic promoter of the science and profession of geophysics and holds numerous editorial and honorary positions. He served as Secretary-Treasurer of the SEG in 1966, and currently has editorial roles with Geophysics, the Journal of Applied Geophysics, and Petroleum Geoscience. Brian was awarded Life Membership in the SEG in 1996, largely for his work in electronic communication, and was elected a fellow of the Australian Academy of Technological Sciences and Engineering in 1998. Last year he organised the highly successful AEM'98 conference in Manly (co-sponsored with the ASEG), and the visualisation workshop at the ASEG conference in Hobart. Brian has over 40 publications and 8 patents.

Brian is looking forward to serving the ASEG over the coming years with the Sydney-based executive committee, and strengthening the society and profession during the current economic downturn. His wife, Pamela, and two delightful daughters, Lexi and Anna, are pleased to be back in sunny Australia.

Calendar Clips

1999

June 7-11	EAGE Annual Meeting Helsinki
Sept 28 - Oct 1	SAGA/SEG Conference Cape Town
Oct 27-29	3D EMT Conference Salt Lake City
Oct 31 - Nov 5	SEG Convention Houston

2000

March 12-16	ASEG 14th Conference Perth
May 23-26	GPR 2000 Gold Coast

Preview Deadlines – 1999

June	May 15
August	July 15
October	September 15
December	November 15

Society Briefs

Membership Matters

It is nearly one year since I took over the responsibility of ASEG membership in Federal Executive. About that time there was a sudden move of the secretariat, which was not without difficulty. The database had to be transferred to the new secretariat that had different software; there was a backlog of processing of membership applications; the fax and e-mail were sometimes down during the transition. The new secretariat settled these matters quickly, but there were some information gaps and we had a few complaints to handle.

Membership Growth

Through the last seven years I have been in the Federal Executive, the ASEG has been receiving about fifteen new member applications a month on average. There are ups and downs in the number of applications. We receive many applications from university and college students during March and April. ASEG events, such as the Conference and the DISC seminar boost membership applications. A recent success is the promotion of the ASEG booth at the SEG conferences. We have also received several applications and enquiries through our Internet home page.

As the membership in 1992 was a mere 1000, a simple calculation of $15 \times 12 \times 7 = 1260$ leads to a conclusion that the membership number has more than doubled in seven years. Wrong! As seen in the last Preview the real membership growth in this period is only about 35 percent or 350 members. This is because we are losing members on the other hand. However, for as long as I can remember there have only been two resignations reported in the last seven years. Others just drop off from the Society without notice.

Lost Members

In many cases, the members simply disappear from their address. Perhaps this is due to the dynamic nature of our industry. Companies moving, internal transfers, company take-overs and retrenchments are common, and all cause members to move. Exploration Geophysics, Preview or a renewal notice comes back to the secretariat with a "Not At This Address" stamp. The secretariat and the publisher compile a list every month. Then we try to contact their old employer or old address by telephone, fax and e-mail to find the members' new contact. Having friends and acquaintances in the industry helps to track them down. But it is not always easy.

In large companies, particularly multi-national organisations, the receptionists do not know the movement of individual staff. Even if a member is transferred within the company, our correspondence is not always forwarded. Perhaps it is easier for the mail-handler to use a "Return to Sender" stamp than to look for a forwarding address. There are also cases of resignation or retrenchment. In such cases, phoning the company is often of no use. "Sorry, there is no person of that name in this company" is a common answer. Sometimes, I am greeted by a fierce stubbornness.

"I am calling from ASEG about Mr X,"

"He is no longer associated with us,"

"So, will you tell me his new contact address to send ASEG membership renewal?"

"Cancel his membership. Company has been paying for him, and he is no longer with us,"

"Well, whoever pays, it is his personal membership. Any idea where I can contact him?"

"I suggest you to check White Page."

"But I am calling interstate and I don't have a copy of phone book of your city."

"Sorry, I cannot help you."

... I wonder if Mr. X had a fight with the company, which led to his resignation.

Some companies may have guidelines not to disclose personal contacts of employees or ex-employee, but it should be overridden for genuine enquiry for his/her benefit. The Internet White Pages are great. I found many missing members through them. But if the missing member's name is Smith or Jones, it is of no use. I also found the database is often out-of-date.

If I have a friend in the company or I can find another geophysicist in the ASEG Membership Directory, I may phone them to find out what happened to this missing member. This often works. Colleagues usually know where they have gone. But when an entire company disappears from the industry, it is worse. I try to trace to a certain extent, but I may hit a brick wall. Information such as "I think he moved overseas" would stop the search. Sometimes, but not often, a missing member's new contact is found in the Yearbook of SEG or EAGE.

State Contacts

In the past, I asked state committees to search for the missing members. This has not been very successful. I thought that the state network should be tighter. The ASEG is implementing a new system where a membership contact person is assigned in each state committee. I hope this will establish better communication between the secretariat database and the state branches and between state branches and members.

So please inform the ASEG secretariat of your change of address or job. This ensures your continuing membership and receipt of publications. If you decide to resign from ASEG, please let us know. It will save us effort in maintaining the database.

Renewals

ASEG membership works by calendar year. We send out renewal forms in December. A directory entry form is attached in the renewal form. This forms a basis of the Membership Directory, a supplement to this issue of Preview. At the time of editorial deadline just over 50% of the memberships due have been paid. The entry of the members who did not return the directory form could not be updated. If the due is not paid by June, the membership will be automatically cancelled and no more publications will be sent to them. Yes, we do send reminder notices but we cannot continue sending them forever. Once membership is cancelled, you will not receive a renewal notice for the following year for the obvious reason.

Directory

The ASEG Membership Directory provides a means for members to keep in touch. Since 1996, it included e-mail addresses. The 1998 version was expanded with membership category, employment area and fields of interest for individual entry, geographical list and corporate directory section. You may have noticed a somewhat awkward format and inconsistent listing of telephone numbers in that directory. It reflected the status of the then database.

This year, the corporate directory section has been expanded to a service directory. Consultants and service providers are sorted by State, so that those who are looking for a service may find it easily. All the telephone and fax numbers in Australia were converted to new 8-digit numbers with 2-digit area code. Overseas numbers are listed with a + sign for ISD access code. It was a tedious task. Bulk change would not work for everything!

Foreign addresses were hard to make right. Some countries have two or more ways to identify them: England and UK; Holland, Netherlands and The Netherlands. It took me a while to find RSA is Republic of South Africa. NT is not only in Australia, but also New Territory of Hong Kong; WA is also in USA.

I hope the 1999 directory proves useful.

Koya Suto
Koya.Suto@oca.boral.com.au

Treasurers Report - 1998

The role of Treasurer of the ASEG proved to be very interesting in 1998. Not only did I have absolutely no idea what I was doing for the first few months, but also this strange beast called a budget reared its ugly head for the first time. No matter how hard the Federal Executive tried, this tiger was not to be tamed. Income and expenditure were their own masters.

Seriously, the advent of the budget was probably one of the more far-sighted ideas the ASEG has had in recent times because it has provided us with a tool by which to monitor the financial health of the society. The great benefit of a simple list of figures like this is that it enables anyone to quickly see where there exists a lack of understanding with regard to financial incomings and outgoings and to react accordingly. Another benefit of implementing a budget was it led to the conclusion that the ASEG needed a series of goals for the future which in turn led to the machinations of the Business Plan.

As can be seen from the 1998 budgeted and actual figures, there are certain areas such as membership and secretariat where we have a good understanding of our financial transactions. Conversely there are areas where our understanding is not so good and one of the great outcomes of the budget process is that these areas are now being addressed. Whilst the 1998 deficit of ~$100,000 looks terrible, it should be noted that in any year that has no proceeds from a conference, a loss will occur based upon the ASEG's current financial model. Effectively 1998 was a non-conference year from a financial perspective due to the profit for the Hobart conference being received in 1999.

A few categories that were not allowed for in the original 1998 budget were the member's handbook and insurance. The recently purchased publicity stand, which has featured prominently at conferences around the world, "blew" the publicity budget.

It is predicted that the implementation of the Business Plan will stabilise the financial status of the society, such that a small surplus will occur in a couple of years.

On a different note, the role of the treasurer has changed considerably over the last couple of months with a part-time accountant now doing the ASEG bookkeeping as well as preparing the end of year financial statements. It is expected that this change will enable the treasurer to spend more time exploring for ways to expand member benefits and less time fighting financial fires.

I would like to take this opportunity to thank all those people who have assisted me during my tenure as treasurer or who have provided ideas and criticism as to how the financial side of the ASEG can be managed better.

Grant Asser
Honorary Treasurer
Grant.Asser@oca.boral.com.au

1999 ASEG BUDGET

INCOME	1998 BUDGET	ACTUAL	1999 BUDGET
M'ship-Personal	84,200	76,000	79,000
M'ship-Corporate	25,000	28,000	32,000
Conference	50,000	20,000	60,000
Expl. Geophysics	64,500	32,000	50,000
Preview	39,100	29,000	72,000
Handbook	0	7,000	20,000
Interest	8,300	10,100	10,500
Total Income	**271,100**	**202,100**	**323,500**

EXPENDITURE	1998 BUDGET	ACTUAL	1999 BUDGET
Preview	70,700	85,000	95,000
Expl. Geophysics	57,400	60,000	100,000
Handbook	0	5,000	10,000
ASEG Res. Foundation	54,000	52,400	55,000
Secretariat	39,700	42,000	42,000
Accounting Fees	16,600	15,000	7,000
Perth 2000 Conf (loan)	10,000	10,000	0
Capitation	9,600	11,340	11,000
Administration	5,300	10,000	10,000
Publicity & Awards	3,200	14,500	5,000
Insurance	0	3,000	3,000
Continuing Education	0	0	6,000
Special Projects	0	0	10,000
Total Expenditure	**266,500**	**308,240**	**354,000**
SURPLUS / LOSS	**4,600**	**-106,140**	**-30,500**

ASEG Branch News

Queensland

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1999 so far has been a flurry of activity for the Queensland Branch. The Branch AGM was held in Brisbane during February. A big thank-you to the outgoing committee members – Andrew Davids (President), Troy Peters (Vice-President), Kathlene Oliver (Secretary), Grant Asser (Treasurer), and Natasha Hendrick, Damian Kelly, Rick Smith and Wendy Watkins. Over the past year these volunteers have coordinated five technical meetings, the Queensland Branch Golf Day, a Student BBQ and a Student Presentation Night, as well as hosting the SEG Distinguished Instructor Short Course. The Branch has also recently started work on its webpage http://www.aseg.org.au/qld. Newly elected committee members for 1999 are: Andrew Davids (President), Troy Peters (Vice-President), Kathlene Oliver (Secretary), Grant Asser (Treasurer), Natasha Hendrick, Gary Fallon, Wayne Stasinowsky, Wendy Watkins and Fiona Duncan.

This year's activities started off with a Conference 2001 BBQ. If you haven't already volunteered to be a part of the ASEG 2001 Conference Organising committee its not too late! Any offer of help is welcomed in the following areas - technical papers, exhibition, sponsorship, workshops and publicity. You can help make our conference a highly successful and memorable event.

During April we will be hosting the Federal AGM. We hope to see many members join in the farewell of the Federal Executive from Queensland and show their appreciation of the time and effort all Executive members have put into their volunteer roles over recent years. We wish NSW Branch all the best in its responsibility of coordinating our organisation over the next three years.

Our next Branch gathering is the Exploration Geophysics Career Night and BBQ being held Tuesday 11 May at the University of Queensland. All university students interested in finding out more about Exploration Geophysics are welcome to attend. Professional members of ASEG are also welcome to attend to meet students and socialise with colleagues. Come along for a fun and relaxing night.

We'll keep you posted on additional Branch Activities via our webpage. Stay tuned!

New South Wales

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Secretary: Dave Robson
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On 18 March 1999 the New South Wales branch held its AGM and monthly meeting. Timothy Pippett was in the chair. In addition to the usual brief reports, Tim made a presentation to Lindsay Ingall - a special citation and the ASEG Service Medal in recognition of Lindsay's long and meritorious service to the ASEG. Lindsay was a founder member of the Society, and has served in a variety of executive roles.

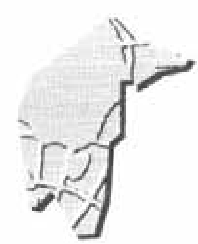
There was a last-minute change in speaker due to an inability of the previously advertised speaker to be present. However, Peter Hatherly stepped into the breach and presented a most informative talk on his seismic and rock stress studies, especially in the Southern Coalfield of the New South Wales. (By coincidence, there had been a noticeable earthquake near Appin just before the talk!)

A new committee was elected (listed below). A big thank you for the work of the outgoing committee.

State Committee:

Richard Facer	Phil Schmidt
Jodie Gillespie (Secretary)	Mark Lackie
Katherine McKenna (Treasurer)	Nigel Jones
Keeva Vozoff	Tim Pippett

ACT



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VicePresident: John McDonald (08) 9266 7194 / Fax: (08) 9266 3407
Treasurer: Bob Groves (08) 9279 6456 / Fax: (08) 9279 6456

Technical and general meetings held every third Wednesday of each month at the Celtic Club, 48 Ord Street, West Perth, from 6pm.

Februrary 1999:

Speakers:

Tom Ridsdill-Smith, UWA	*"Wavelet transforms and space-frequency analysis"*
Marianne Rauch, CGG	*"Cape Ford-1, an example of the consequences of true amplitude processing for inversion to acoustic impedance and porosity prediction."*

Technical Meeting sponsored by CGG

Recent Workshops:	Hampson-Russell Software Services
Multi-Attribute Analysis	March 8th, 1999
Seismic Inversion	March 9th, 1999
AVO Analysis	March 10-11th, 1999

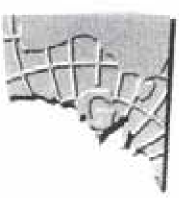
March 1999:

Speakers:

Mark Murphy, Byfields	*"Trust and Companies Tax Structure – Tax Planning Strategies"*
Alan Stein, IKODA	*"More For Less - 3d Seismic - Changing The Paradigm"*

If your company would like to advertise at future meetings please contact one of the persons above about sponsorship possibilities.

South Australia



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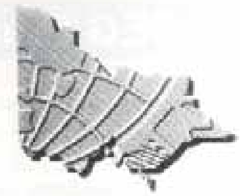
Not all that much to report from the SA branch since we last wrote. 1999 has started on a bit of a slow note. We are looking forward though to the resumption of our monthly meetings starting in April.

We held our AGM on the 2nd of March. There aren't too many changes among the office bearers, although there are some new faces on rest of the committee.

Looking forward to seeing quite a few of you at talks during the next few months.

Victoria



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3-Dimensional Treatment of Inverted Induced Polarisation Data

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Abstract

Even though there has been an increasing usage of modelling methods for certain geophysical data, especially resistivity and chargeability data from Induced Polarisation and CSAMT (Controlled Source Audio Magneto Telluric resistivity) surveys, the data are still normally presented as two-dimensional sections. This paper describes how data from an I.P. survey were modelled in three dimensions to give a solid model of the electrical properties of a prospect, and simple tests to gain confidence in the model.

Introduction

Mount Wellington Gold NL holds exploration licences covering approximately 500 square kilometres in the eastern highlands of Victoria. The target mineralisation is gold and base metals in a volcanic hosted massive sulphide setting, similar to that occurring in the Mt Read Volcanics in Tasmania.

Mt Wellington has identified seven areas of anomalous mineralisation in the Cambrian Barkly River Greenstones, a package of andesitic to rhyolitic lavas and associated sediments. The principal prospect, Hill 800, is located within a mixed package of andesite lavas, intrusives and andesitic sediments, and is located in EL 3592, north of the Jamieson River - see Figure 1.

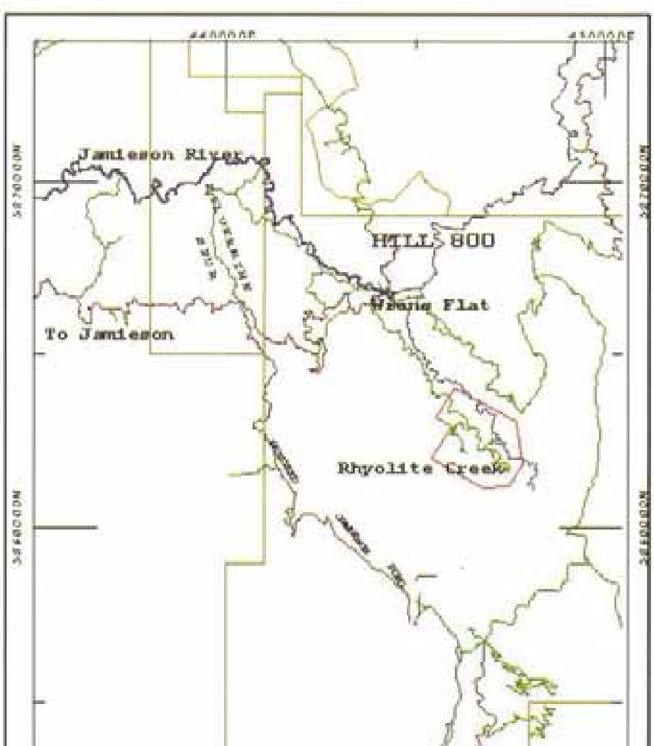

Figure 1. Location Map.

The Hill 800-Hill 700 ridge rises 300 metres above the Jamieson River, with hill slopes around 20° but commonly 30° with cliff faces in some areas. The hill is covered with eucalypt forest, and a thick lower storey scrub necessitating the cutting of grid lines by hand for access.

Hill 800 mineralisation is characterised by strong silica+sericite+pyrite alteration, principally of the sediments, and carries gold ranging from 0.2 gm/tonne to over 100 gm/tonne over intervals from 1 to 50 metres. The gold is finely disseminated throughout the more strongly altered zones, and visible gold is quite rare. The pyrite occurs as very fine disseminated grains and clots, but can also occur as semi-massive brecciated pyrite up to 2.5 metres thick in drill core. The higher gold grades are associated with strong silica "flooding" alteration, with up to 20% very fine disseminated pyrite. Copper occurs as disseminated grains of chalcopyrite in some of the pyritic zones, but more commonly as thin (1-2 cm) stringer replacement veins in less altered lavas. Copper intersections to 2% have been recorded. (Turner, 1996 and Cherry, 1998).

The principal exploration strategy is based on geological mapping and geochemistry, but geophysics has been used on 5 prospects, and extensively on the Hill 800 Prospect (Turner, 1998). The topography and vegetation cover deter the use of some geophysical methods, such as moving loop EM, and Induced Polarisation developed as the preferred geophysical tool due partly to its relative ease of use.

Induced Polarisation Survey

An I.P. survey was undertaken in 1997 over the Hill 800 and Hill 700 (1 kilometre south) prospects in order to map out the pyrite alteration zone. The survey was a 100 metre dipole-dipole on east west lines 200 metres apart using the time domain method. The contractor was Geoterrex Pty Ltd using a VIP 3000 transmitter, and data were recorded with an ELREC6 receiver. Eight lines approximately 1600 metres long were surveyed over a 12 day period. Pseudo-sections were supplied on a daily basis by the contractor, as were the original data files.

Interpretation

The chargeability pseudosections showed only weakly anomalous areas, and were most disappointing across the areas drilled where we knew there was strong pyrite mineralisation. Chargeabilities reached 13 msec over backgrounds of 5 to 8 msec, and the typical "pants-leg" structures were poorly developed. However, a strong chargeability anomaly to 30 or 40 msec developed on the

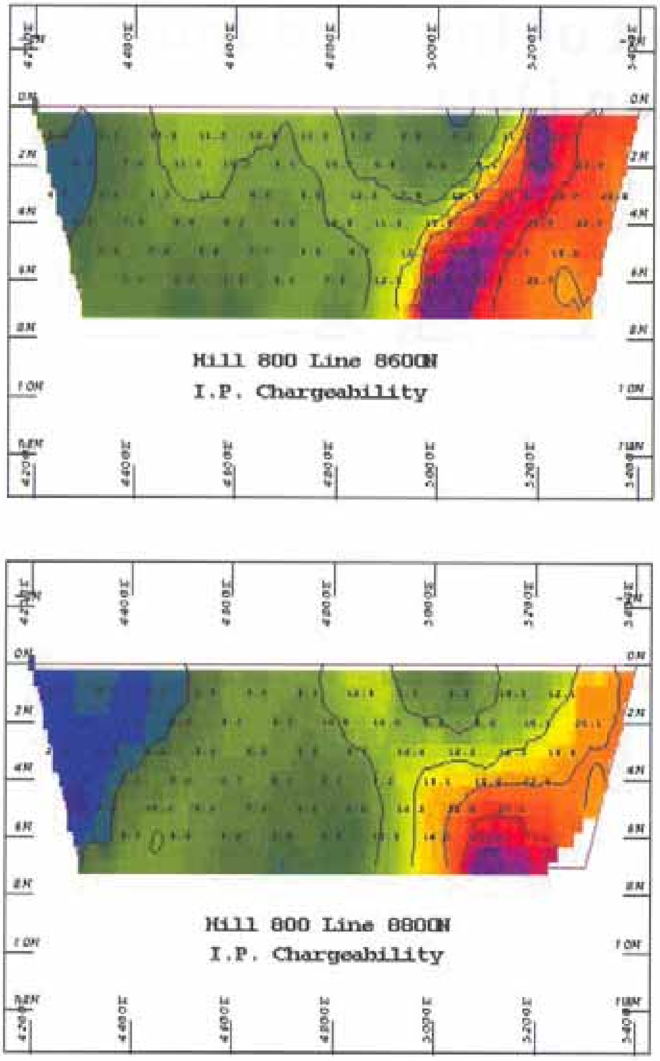

Figure 2. I.P. Chargeability Pseudosections. A weak "pants leg" structure is noted on line 8800N, and only a subtle response is seen in the mineralised zone in line 8600N. The eastern anomaly (>20 mrad, red-magenta) is thought to be due to black shales on a faulted contact.

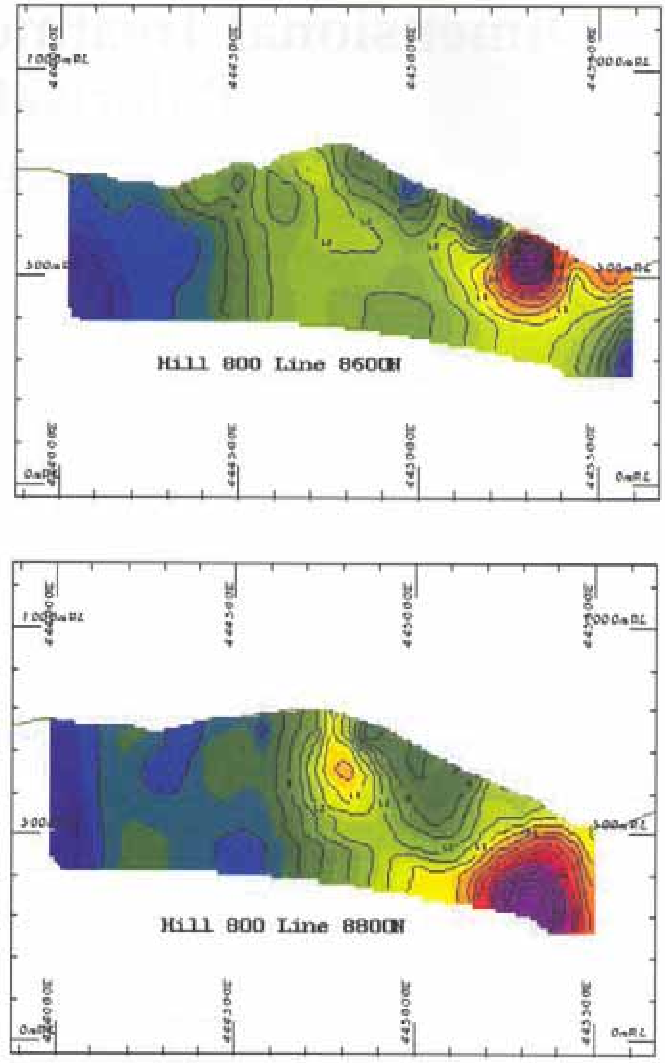

Figure 3. Inverted Chargeability data for lines 8800N and 8600N. The blue shading denotes chargeability values in the range 0 to 4 msec, increasing through green and yellow to magenta at 30 msec. Note the development of a significant anomaly at around 4800E on Line 8800N. Gold rich gossans outcrop at 4700E on line 8600N, where drilling to at least 100 metres depth intersected variable concentrations of very fine grained disseminated pyrite.

eastern ends of the three northern most lines, which is suspected to be caused by a sequence of black shale. *See figure 2 Lines 8600N and 8800N.* Lines at Hill 700 (lines 7600N and 7800N) showed only slight increases in chargeability from 2 msec (background) to highs of 4.5 to 5.0 over the known mineralised area.

The resistivity pseudosections were equally difficult to interpret, but abrupt changes in resistivity in some lines were readily apparent. Subtle changes in resistivity and chargeability were complicated by the steep topography of the prospect.

The data were later modelled using the RS2DIP Smooth Inversion algorithm developed by Zonge Engineering and Research Organisation. This algorithm uses a 2 dimensional finite element method which incorporates topography in modelling resistivity and chargeability data by 'inverting' the data to produce a best fitting electrical model of the geology (MacInnes and Zonge, 1996). Figure 3 shows the resultant sections produced from the pseudosections in Figure 2.

Zonge supplied printed cross sections as well as the modelled data.

The modelled sections did not show significant increases in chargeability in the known mineralised area (from 8600N to 8750N, at around 4750E), but there were some patterns in the resistivity results to suggest that the geology had been reasonably well modelled. The stronger chargeability zone on line 8800N at around 4850E (Figure 3) was targeted by diamond hole HED3 which intersected only weakly mineralised but strongly sericite altered volcanics at 150 m down hole.

The mineralised zone at Hill 700 was only poorly outlined.

As the modelled data did not produce any strong targets, apart from the 8800N 4850E high chargeability zone, the results were shelved in favour of geochemical and geological data which were considered to be more reliable at the time.

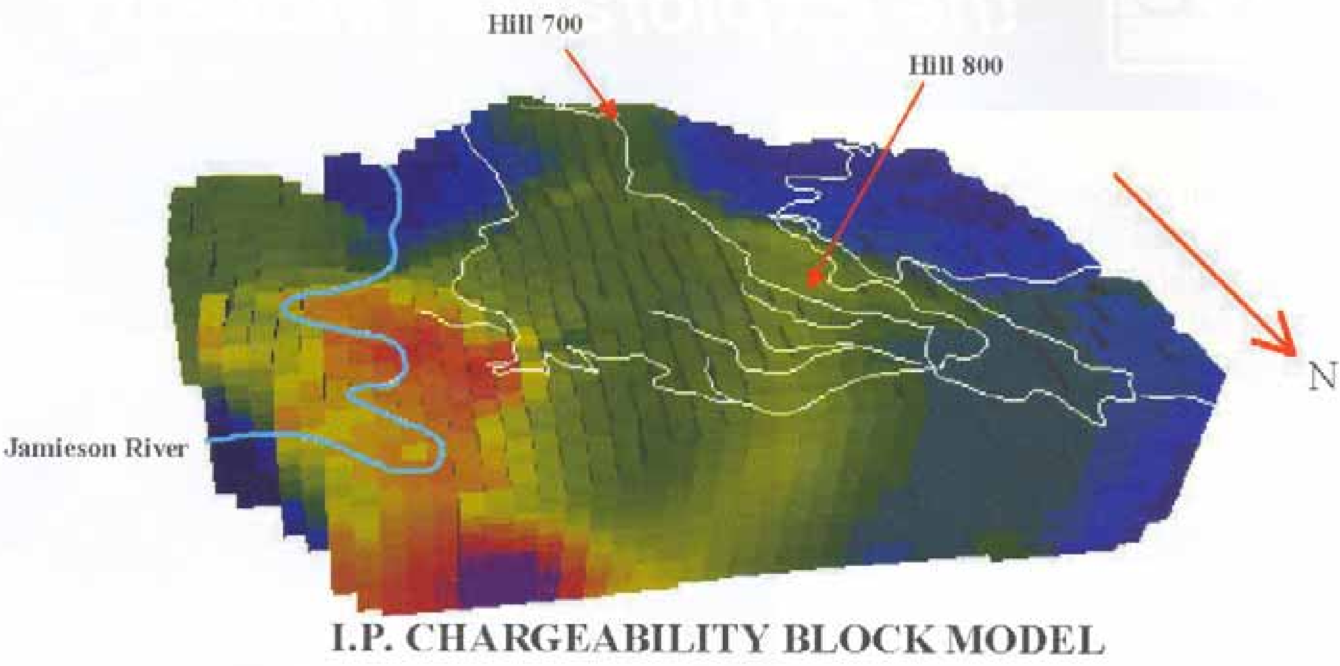

Figure 4. I.P. Chargeability Block Model - perspective view from the north-east. A 3-dimensional block model of the IP chargeability response of the rock units to a depth of around 400 metres. The model has been corrected to conform to the topography of the Hill 800-Hill 700 ridge, and the Jamieson River (blue) and tracks (white) overlain on the surface. The lowest chargeability areas are in the darker blue, grading through green and yellow to the highest chargeability in deep purple. To date, only the areas of medium chargeability (green-yellow) have been drilled.

3-D Modelling

The modelled data were revisited early in 1998 when it was decided to try presenting the 2-dimensional IP data in three dimensions. The Micromine® 3-D Block Modelling algorithm (Mmine ver. 7) which is normally used for ore block modelling of drill results was used, with the following parameters:

method of block calculation	inverse distance squared,
data search	sphere with 200 metres radius,
block size	50 metres horizontal, 20 metres vertical

The block model was then stripped of blocks that were calculated above ground surface using the standard Digital Terrain Model of the area. The resulting solid model of both Resistivity and Chargeability (see Figure 4) could then be displayed in plan or section, with oblique sections possible. One feature that gave confidence in the method was the presence of NE striking zones of moderate (10 to 15 msec) chargeability that corresponded to a similar trend in surface rock geochemistry. It soon became apparent, after selecting a suitable colour range to show the weak variations in chargeability, that the I.P. survey had detected the zone of disseminated pyrite and was now clearly visible in the plots as green in these figures, corresponding to a chargeability range of 10 15 msec. The Resistivity model clearly showed a major fault located west of the Prospect as a clear contrast in resistivity. This fault was already known to the project geologists, and sections cut normal to this fault gave a probable dip.

Confidence in the model was given a significant boost when the geochemical database was re-visited. Contouring of the gold in soil geochemistry produced a S-shaped outline, with the long limbs representing the

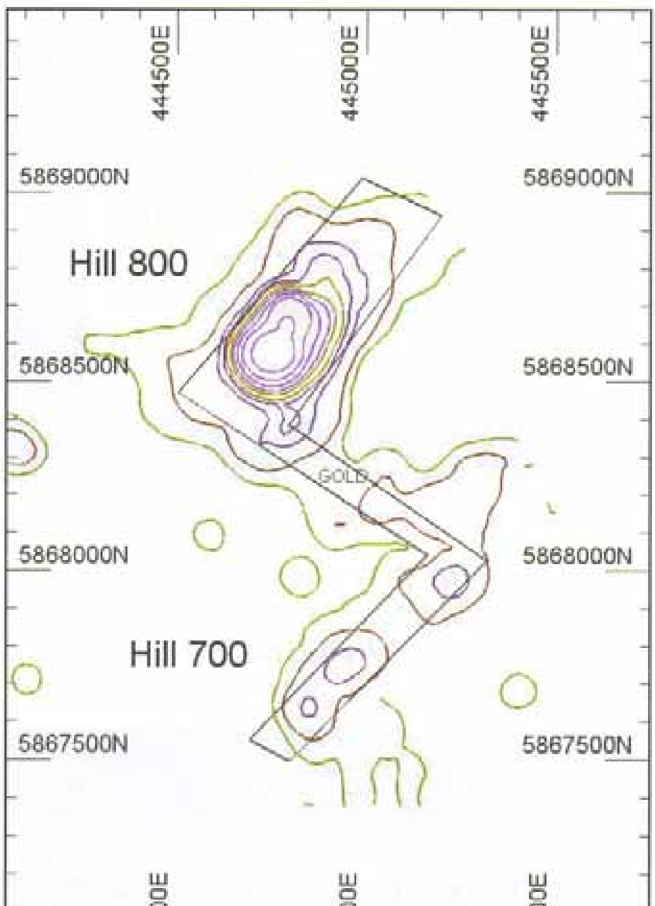

Figure 5. Plan showing gold in soil contours (minimum 10 ppb in green, maximum 3000 ppb in magenta) over Hill 800 (northern anomaly) and Hill 700 (southern anomaly), with rectangular outlines superimposed to highlight the mineralised areas.

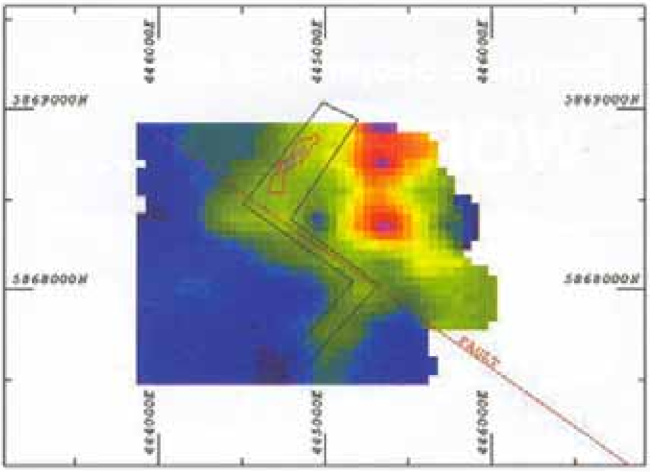

Figure 6. Geochemical outline superimposed over the IP Chargeability model at 400 mRL. The red and magenta outlines enclose surface rock chip sampling greater than 1 ppm and 5 ppm gold at Hill 800. The red line denotes a fault predicted by the geochemistry and geophysics model, and since located on the ground.

separate Hill 800 and Hill 700 anomalies (see Figure 5). An outline following the 15ppb line was strikingly similar to fault displaced gossans on the top of Hill 800, with the same sense of sinistral displacement. A fault was then postulated (and later confirmed in the field) separating the Hill 800 and Hill 700 anomalies, thus leading to the significant conclusion that the two anomalies were an expression of the same mineralised structure, but faulted.

The geochemical outline and fault were overlain on the plan view of the Chargeability block model with some striking similarities (Figure 6).

Discussion

In using this method of block modelling, a number of assumptions had to be made.

- The field data are collected and processed in the receiver. These data are then computer modelled to produce the inverted 2-dimensional model. These processed data are then re-processed to produce a 3-dimensional block model. Any errors in assumptions in using the relevant algorithms can be compounded leading to a purely fictional model.

  In this case, the model was checked at each stage with reality (using geology and geochemistry) to give confidence in each step. It would be presumptuous to assume that this method will work in all cases

- The 2-D inversion program assumes a body of certain electrical characteristics to be of infinite length, and normal to the survey line, whereas three dimensional modelling produced finite length electrical zones oblique to the survey line. This apparent contradiction is not seen as a problem, as the inverted data are used purely as two dimensional sections which are assumed to carry no artefact of the original orthogonal infinite assumption.

- The RS2DIP Smooth Inversion algorithm corrects for topography in 2 dimensions only, and the 3-D block model adjusts for 3 dimensional topography. Correction for topography in 3 dimensions as well as modelling finite 3-dimensional bodies oblique to the survey lines would be the next logical developments in this (inversion) technology.

- The Inverse Distance Squared weighting method was used to calculate values for the blocks. Geostatisticians might argue that this method may be invalid, and a more rigorous statistical approach be used. Also, the block model may be refined once directional parameters can be established, giving more pronounced plunge or strike to the model.

- The block sizes give a coarse picture of the electrical characteristics of the prospect. Large block sizes were used as the survey lines were 200 metres apart - consequently better definition would be obtained by using closer spaced survey lines. As setting up the transmission electrodes is a significant cost of any program, a logical step in the collection and interpretation of I.P. data would be to collect data from lines adjacent to the transmission lines.

Conclusions

This 3 dimensional treatment of I.P. data has been found to be much more useful than the raw pseudosections which were originally considered to have missed the zone of disseminated mineralisation. Judicious treatment of the data at all stages, including the selection of colours to define zones of different electrical character has proved to be fruitful. There is no reason why this method could not be used in other areas where gold mineralisation is associated with weakly disseminated sulphides, such as sediment hosted disseminated gold deposits (in Victoria), or Archaean shear hosted gold deposits, where I.P surveys may produce more subtle responses. There may be a number of such deposits where I.P. has been tried and rejected on the basis that no clearly defined anomaly had been located, and further analysis of rejected data is warranted.

Once confidence in the 3-D block model has been established, not only sections but plans of both Resistivity and Chargeability can be produced. These plans are superior to those produced by gradient array IP in that variations in electrical characters with depth can be easily seen, which gradient array methods cannot produce.

Acknowledgments

The author acknowledges permission by Mount Wellington Gold NL to publish this paper. Thanks are also due to John Bishop of Mitre Geophysics Pty Ltd and Mike Hatch of Zonge Engineering and Research Organisation for reviewing the paper and making editorial suggestions.

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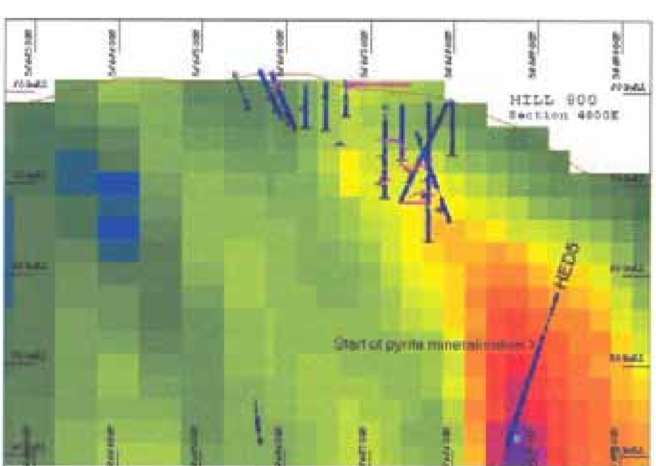
Geoff Turner *has over 20 years experience in mineral exploration within most parts of Australia, and has a Masters Degree in Exploration and Mining Geology from James Cook University. He is currently Chief Geologist with Mount Wellington Gold NL, and is a Registered Professional Geoscientist with the Australian Institute of Geoscientists.*

Post Script

Since writing the paper, we completed an IP survey to infill lines as 100 metres spacing, and extended another 300 metres north of the existing survey. I then block modelled the inverted data using 10 x 10 x 10 m blocks on the infilled area. The new data gave us a very strong IP Chargeability anomaly centred on 4800E, 8900N associated with very high resistivity - a target we could not ignore! Hole HED5 was drilled using the LONG SECTION on 4800E, as shown on the attached section. Sulphide mineralisation was predicted at 180 to 220 metres down hole (drilled oblique to the section), and encountered after a 7 metre fault zone at 203 metres. The mineralisation continued to 330 metres, below the limits of the survey.

This prediction could only have been made through:

1. Using inverted IP data, as the pseudo sections did not give much indication of the anomaly.
2. Using a 3-d block model of the inverted data, as the drill hole was planned using long sections, i.e. sections cut normal to the survey lines.



Airborne Radiometric Corrections: High-Level Background Calibration

P. Robert Groves: prg@iname.com

Introduction

Airborne radiometric corrections have been the subject of increasing scrutiny, over the last ten years, since large-scale, long-term, multiple-aircraft data acquisition became the norm and data processing had to contend with discontinuities in the datasets prior to image processing.

The first correction to be performed on the raw radiometric dataset, prior to any proprietary radiometric processing, accounts for permanent *Aircraft Background* radiation and the *Cosmic Rate* stripping ratio, which describes how the aircraft survey installation scatters incoming cosmic radiation before it strikes the detector. These parameters are most commonly estimated by acquiring data at a set of fixed elevations and away from any ground effects.

Theory & Method

Preferably, an aircraft will fly offshore, with a prevailing sea breeze, at a series of fixed elevations. Typically, these might range from 1525 metres to 3050 metres ASL[1], at 305 metre intervals. The mean cosmic countrate is directly proportional to altitude and used as the independent X-variable in regression.

Each elevation is accompanied by five to ten minute intervals of data acquisition. At these altitudes, and offshore with a sea breeze, there is no terrestrial radiation (from underlying geology) and the likelihood of poor results due to radon corruption is markedly reduced. Radon is a radioactive gas with a half-life of 4.3 days and is a daughter product in the decay series of Uranium U-238, which is geologically significant.

$$Y_i = mX_i + b \qquad (1)$$

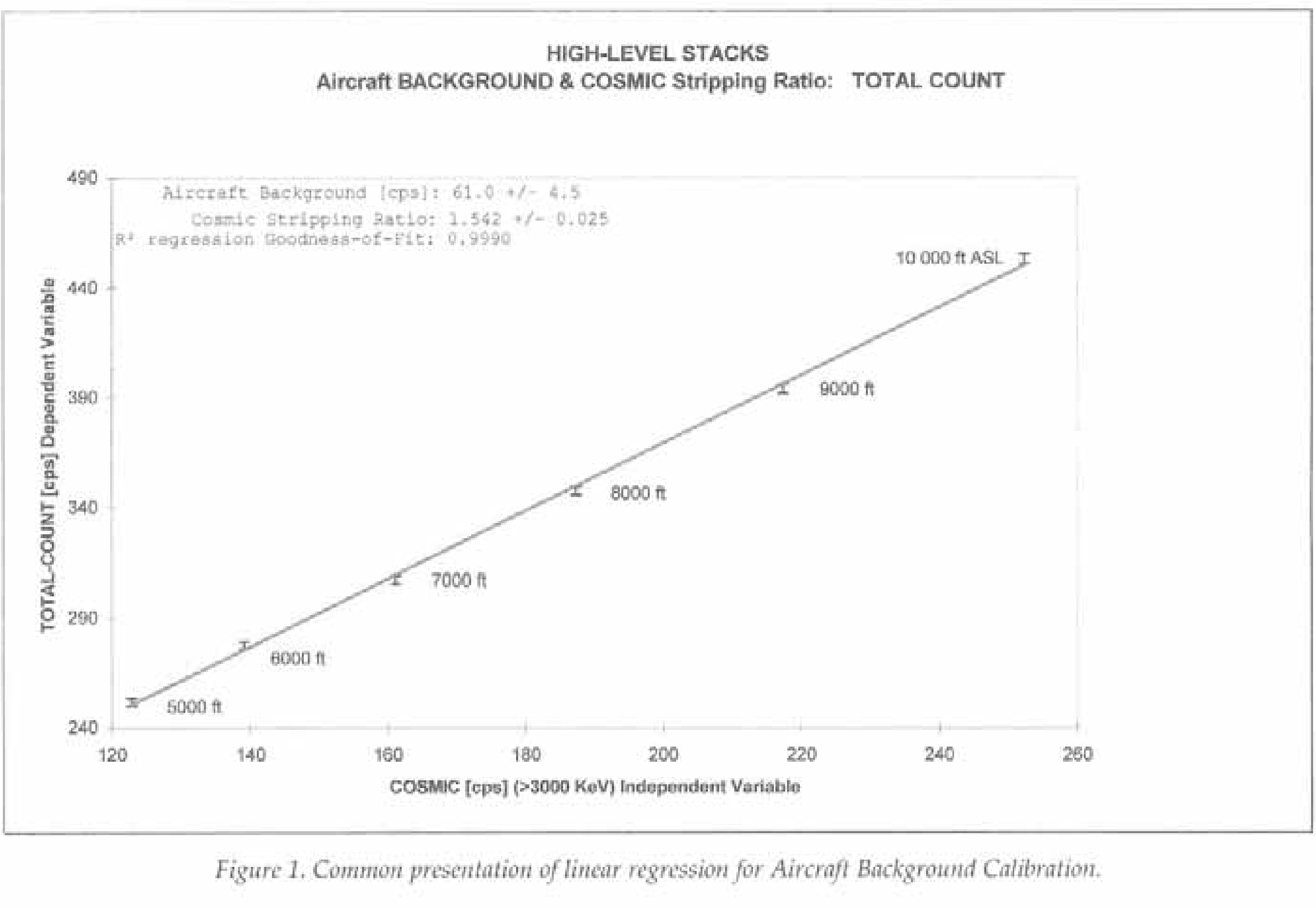


Figure 1. Common presentation of linear regression for Aircraft Background Calibration.

[1] 5 000 feet to 10 000 feet Above Sea Level (aircraft instrumentation is graduated in Feet)

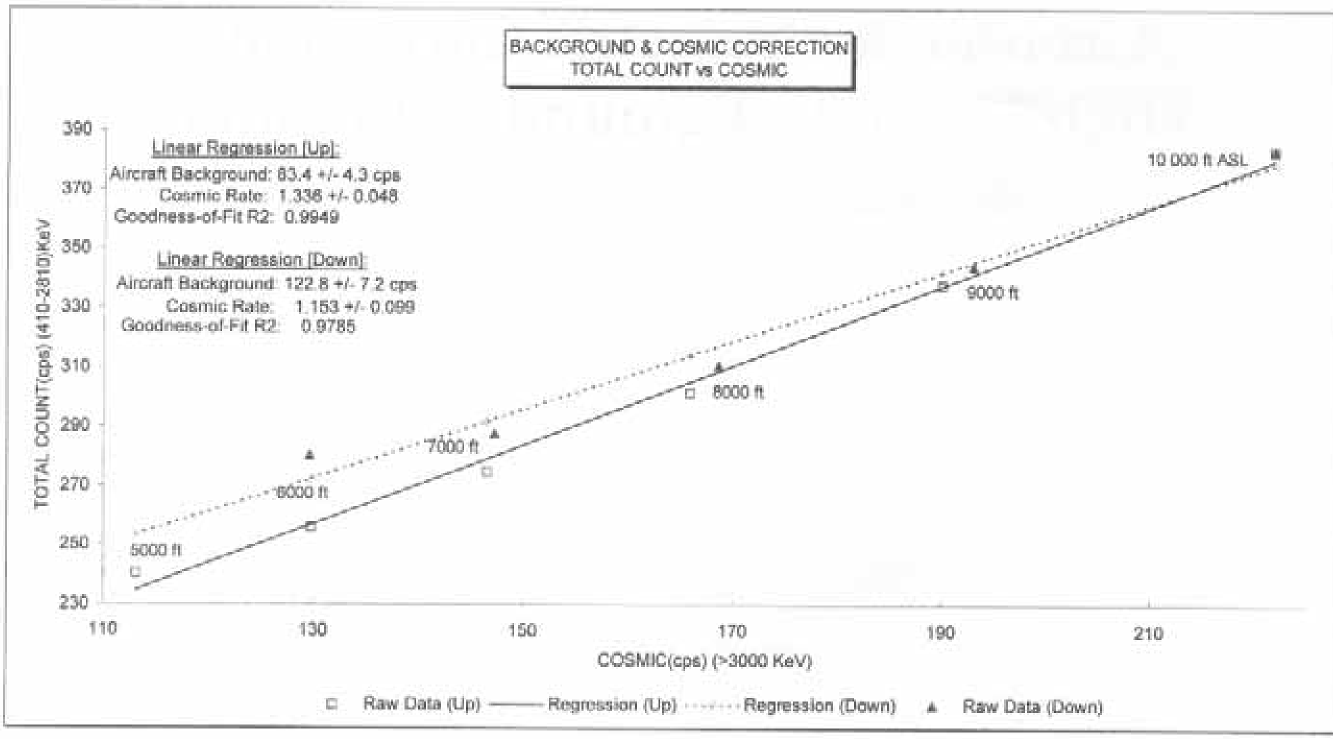


Figure 2. Disparate results from regression of data from a common flight: ascent vs. descent.

The dependent Y-variable observations can refer to any measured spectral window and the *bias* [or Y-intercept] parameter, *b*, of the regression represents the permanent component of background radiation [in that window] that is unchanging at all elevations. The *rate* parameter, *m*, represents the cosmic rate multiplier that is applied to the Cosmic Window countrate to estimate the component of *skyshine* that is incorporated in the simultaneous reading of the spectral window relevant to these parameters.

Assuming the absence of radon, the only source of radioactivity will be that permanently resident in the aircraft and the variation due to impinging cosmic radiation. Acquisition of radiometric data at the suggested elevations will produce a dataset for linear regression as displayed in Figure 1.

The Problem

Current practice relies on past techniques involving calculation of the mean countrate of relevant spectral windows from the dataset acquired at each elevation. But this assumes that the countrate at each elevation is relatively constant. And this has resulted in only a handful of data points used for linear regression.

It can be seen, in Table 1, that the spectral response, to a given cosmic countrate, is not constant but is scattered about the mean. And the theory of radioactive decay (as a Poisson distribution) suggests that the standard deviation of that scatter will vary according to the square root of the mean countrate.

Table 1. The sample standard deviations compare favourably with the square root of the estimated mean countrates which are the theoretical standard deviations.

Cosmic= 128 cps	TC [cps]	U(609) [cps]	K [cps]	U(1762) [cps]	Th [cps]
Mean Countrate:	263.8	49.62	21.60	10.40	10.3
Sample StdDev:	22.43	7.339	4.987	3.443	3.676
Sqrt (Mean):	16.24	7.044	4.647	3.226	3.213

The reliability of averaging the data at each level has been frequently brought into question by results such as those displayed in Figure 2 and Table 2. In this calibration, two datasets were acquired in a single flight by using the standard procedure. One was collected during the *ascent*, while the other was accumulated during the *descent* from high altitude - a method most likely to produce repeatable results.

Table 2. Parameters estimated from independent datasets acquired during the same flight - but still a poor comparison.

Dataset:	UP (5000' - 10 000')	DOWN (>5000')
Aircraft Background:	83.4 +/- 4.3 cps	122.8 +/- 7.2 cps
Cosmic Rate:	1.336 +/- 0.048	1.153 +/- 0.099
Goodness-of-Fit R^2:	0.9949	0.9785

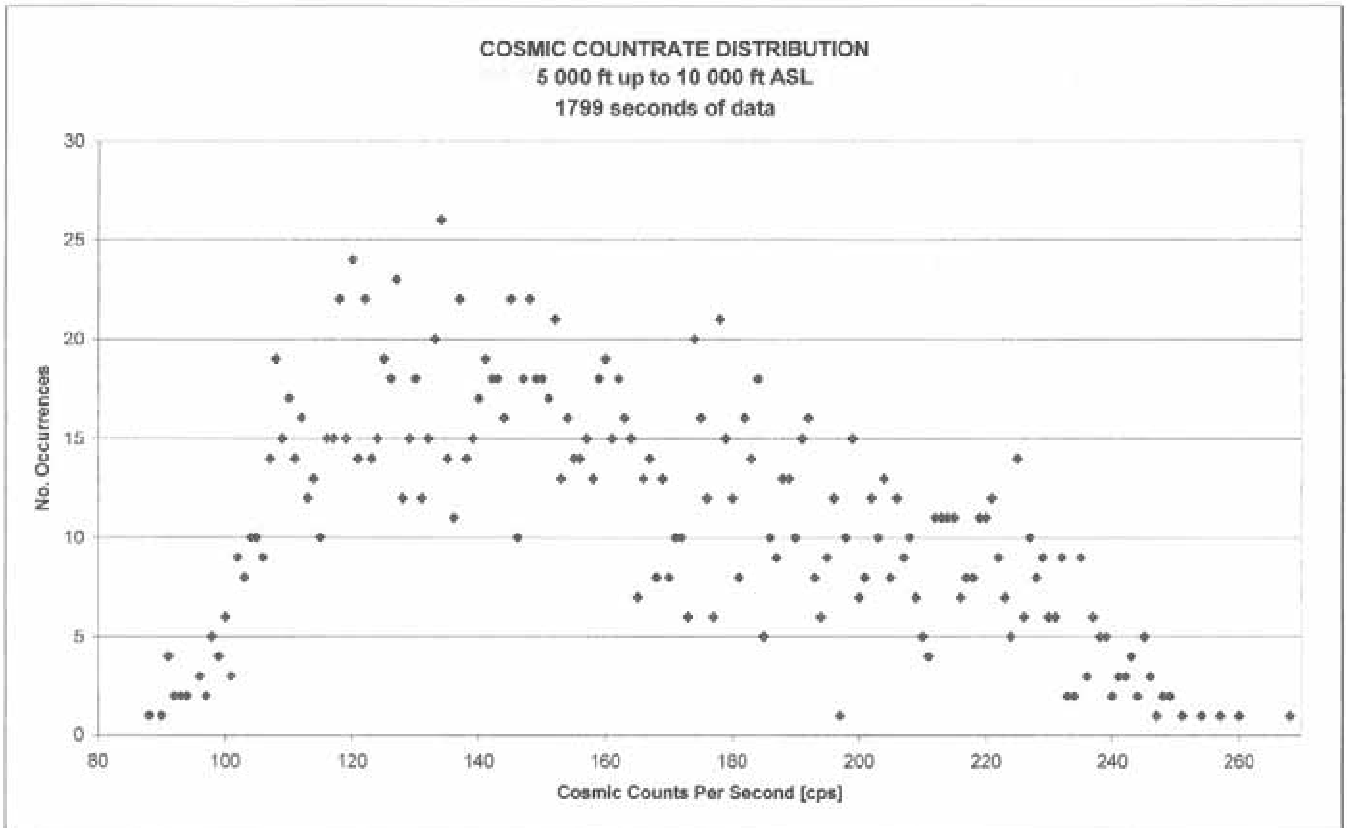


Figure 3. Cosmic countrate distribution during ascent of High-Level Calibration for Figure 2.

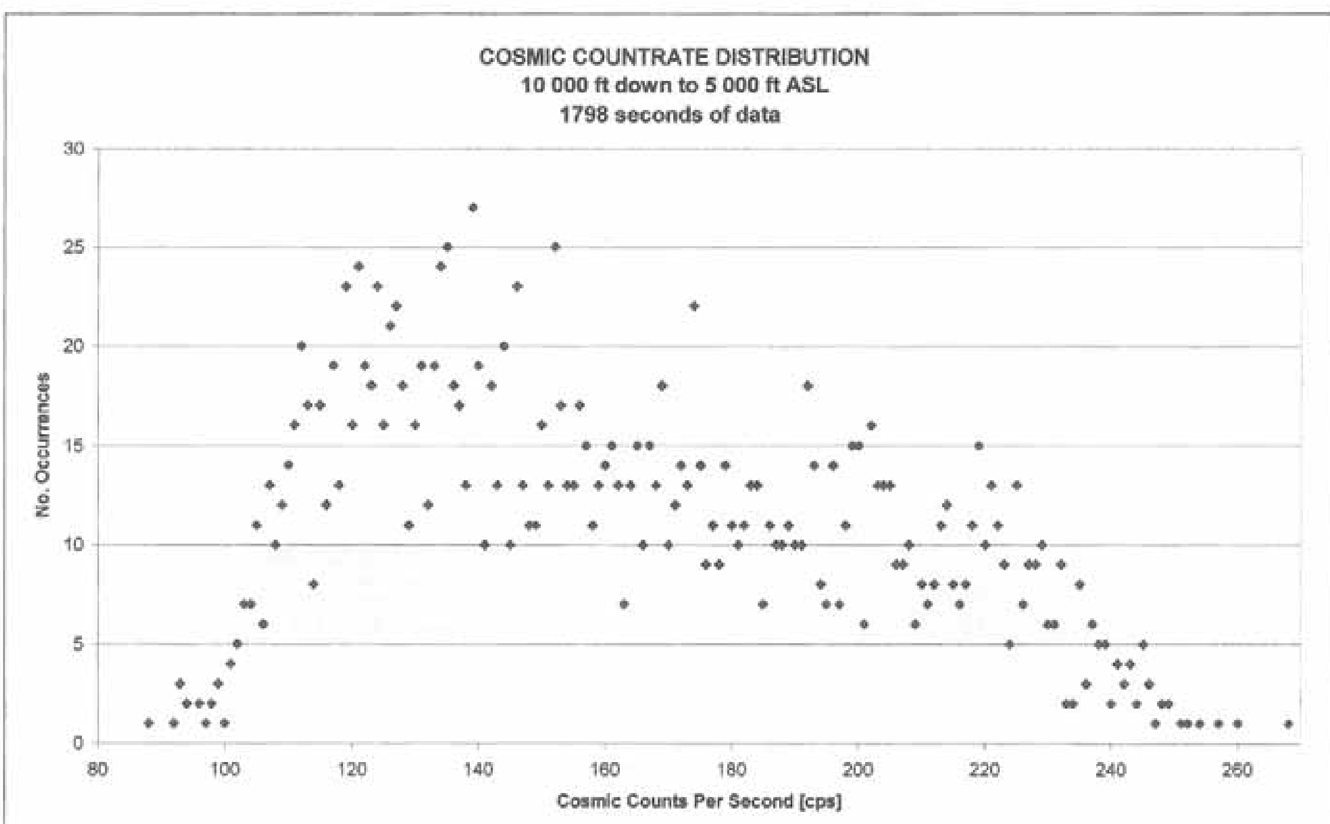


Figure 4. Cosmic countrate distribution during descent of High-Level Calibration for Figure 2.

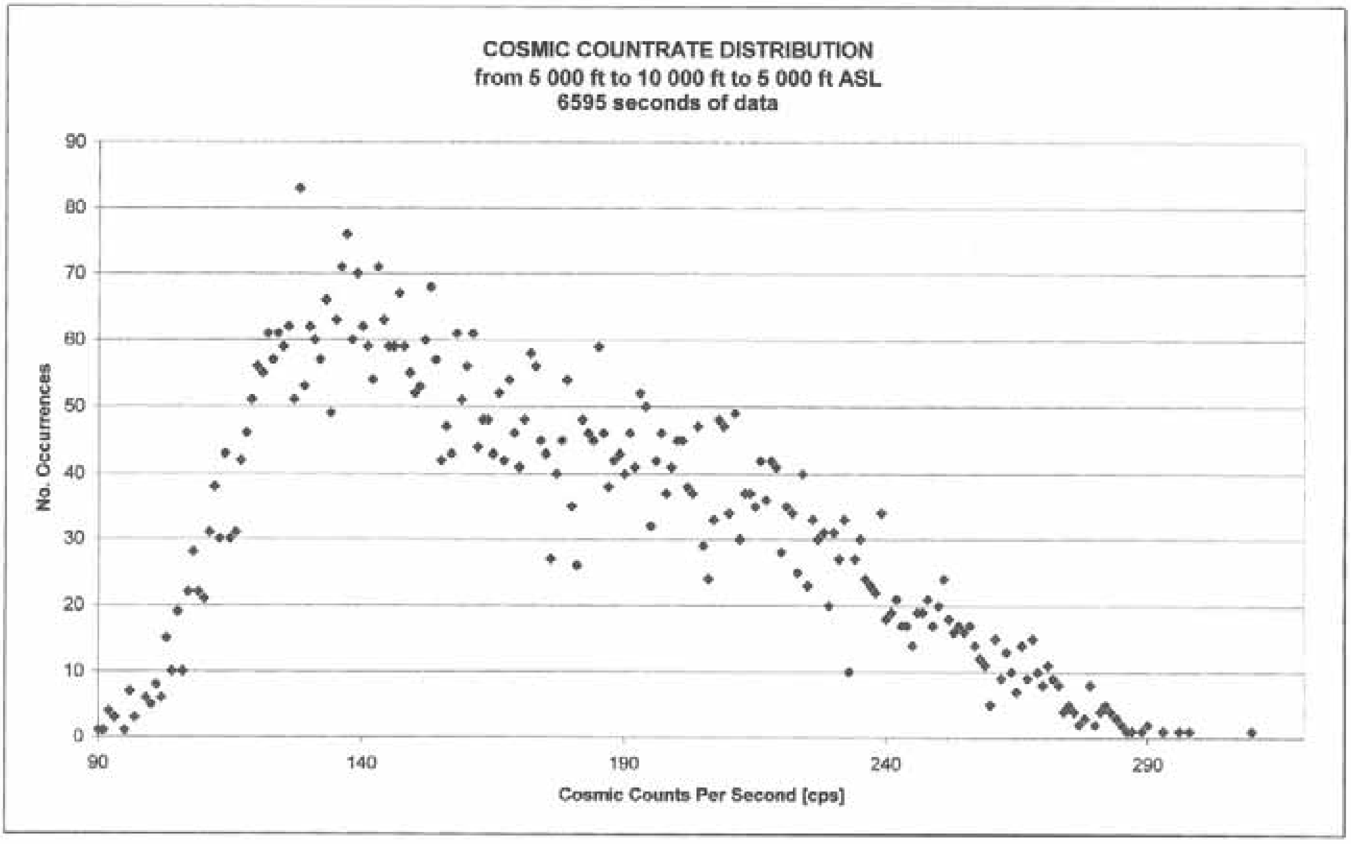


Figure 5. Cosmic countrate distribution for full dataset of High-Level Calibration for Figure 6.

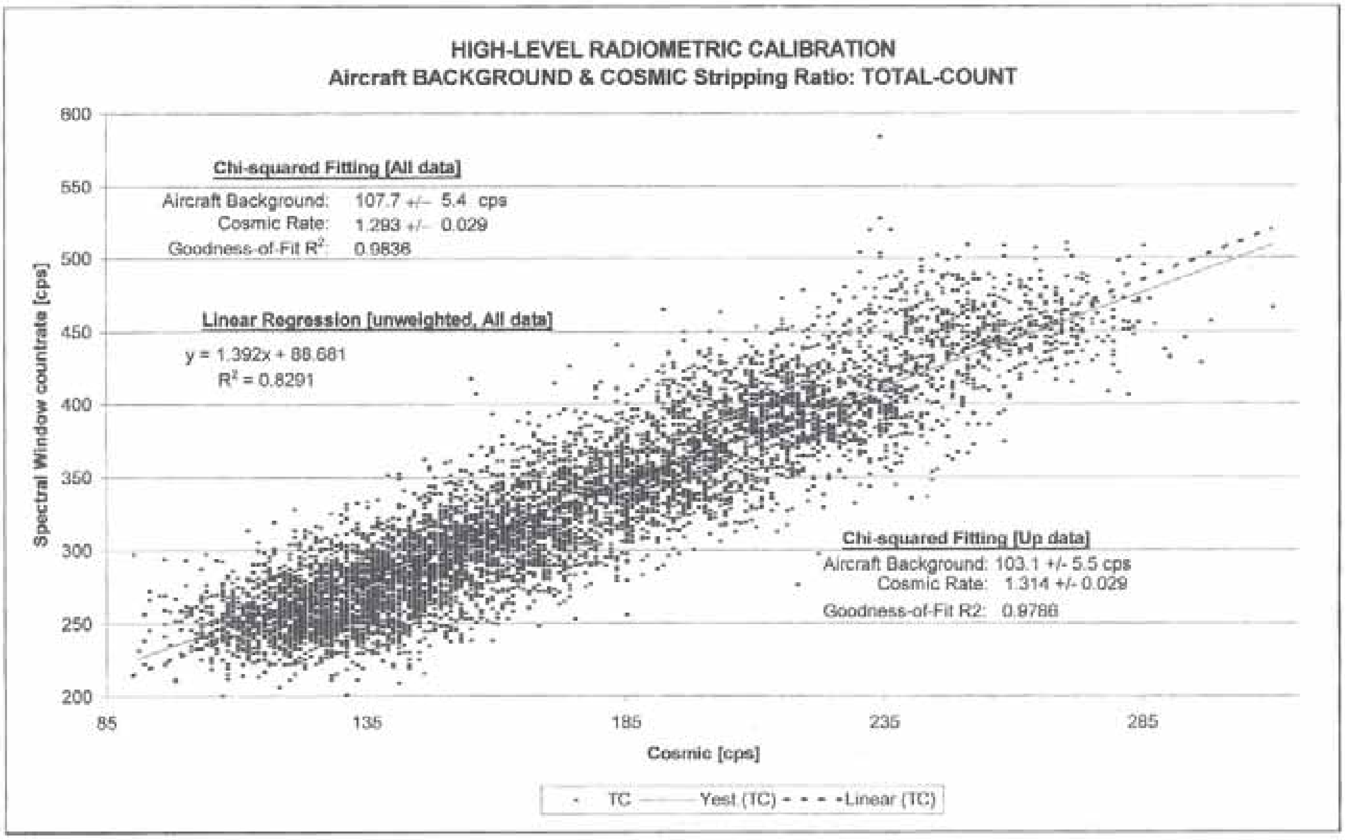


Figure 6. Scattering of Total-Count data encountered during a High-Level Calibration.

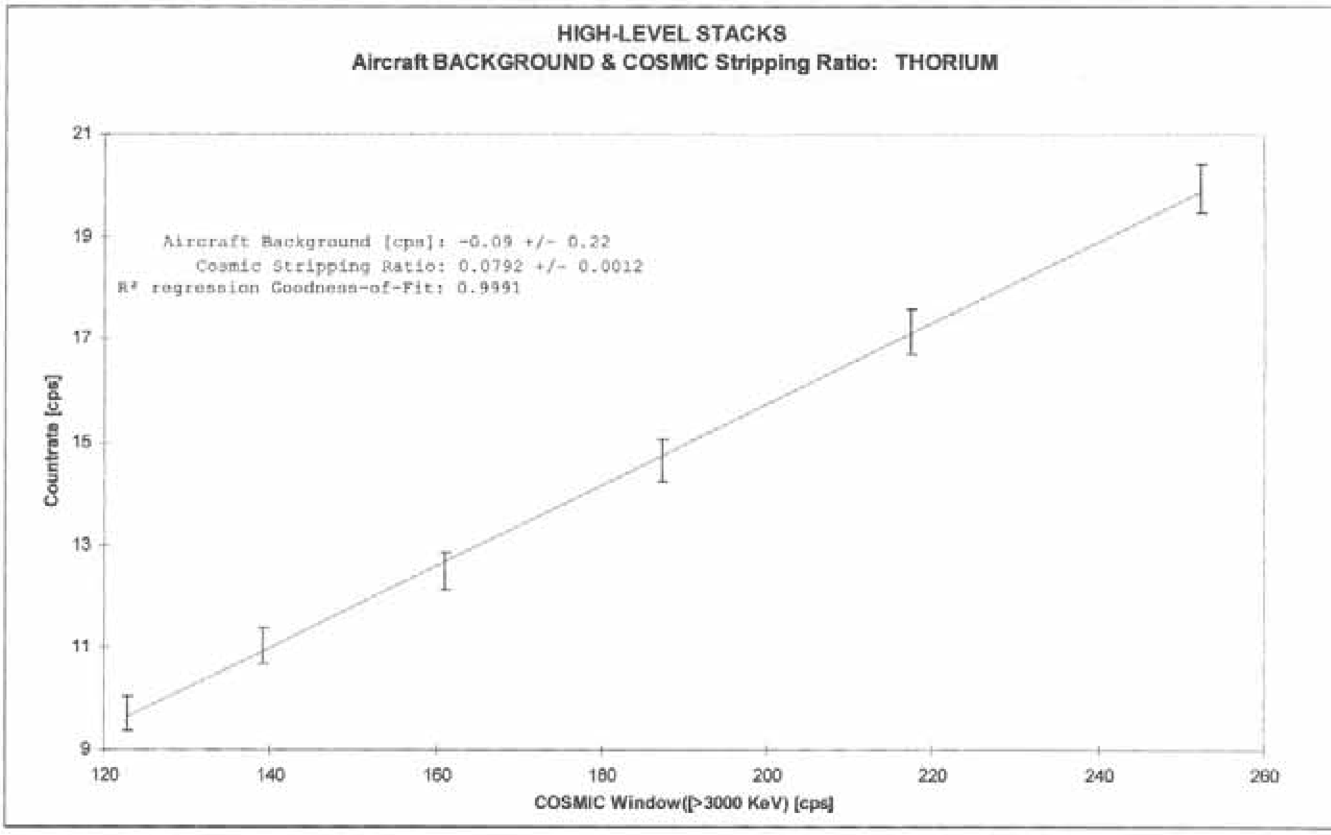


Figure 7. Common problems with linear regression of low countrates - Y-intercept parameters<0 imply a negative background radiation countrate.

Linear regression was performed on the mean countrates for each elevation (excluding data collected at the 5000 ft ASL elevation for the dataset acquired during descent) and the Aircraft Backgrounds and Cosmic Rates were determined. A cursory review suggests that radon, at the lower elevations, may have skewed the results.

These parameters, independently determined from the two datasets, should have had similar values, yet differ by more than three standard deviations - within which 99% of the variation of the data should have been contained.

This indicates that by utilising the mean countrates, as calculated for each elevation, the scatter of the data may not be accurately reflected in the resultant standard deviation. Figures 3 & 4 show the distributions of cosmic countrates that were accumulated during each calibration. The high value cosmic countrate data, acquired at 10 000 feet ASL, are common to both datasets and both display a similar distribution of cosmic countrates.

A Solution

Chi-squared [χ^2] fitting requires knowledge of the estimated mean and sample standard deviation of each observation point within a dataset. Figure 5 shows the Cosmic Countrate distribution of a typical dataset from a High-Level Calibration. The mean countrate, in any given spectral window, has been determined by a variable number of occurrences, depending on the cosmic countrate. This variation can be used to generate the information required for chi-squared fitting.

With reference to Figure 6 & Table 3, consider the need to include all the data in the linear regression - to estimate the parameters for background radiation and cosmic scattering. The theory of linear regression assumes that *all* data observations Y_i have equal uncertainties [standard deviations σ_i] associated with the measurement of each observation.

Table 3. Linear regrssion eof unweighted Total-Count data versus chi-squared [weighted] fitting.

Total-Count Dataset	Unweighted (ALL)	Chi-square χ^2 (ALL)	Chi-square χ^2 (UP)
Aircraft Background:	88.68081	107.72 +/- 5.45 cps	103.06 +/- 5.53 cps
Cosmic Rate:	1.391989	1.293 +/- 0.029	1.314 +/- 0.029
Goodness-of-Fit R^2:	0.829118	0.9836	0.9786

But this can degrade the outcome by including statistical outliers that skew the results. Compare the Goodness-of-Fit in Table 3.

Table 3 describes the relatively well-behaved results of linear regression on the Total-Count data displayed in Figure 6. Unweighted linear regression of *all* the data results in parameters that account for 82.9% of the variation in the data.

It can be shown that the chi-squared Goodness-of-Fit indicator [R^2] is equivalent to Pearson's Statistic [R^2] as applied to unweighted linear regression. As such, the chi-

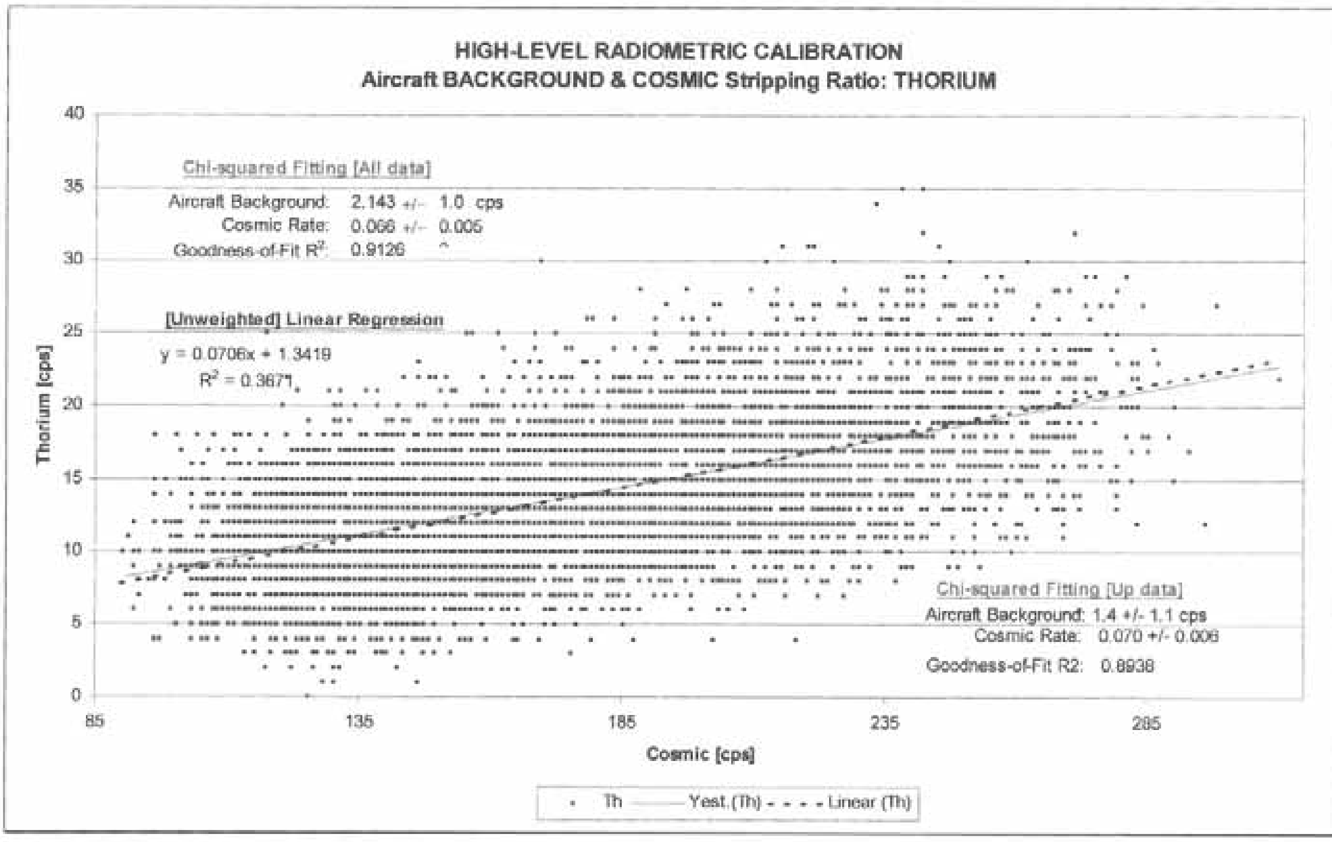


Figure 8. Scattering of Thorium data and stability of Chi-squared fitting.

squared [weighted] regression improves the fit of the model to 98.4% while the stability of chi-squared fitting is reflected in the third column where the parameters are estimated from only *half* the dataset - only the data acquired during the ascent to high elevations. The resultant parameters deviate by less than one standard deviation while the goodness-of-fit is reduced by only 0.5%.

For time-based radiometric sampling, this assumption of equal uncertainties in sampling is simply not the case. It can be seen that each observation must be weighted and the multiplier, w_i, is set according to the equation

$$w_i = \frac{1/\sigma_i^2}{(1/N)\sum(1/\sigma_i^2)} \qquad (2)$$

where N represents the number of samples in the population and the weighting factors w_i for each data point are the inverse of the variances σ_i^2 that describe the uncertainties in each point, normalised to the average of all the weighting factors. In the context of a least-squares fit to a straight line, this is Chi-Squared Fitting.

Discussion

A similar investigation can be made using the data from the spectral window at 2.62 MeV - used to monitor the Thorium Th-232 decay series. At such a high energy, the countrates are typically low and the products of linear regression are more sensitive to statistical outliers.

In Table 4, which summarises the results displayed in Figures 7 & 8, the Aircraft Background, as determined by regression of the mean countrates per elevation, is evaluated as a *negative* number - a physical impossibility! The goodness-of-fit may be 99.9% but only 6 data points were used in the regression.

Compared with Table 3, and the Total-Count goodness-of-fit of 82.9%, the unweighted linear regression (displayed in Figure 8) is only 36.7% successful at fitting the Thorium data. In contrast, the chi-squared fitting accounts for 91.3% of the variation in the 189 data point sample population.

Table 4. Linear regression of Thorium data - mean countrate per elevation versus unweighted regression and chi-squared [weighted] fitting.

Thorium Dataset	Mean Countrate (elevation)	Unweighted (ALL)	Chi-square χ^2(ALL)
Aircraft Background:	-0.09 +/- 0.22 cps	1.342	2.14 +/- 1.03 cps
Cosmic Rate:	0.0792 +/- 0.0012	0.0706	0.066 +/- 0.006
Goodness-of-Fit R^2:	0.9991	0.3671	0.9126
Sample Population:	6	6595	189

In Figure 8, as also displayed in Figure 6, the difference in parameters generated by half [up only] and full [both up & down] datasets was less than one standard deviation. Careful scrutiny of the standard deviations may permit a reduction in acquisition time during high-level calibrations - given an a *priori* technical judgement on the required accuracy for operation.

Conclusions

This lack of repeatability of calibration has plagued airborne surveyors for years. The ultimate worth of these calibrations has been brought into question by both processing staff *and* management.

If results cannot be duplicated in calibration then the processing staff have no compulsion to restrict themselves to the neighbourhood of values surrounding those parameters determined at calibration.

Likewise, if the accuracy of calibration results was dubious, management couldn't justify repeating the activity and would rely on existing calibration parameters - only contractual obligations would provoke a different response.

The use of chi-squared fitting puts paid to any support of such notions and shows that the difficulties with calibration repeatability have not been artefacts of acquisition but problems with processing. The methodology has always been correct - only the processing algorithm has needed refinement.

The superior results of chi-squared fitting should improve the accuracy and stability of downstream processing such as data inversion (to equivalent radio-element concentrations) and downward continuation [from survey height to ground level].

Acknowledgements

The ten years of occasional airborne radiometric calibration with World Geoscience Corporation [formerly Aerodata] must be acknowledged as the major source of experience on which these observations and inferences are based. I thank them for the opportunity to refine a calibration process that is so extended; *success* often becomes a value judgement - a subjective rather than objective evaluation.

Brian Minty must be acknowledged for his work on this subject and I thank him for the advice & assistance he has offered during my investigations.

And, most importantly, credit must be given to Bob Grasty, and his years of experience with airborne radiometric calibration. After each of various discussions, I invariably expanded my understanding of airborne radiometrics and, ultimately, formulated the basis of this discussion.

To all those directly and indirectly associated with my efforts to produce this; I thank them for their support.

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Self-Demagnetisation

"The Rock Doctor"

DA Clark & DW Emerson

Introduction

In exploration and environmental magnetic studies the depth, geometry, attitude and magnetisation of a causative body are the relevant variables. The key elements of a body's magnetisation comprise its susceptibility (which may be anisotropic in foliated rocks) and its remanence. If a body has a high susceptibility, say in excess of $10,000 \times 10^{-6}$ CGS, or $13,000 \times 10^{-5}$ SI, then demagnetisation corrections are necessary in the analysis. In exploration advisory work we often encounter rock samples with high to extremely high susceptibilities for which appropriate allowance must be made for demagnetisation in petrophysical measurements, but the consideration of demagnetisation is also vital in the magnetic modelling of the parent body from which the samples were taken. In this article we look at demagnetisation and see how to apply corrections to a tabular body. Detailed principal profile modelling of such bodies, and other geometries, has been outlined by Emerson, Clark & Saul (1985).

High Magnetic Susceptibility Body

Magnetisation in a rock, whether induced or remanent, produces a back-field which acts only through its susceptibility. If the susceptibility (k) is high, then this back- or demagnetising field can have significant effects on resultant magnetisation. In Figure 1 (from Emerson et al, 1992) the process is shown schematically for a homogeneous magnetised ellipsoid in a non-magnetic medium. For simplicity, we assume the body is not remanently magnetised. The mathematical analogy between magnetostatics and electrostatics allows us to analyse magnetostatic phenomena in terms of pole theory. The internal magnetic field, $\tilde{H}$, produces an induced magnetisation $\tilde{J} = k\tilde{H}$, which generates fictitious but mathematically convenient poles (analogous to electric charges on the surface of an electrically polarised body) on the surface. These poles produce an anomalous magnetic field. Outside the body, this anomalous magnetic field is non-uniform and perturbs the applied magnetic field, $\tilde{H}_o$, producing a resultant field that is non-uniform. Within the ellipsoidal body, the anomalous field arising from the surface poles is uniform and proportional to the magnitude of $\tilde{J}$, and is opposed to the ambient field. If $\tilde{H}_o$ is aligned with a principal axis of the ellipsoid the internal anomalous field is precisely antiparallel to $\tilde{H}_o$. Then the internal back-field, or demagnetising field, $\tilde{H}_D = -N\tilde{J}$, where N is called the demagnetising factor. N is shape dependent and differs for each ellipsoid axis of unequal length. N approaches zero along the long axis of a needle shaped body and is a maximum normal to the plane of a disc-shaped body. As $\tilde{H}_D$ opposes and diminishes the applied field, $|\tilde{H}| < |\tilde{H}_o|$, i.e. $|\tilde{J}|$ is reduced with respect to the value it would have within a needle-shaped body aligned with the field, for which $N \to 0$. The resultant magnetisation is given by:

$$\begin{aligned} \tilde{J} &= k\tilde{H} \\ &= k(\tilde{H}_o + \tilde{H}_D) \\ &= k(\tilde{H}_o - N\tilde{J}) \\ \therefore \quad \tilde{J} &= (k/[1+Nk])\,\tilde{H}_o \end{aligned}$$

The external anomalous field, which is the field of interest in conventional magnetic surveys, arises from the resultant magnetisation $\tilde{J}$. If $\tilde{H}_D$ is negligible then $\tilde{J} = k\tilde{F}$ where $\tilde{F}$ is the Earth's field ($\tilde{F} = \tilde{H}$), as is usually assumed in magnetic modelling. But $\tilde{H}_D$ is not negligible when k is high, so the magnetisation is attenuated by the $1/[1+Nk]$ factor. It is easily shown that this susceptibility-dependent attenuation applies to both induced and remanent components of magnetisation (Emerson, Clark & Saul, 1985).

Note that if $\tilde{H}_o$ is not parallel to an ellipsoid axis, $\tilde{H}_D$ is no longer antiparallel to $\tilde{J}$, as N differs for magnetisation components along different axes. The attenuation factors (1+Nk) also differ along different axes, and therefore $\tilde{J}$ is no longer parallel to $\tilde{H}_o$. In this case self-demagnetisation produces an apparent macroscopic anisotropy of susceptibility.

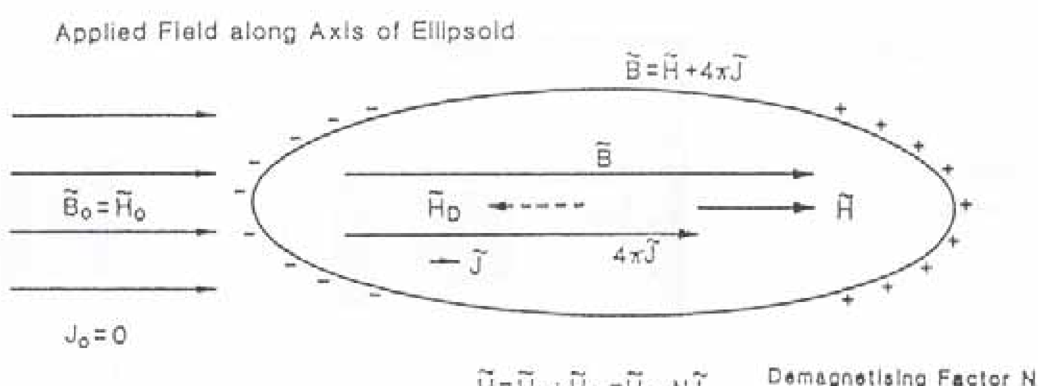

Figure 1. Ellipsoid.

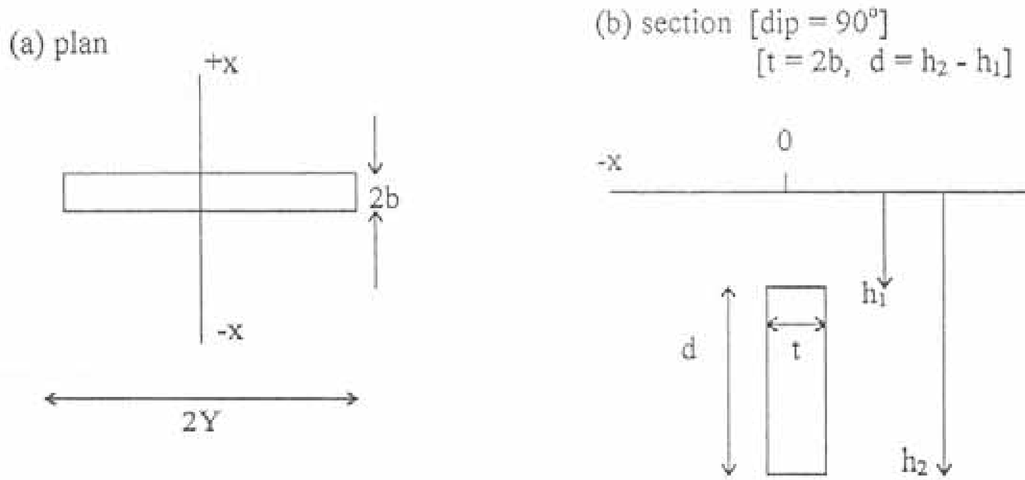

Figure 2. Tabular.

The Demagnetisation Factor, N

Uniform magnetisation is possible only for bodies bounded by second degree surfaces, i.e. spheres and ellipsoids (Jahren, 1963). For such bodies an analytic determination of N is possible along the three mutually orthogonal principal axes. Formulae for the demagnetising factors of triaxial ellipsoids are given by Clark, Saul & Emerson (1986). Emerson, Clark and Saul (1985) give expressions for demagnetising factors of prolate and oblate ellipsoids of revolution and for 2D elliptical cylinders. The sum of the three demagnetising factors is always 4π, in CGS, or 1 (SI). In the case of a sphere, N_{CGS} is $4\pi/3$.

For other uniformly magnetised bodies, including tabular bodies, the demagnetising field is not uniform and the orthogonal demagnetising factors are point functions that vary throughout the body. At each point , however, the sum of the demagnetising factors is constant and equals 4π (Schlomann, 1962; CGS). For any uniformly magnetised body, three mutually orthogonal directions of magnetisation can always be found such that the volume-averaged back field is exactly antiparallel to the magnetisation (Brown, 1962). The magnetometric demagnetising factors, N_i, along these principal axes are defined by the relation $<\bar{H}_D>_i = -N_i \bar{J}_i$, where < > denotes a volume average. The sum of the three magnetometric demagnetising factors is also 4π. The demagnetising factors along the three principal axes are constrained by the symmetry of the body. Equidimensional bodies of high symmetry (cubes, tetrahedra, octahedra etc.) have all three magnetometric demagnetising factors equal (Moscowitz and Della Torre, 1966). For such bodies, self-demagnetisation is

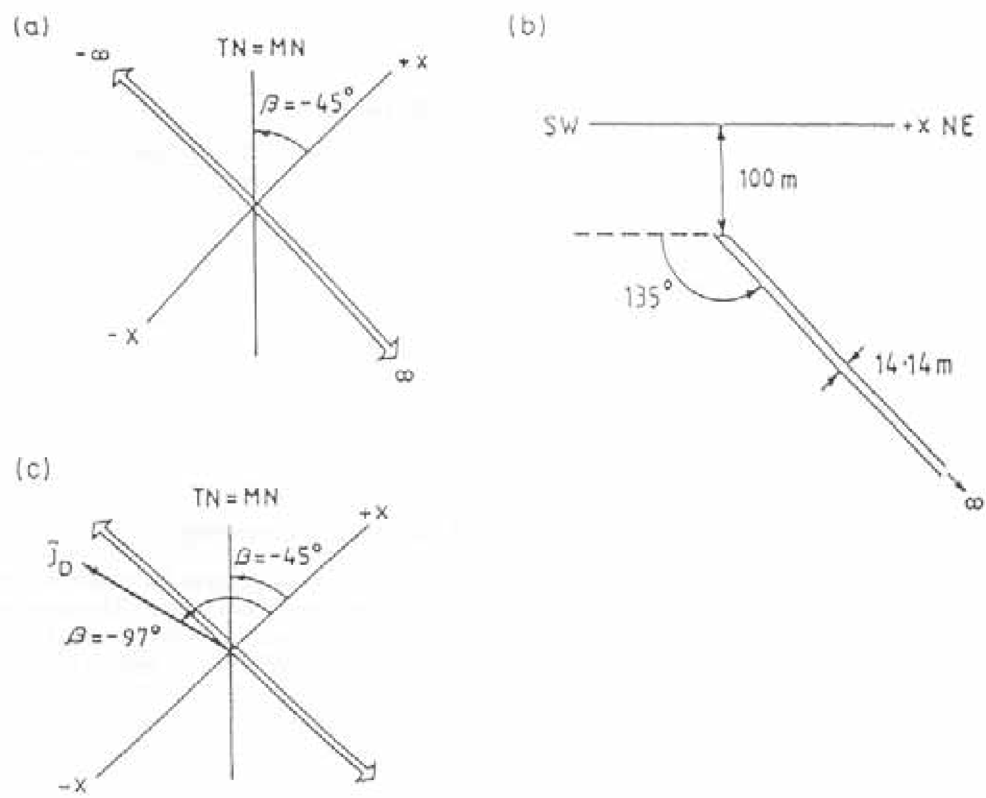

Figure 3. Dipping Sheet.

isotropic, in the uniform magnetisation approximation, and $N = 4\pi/3$ along all directions, i.e. they behave like spheres.

We now have the means to handle the effects for a tabular body. For a highly susceptible body magnetised by induction only, demagnetisation will shift the induced magnetisation direction away from the ambient field direction and diminish the magnetisation magnitude. For a remanently magnetised body with appreciable susceptibility, demagnetisation acts on the resultant magnetisation. Thus magnetic anomaly shape and amplitude may be signficantly affected.

Tabular Body

Following the principal profile approach of Emerson, Clark & Saul (1985) we denote along-strike, down-dip, and across-dip directions by =, ||, and ⊥, respectively. The component demagnetisation factors are regarded as being in direct proportion to the areas of cross-section (of the tabular body) in planes normal to the three corresponding directions of demagnetisation (Werner, 1953). The scheme is depicted in Figure 2 for a vertical dyke. The tabular body dimensions are $2Y \times t \times d$ [i.e. strike length × thickness × depth extent]. The topside (=) area is $2Y \times t$, the down-dip (||) area is $2Y \times d$, and the across-dip (⊥) area is $t \times d$. So the CGS demagnetisation factors are readily (and approximately) calculated:

$$N_{\parallel} = 4\pi\,[2Yt/(dt + 2Yt + 2Yd)]$$

$$N_{=} = 4\pi\,[dt/(dt + 2Yt + 2Yd)]$$

$$N_{\perp} = 4\pi\,[2Yd/(dt + 2Yt + 2Yd)]$$

When the tabular body has a long strike length ($Y \to \infty$) and depth extent ($d \to \infty$) then $N_{\parallel} = 0$, $N_{=} = 0$, and $N_{\perp} = 4\pi$. If the body dips then appropriate trigonometry can be applied to obtain the areal ratios.

Magnetisation Shift

We now need to calculate the corrected magnetisation for input to a magnetic modelling program (e.g. MAGMODS VII or VIII in Emerson, Clark & Saul, 1985). In doing this, x, y, z components are considered and a magnetisation vector's position is described by its inclination I w.r.t. horizontal and its bearing β w.r.t. the positive x axis of the principal profile across the body i.e. a polar co-ordinate system. Accordingly:

$\tilde{J} = (J, \beta, I)$ [nominal magnetisation along mag N]

$J_x = J\cos\beta\cos I$ [components]

$J_y = J\sin\beta\cos I$

$J_z = J\sin I$

$J_{\parallel} = -J_x\cos D + J_z\sin D$ [components, demag., D is dip]

$J_{=} = J_y$

$J_{\perp} = J_x\sin D + J_z\cos D$

$J'_{\parallel} = J_{\parallel}/(1 + N_{\parallel}k)$ [attenuation]

$J'_{=} = J_{=}/(1 + N_{=}k)$

$J_{\perp} = J_{\perp}/(1 + N_{\perp}k)$

$J'_x = -J'_{\parallel}\cos D + J'_{\perp}\sin D$ [corrected x, y, z components]

$J'_y = J'_{=}$

$J'_z = J'_{=}\sin D + J'_{\perp}\cos D$

$\therefore\ J' = (J'^2_x + J'^2_y + J'^2_z)^{1/2}$ [demagnetised magnitude]

$\beta = \tan^{-1}(J'_y/J'_x)$ [azimuth of corrected magnetisation]

add 180° if $J'_x < 0$

$I' = \sin\text{-}1\,(J'z/J')$ [inclination of corrected magnetisation]

Thin Dipping Tabular Body Example

Figure 3 (Emerson, Clark & Saul, 1985) depicts a magnetite-rich thin 2D sheet ($t = 14.14$ m, $2b = 20$ m) model at around the latitude of Perth, and demonstrates how demagnetisation affects magnetisation: (a) Plan view of thin sheet striking NW-SE. (b) Cross section -x to +x, SW-NE, showing dip of 135°, i.e. 45° NE. (c) The Earth's field F = 58000 γ (nT), k = 0.1 CGS (1.26 SI), I = -65°, no remanence; when demagnetisation is neglected the induced magnetisation is J, β, I nominally: 5800 γ, -45°, -65°; demagnetisation is significant here because of the very high k. When corrections are applied using the above procedure the induced magnetisation is reduced in magnitude and shifted substantially, towards the plane of the sheet: J_D, β_D, I_D = 3743 γ, -97°, -62°.

An algorithm (VECT) for calculating demagnetisation-corrected magnetisations of dipping sheets was presented by Emerson, Clark & Saul (1985, pp. 87-89).

Conclusions

The effect of self-demagnetisation on the magnetisation of high susceptibility bodies has been known for a long time, but its importance for correct magnetic modelling sometimes seems to be forgotten. The theory outlined here shows that self-demagnetisation can exert a profound influence on magnetic anomalies, but that corrections can be performed quite simply. There is therefore no excuse for neglecting effects of self-demagnetisation when modelling anomalies due to strongly magnetic bodies. In the next article, we will present case studies that illustrate the importance of self-demagnetisation.

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Book Review – "Sedimentology and Stratigraphy by Gary Nichols."

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This is a textbook aimed at University students as an introduction to the study of Sedimentology and Stratigraphy. As such it is a useful text for those in the involved in the Petroleum or Mining Industry who may require a 'fresher' in aspects of the study. The author suggests that those who require an in-depth account of various aspects sedimentology and stratigraphy consult other texts that cover areas in greater detail.

Each chapter has a brief introduction providing an idea of the scope and importance of the subject covered by that particular chapter and places it into the broader scheme of things. A short (in some case too short) summary is also provided at the end of each chapter along with suggested further reading. The writing style is easy to read and avoids jargon where possible, providing an explanation where unavoidable, and while not hitting any subject matter in great depth, provides a concise, relatively insightful explanation of individual topics. The text is well supported by simple line drawings, photographs and schematic sedimentary logs.

The book could be arranged into three broad parts, the first six chapters serving as an introduction and explanation of the building blocks of sedimentology: the classification of sediments, size and shape of sediments, transport mechanisms and finally the concept of facies and environments of deposition. Also included at this stage is a discussion on the methods required for the measuring and recording of data required for a sensible analysis.

The second broad section of the book is divided into chapters covering individual depositional settings. The subject matter for each chapter alone generally warrants numerous specific texts and consequently Nichols does an admirable job in providing a sensible precis of the topics. Undoubtably individual readers will find areas that may be a bit thin - especially if the subject is the reader's particular field of interest - but for those unfamiliar it should provide enough information to put them on the right track.

The latter third of the book concentrates on aspects of stratigraphy, including the fields of biostratigraphy, lithostratigraphy, sequence stratigraphy and seismic stratigraphy. Once again, these are areas which require vast volumes of writing to explain in detail, do not expect to find any 'cook book' methodology in this text as this was never the author's intention. This broad section is rounded off with a chapter focussing of the broader picture-sedimentary basins and tectonic setting. This takes the reader away from the detail of depositional settings and facies associations and places the emphasis on the overall controlling factors of basin development, the regional tectonic setting. This helps the reader put the detail covered in preceding sections into perspective.

The concluding chapter of the book considers the implication of uniformitarianism versus catastrophism and the importance of extraordinary events such as meteorite impacts that produce unique scenarios both worldwide and locally. A number of interesting examples are provided including earthquakes, volcanic eruptions, dam bursts, hurricanes, submarine slumps and fires. Consideration is also given to the effect the changing composition of the Earths atmosphere, plate tectonics and climate changes have had in the Earth geologic past. The point is made that the principle of uniformitarianism should be used with care. This chapter is an excellent way of concluding the text, essentially reminding the reader of the limitations of much of the data that we as Earth Scientists have available.

Overall the text book is good for the targeted audience and is recommended for geophysicists, engineers (can they read?) and managers who need to be involved with soft rock studies and are not trained in the area. Geologists who have specialised in 'hard rock' geology and find themselves becoming involved with 'soft rock', will also find value in the text given its introductory level and up-to-date nature. Experienced 'soft rock' geologists seeking the answer to a specific sedimentological or stratigraphic problem would most likely be better served consulting a higher level text.

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P.E.S.G.B. Data Management Group

SEGY Usage Recommendations - Working Draft

Wal Muir recently attended the PETEX conference in London and found the above group who are working on revisions to the SEGY standard. The following is an extract of some of the material that has been circulated within that group. The editor has shortened it for reasons of clarity and space but can forward the original document to anyone interested. Why 'Y'? Originally the SEG set a standard for data exchange specified as SEG-X where X was for exchange, a bit like DXF. SEGY was a revision of that standard.For more uptodate information contact:

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1. Introduction

At the meeting of the PESGB Data Management Group on Tuesday 2nd September 1997 at the offices of Enterprise Oil in London, it was decided to form a subcommittee to investigate the usage of the headers in the SEGY format, particularly with a view to easing the task of loading seismic data into data banks. This document is the working draft of that subcommittee, and is being presented as a discussion document, with feedback being sought from all interested parties.

Despite the fact that the original SEGY standard was published by the SEG Technical Standards Committee as long ago as 1975, the SEGY format has stood the test of time remarkably well, and is still the "gold standard" for the interchange of seismic data. However, the nature of seismic data acquisition and processing has changed in that time, particularly with the introduction of 3D, and modern data requires certain header entries that were not defined in the original SEGY standard. Unfortunately, because there has been no standard way of recording these entries, this has led to a multitude of proprietary variations of SEGY. The set of recommendations in this document is an attempt to alleviate this situation and provide a new data exchange format for the future.

2. SEGY File Structure

The original SEGY standard was produced at a time when 9-track tape was the normal storage medium for seismic data, with 800 bpi and 1600 bpi in common usage and 6250 bpi on the horizon, and considerable space in the standard is devoted to defining the physical characteristics of this medium. There have obviously been considerable advances in storage technology since then, with several kinds of high-capacity tape devices and vast amounts of online disk storage available in a typical processing centre. The SEGY standard is really defining a data format, albeit tied to a block structure based on the model of a 9-track tape, and thus it is felt that the format should be independent of the actual medium on which it is recorded. Also, the stipulation in the standard that "no more than one line of seismic data is permitted on any one reel" became impractical long ago, and obviously no longer applies. With this in mind, it was felt that the term "SEGY file" would be more appropriate than the term "seismic reel" used in the standard.

How a SEGY file is structured

The first 3600 bytes of the file are the "traditional" SEGY file header, written as a 3200 byte EBCDIC Header record and a 400 byte Binary Header record. This is followed by the Extended EBCDIC Header, which consists of zero or more EBCDIC Header Extension records. The remainder of the SEGY file contains a variable number of trace records, each with a 240-byte trace header. The Extended EBCDIC Header is the only structural change introduced in this revision, and has been carefully designed to be downward compatible with the original SEGY format; it is described fully in section 5.

Relationship of SEGY format to the underlying medium

Whatever the medium, the data must be resolvable to a stream of variable length records, which is how the SEGY format is defined. This might be done by hardware or software depending on the medium being used. Tthe "traditional" binding was to a tape device which supports variable length records directly in hardware, including 9-track tape and 3480 cartridges. This revision also includes more modern high-capacity tape devices such as DD2 or 3590, although with these it is probably desirable to use some kind of blocking or encapsulation layer, to utilise the tape more efficiently and possibly to allow the recording of associated metadata. In particular, a SEGY file may be written as a logical file to a SEG RODE encapsulated tape. Obviously when seismic data is being exchanged in SEGY format, the medium and encapsulation scheme used must be acceptable to both the provider and recipient of the data.

One important class of media that does not conform to the variable length record model is the disk file, which is defined on modern systems as a byte stream without any structure. It has become common practice in recent years to write SEGY data to disk, particularly CD-ROM, for data distribution. Since SEGY is a tape format rather than a disk format, certain rules have to be followed for this to work correctly. Appendix A defines how SEGY data should be written to a disk file.

In order to bring SEGY into line with the SEGD Rev 2 standard, Appendix B defines a tape label for SEGY tapes, using a format based on the RP66 Storage Unit Label. Labels are not compulsory for SEGY, but their use may be desirable in some environments, particularly where robotic tape libraries are being used.

Appendix C defines a simple blocking scheme for SEGY data to allow more efficient use of high-capacity tape media. Again, this is based on the scheme defined in the SEGD Rev 2 standard.

Number Formats

In the original SEGY standard, all binary values are defined as being written using "big-endian" byte ordering. This means that, within the bytes that make up a number, the most significant byte (containing the sign bit) is written closest to the beginning of the file, and the least significant byte is written closest to the end of the file. This byte ordering convention is maintained in this revision of the SEGY format, and it is intended that it should be adhered to for all conforming versions of SEGY. Note that this is independent of the medium to which a particular SEGY file is written, i.e. the byte ordering is no different if the file is written to tape on a mainframe or to disk on a PC.

It is recognized that there is a whole class of computer systems that use "little-endian" byte ordering as their native internal format, the most prominent being the PC, and it has been suggested that a revised SEGY format should allow a file to be written using either byte ordering convention, indicated by a flag in the binary file header. However, there is really nothing to be gained by allowing this, since SEGY reader software would then have to be capable of dealing with both big-endian and little-endian files, rather than just big-endian as now. Therefore it was decided to stick with big-endian values in the standard SEGY exchange format. Of course, an implementation is perfectly at liberty to use little-endian byte ordering for internal use, but a SEGY file written using little-endian byte ordering does not conform to the SEGY standard, and should not be used for exchange.

All values in the binary file header and the trace header are defined as being twos-complement integers, either two bytes or four bytes long. Note that there are no floating-point values defined in the headers, and this situation is maintained (apart from anything else this neatly side-steps the issue of which floating-point format should be used).

Trace sample values are defined as being either twos-complement integers or floating-point. The original standard defined IBM 32-bit floating-point, and this document adds IEEE 32-bit floating-point. Both IBM and IEEE floating-point values are written in big-endian byte order, i.e. with the sign/exponent byte written closest to the beginning of the file.

Varying Trace Lengths

The SEGY standard specifies fields for sample interval and number of samples at two separate locations in the file. The binary file header contains values which apply to the whole file, and the trace header contains values which apply to each individual trace. However, the original standard is unclear as to how these are intended to be used together. One school of thought has interpreted this as meaning that variable length traces are supported in SEGY, with the number of samples in the trace header allowed to vary from trace to trace, and from the value in the binary file header. The other school assumes that all traces in a SEGY file will be the same length, with padding or truncation as necessary, and the value for number of samples will be the same in the binary file header and all trace headers.

It is proposed that varying trace lengths in a file should be explicitly allowed. The values for sample interval and number of samples in the file header should be for the primary set of seismic data traces in the file, which allows you to read the file header and say, for instance, "this is 6 second 2 mil data". The value for number of samples in each individual trace header may vary from the value in the file header, and reflects the actual number of samples in the trace. The number of bytes in each trace record must be consistent with the number of samples in the trace header. This is particularly important for SEGY data written to disk files (see Appendix A).

It is recognized that allowing variable length traces in a SEGY file will not suit everyone, and indeed there has been much discussion on this topic. In particular, one consequence of allowing variable length traces is that it enforces sequential access, and precludes random access in a disk file, since the locations of traces after the first are not known. In order to alleviate these concerns, a new field in the binary file header has been defined as a fixed length trace flag. If this flag is set, then it is guaranteed that all traces in the file are the same length. This will typically be the case for post-stack data.

There has been a strong lobby for making the value for number of samples in the binary file header the <u>maximum</u> trace length in the file, rather than the length of the primary set of data traces. However, it has been pointed out that the maximum trace length is typically not known at the time the binary file header is written; this is the same reason why there are no fields in the file header such as "first and last record number". The fixed length trace flag goes some way to appeasing the maximum trace length lobby; if it is set, you <u>know</u> what the maximum trace length in the file is (they are all the same length). Also, an additional field has been defined in the Binary Header so that the maximum trace length can be recorded in cases when it is known - but software cannot rely on this being present.

Large Datasets

One major change that has taken place since the original SEGY standard was published is the sheer volume of data involved in a modern seismic survey. This raises issues of how large datasets should be written to SEGY. For instance, it is now perfectly feasible to write an entire 3D pre-stack data set as a single SEGY file on a modern high-capacity tape. Whilst not specifically prohibiting it, it is felt that such practice will typically make the dataset unwieldy from a transcription logistics point of view, and also introduces potential technical problems (files larger than 2 Gbytes cause problems on a lot of systems). Thus it is recommended that large datasets should be broken down into manageable "chunks" rather than being written as one long SEGY file. One common technique is to split a dataset into 3480 cartridge sized chunks (approximately 200 Mbytes), which has considerable advantages.

For 3D post-stack data, there have been two opposing schools of thought as to how the data should be written to SEGY. In one school, the whole survey is written as one SEGY file, with the inline number written in the trace header, typically encoded somehow in the CDP number, which results in a very large SEGY file. The other school writes each inline as a separate SEGY file, with its own file header. It is proposed that the latter method should be used in the future, for the reasons set out above.

3. EBCDIC File Header

The 3200 byte EBCDIC File Header record contains 40 lines of textual information, providing a human-readable description of the seismic data in the SEGY file. This is essentially free-form, and is the least well defined of the headers in the SEGY standard, although the standard does provide a suggested layout for the first 20 lines. While there would be distinct advantages in making the layout of this header more rigid, it was decided that it would not be practicable to produce a layout that would be acceptable to everyone in the light of how it is currently used. However, this is the only place that certain pieces of information can be recorded.

Hence it was decided to define a separate textual header with a more rigidly defined structure, where textual information can be stored in a machine-readable way. This new header will be known as the Extended EBCDIC Header, and it is described in detail in section 5. It is defined in such a way that the format is downward compatible with the original SEGY standard. Note that the "traditional" EBCDIC Header is completely separate from the Extended EBCDIC Header, and will still be the primary location for human-readable information about the contents of the file. In particular, it should contain information about any oddities in the file, e.g. if the delay recording time in trace header bytes 109-110 is non-zero, this fact should be noted. Also, if a SEGY file conforms to the SEGY Standard Revision 1 defined in this document, this fact should be noted.

One, perhaps inevitable, suggestion has been that the "EBCDIC" file header should be allowed to be written in ASCII character code. Since EBCDIC is a vestige of IBM mainframes, and the vast majority of modern computer systems use ASCII, there would certainly seem to be some logic to this. However, the prevailing opinion in the committee was that this should not be adopted. The arguments are essentially the same as those against allowing little-endian byte ordering, i.e. the SEGY reader software would still have to be able to decode EBCDIC as well as ASCII, so nothing is really gained.

4. Binary File Header

The 400 byte binary file header record contains various binary values which relate to the whole SEGY file. Certain values in this header are crucial for the correct processing of the seismic data in the file, particularly the sample interval, trace length and format code. This header was actually well-defined in the SEGY standard, and has not caused as many problems as the EBCDIC and trace headers.

5. Extended EBCDIC Header

In almost all of the discussions which we have had it has been evident that more space is required for header information. The types of information required range from the navigation projections and 3D bin grids to processing history and acquisition parameters. By creating an extra set of headers the pressure is immediately relieved on the tradition free-form EBCDIC header.

As these are a new set of headers they are to be organised in the form of stanza's so that with the use of keywords and values they may be produced and read by machine as well as remaining human readable.

The stanzas that have been identified at this stage are:

General Data Parameters (e.g. Licence Block, Date, Operator, Line etc.)
General Acquisition Parameters
Geodetic Projection
Survey Outline
3D Bin Grids
Processing History
SP to CDP relationship
Usage of Optional parts of Trace Headers
Decoded Binary Header Contents

Stanza's should be well explained either via SEG web-site or format documentation e.g.

- the need for a glossary of terms which would include Dataset, File, Segment, Volume as well as the definitions for the various headers
- a stanza to provide an overview of the file and complete dataset to which a specific file belongs
- there are to be no "c" characters at the beginning of each 80 byte card
- the need for version number control and reference to convention being used for the information
- Freeform Stanza's
    - Processing History
    - General Comments
- Stanza Ground Rules
    - A stanza header is a keyword enclosed in square brackets
    - A stanza header begins in column 1
    - A keyword starts at first non-blank character on a line
    - A keyword is followed by an equals sign
    - A value is placed after the equals sign
    - A value will be pre-defined when and where possible
    - Values may be comma separated
    - Stanza's comma separated but not pre-defined, comment to explain layout
    - A keyword may be any printable character accept equals or square brackets
    - A keyword is not case sensitive
    - White space is not significant
    - Ampersand as last non-blank character indicates value continues next line
    - Hash sign as first non-blank signifies comment line

Example of Stanza

[Data File Contents]
Line Name Convention=CDA
Line Name=As per convention above
First Trace In Dataset =numeric value
Last Trace In Dataset=numeric value
First Trace In Segment=numeric value
Last Trace In Segment=numeric value
First SP In Dataset=numeric value
Last SP In Dataset=numeric value
First SP In Segment=numeric value
Last SP In Segment=numeric value
First CDP In Dataset=numeric value
Last CDP In Dataset=numeric value
First CDP In Segment=numeric value
Last CDP In Segment=numeric value

The final 3200 byte extended header will start on line one with [end text] and nothing else will be written in this block to enable further easy identification of the end of the extended header blocks.

6. Trace Header

The SEGY trace header contains a whole range of trace attributes, all of which are defined in the standard as 2-byte or 4-byte integers. The values in bytes 1-180 are defined in the standard, and the intention of the committee is to use these entries as intended by the original SEG Standards Committee. Bytes 181-240 are available for optional information, and this has been the main area of conflict between different flavours of SEGY, and probably the main task of this committee is to recommend standard locations for values which are needed in modern data. In particular, lack of standard locations for a shotpoint number and CDP coordinates has been a constant problem in recent years.

17-20 Many people have used this entry for a shotpoint number. While not precluding its use for this purpose, it was felt that this is not actually how it is defined in the SEGY standard. Also, since it is an integer, it is not possible to record a fractional shotpoint number using this field. Thus it is recommended that the new entry defined in bytes 197-202 be used for shotpoint number in the future.

71-72 This is a scalar for the source and receiver coordinates recorded in bytes 73-88. This same scalar will apply to the new entry for CDP coordinates in bytes 181-188.

109-110 Several committee members have had experience of data with negative start times, i.e. data recorded before time zero, presumably as a result of static application in land data. It is proposed that the definition of this value in the SEGY standard as delay recording time should be broadened to allow for a negative start time. If a non-zero value (negative or positive) is recorded in this entry, a comment to that effect should appear in the EBCDIC header.

115-116 Number of samples in this trace.

117-118 Sample interval in microseconds for this trace.

The number of bytes in a trace record must be consistent with the number of samples written in the trace header. Strictly speaking, for a SEGY file on tape the number of samples in the trace header is redundant, since it can be determined from the length of the trace record. However, it is crucial for the correct processing of SEGY data in disk files (see Appendix A).

If the fixed length trace flag in the binary file header is set, the sample interval and number of samples in every trace in the SEGY file must be the same as the values recorded in the Binary Header. If the fixed length trace flag is not set, the sample interval and number of samples may vary from trace to trace.

181-184 X coordinate of CDP position of this trace (scalar in 71-72 applies).

185-188 Y coordinate of CDP position of this trace (scalar in 71-72 applies).

189-192 For 3D post-stack data, this field should be used for the inline number. If the recommendation of one inline per SEGY file is being followed, this value should be the same for all traces in the file, and the same value will be recorded in bytes 3205-3208 of the Binary Header.

193-196 For 3D post-stack data, this field should be used for the crossline number. This will typically be the same value as the CDP number in 21-24, but this doesn't have to be the case.

197-200 Shotpoint number. This is probably only applicable to 2D data. Note that it is assumed that the shotpoint number refers to the source location nearest to the CDP location for a particular trace. If this is not the case, there should be a comment in EBCDIC Header explaining what the shotpoint number actually refers to.

201-202 Scalar to be applied to the shotpoint number in 197-200 to give the real value. If positive scalar is used as a multiplier, if negative as a divisor, if zero the shotpoint number is not scaled; i.e. it is an integer. A typical value will be -10, allowing shotpoint numbers with one place of decimals.

Note that this scheme for the shotpoint number was chosen rather than a floating-point value to be consistent with existing trace header entries (there are currently no floating-point values in the trace header). It also avoids problems with rounding errors with values that cannot be represented exactly as a binary fraction, e.g. one third and one tenth are recurring binary fractions.

7. Summary and Conclusions

This document has presented a set of recommendations for the use of the SEGY format with modern data and with processing systems, particularly with a view to easing the loading of data into databanks. The use of some existing header entries has been clarified or extended, and new entries have been suggested where appropriate. The reason for the convening of this subcommittee was that it was felt that such guidelines and recommendations are desperately needed, and it is hoped that all interested parties will now provide feedback so that the document can be developed and enhanced further. The important thing is that everyone is comfortable with the final document, so that it is actually used rather than sitting on a shelf gathering dust.

Appendix A *Writing SEGY Data to a Disk File*

Appendix B *SEGY Tape Labels*

Appendix C *Blocking of SEGY Files on Tape*

ASEG RF – Donations

The ASEG Research Foundation gratefully acknowledges donations from the following companies:

ASEG	$30,000
Data Science	$200
SEG	$2,500