Australian
Society of
Exploration
Geophysicists
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Preview

April 1998

Issue No. 73

AEM'98

A Roaring Success

See pages 29-30

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Editor's Desk

Nothing ever stays the same and *Preview* is no exception. However changes at *Preview* are more evolutionary than revolutionary and as always feedback and input from the readership is essential.

It is my intention to change the emphasis of the Unipulse section to be more of a news and events section covering such things as conferences, workshops, appointments, research projects and student matters. Letters to the Editor on related topics will be included. I am looking for a Unipulse editor to solicit this material.

Preview is living in a somewhat hand to mouth manner at the moment and this is not as I would like it. This is mainly due to the fact that it relies too heavily on my input and the effort needs to spread around. I am looking for guest editors for thematic issues of *Preview* in the following areas (or others): Seismic acquisition; processing; interpretation; tutorials; coal geophysics; student issues (Feb 99); borehole geophysics; AEM and groundwater.

Corporate Member profiles will re-appear from the next issue.

Preview is also being used more and more to promote the society. Spare copies of *Preview* were distributed at the SEG conference in Dallas and the AEM conference in Sydney. In addition the last *Preview* was distributed to library subscribers of *Exploration Geophysics* and this will continue on a trial basis pending feedback from these subscribers.

Regards
Henk van Paridon, Editor

Corporate Members - Paid 1998

Digicon Geophysical Limited
Mincom Pty Ltd
M.I.M. Exploration Pty Ltd
Oil Company of Australia
Rio Tinto Exploration
Veisels Pty Ltd

Corporate Associate Members - Paid 1998

Acrodata Holdings Limited
Ashton Mining Limited
Boral Energy Resources Limited
Encom Technology Pty Ltd
ECS International Pty Ltd
Geo Instruments Pty Ltd
Pasminco Exploration
Petroconsultants Digimap (Geodata Service)
PGS Exploration
Quantec Consulting
RGC Exploration Pty Ltd
SA Department of Mines & Energy Resources
Schlumberger Australia Pty Ltd
Scintrex Pty Ltd
Western Atlas International Inc
Woodside Offshore Petroleum Pty Ltd
Zonge Engineering & Research Organisation

President's Piece

The 1997/1998 ASEG year has ended in turmoil for part of our industry. We are seeing explorationists particularly in the base metal area being made redundant at an alarming rate. Corporate Australia appears to have lost the will to think independently and have decided to minimise exploration groups and thus increase the bottom line. The various causes for this are the low commodity prices, the Asian Melt Down and the perceived difficulty of exploring in Australia This short term view will obviously have some immediate effects in the lack of jobs and reduced exploration programs but the long term effects could change the face of the industry. Firstly the reduced exploration expenditure will limit the future discovery rate and hence our long term balance of payments (assuming mining is still a major contributor to this). Secondly companies will generally use more of a contracting style workforce and thus reduce the career geophysicist's future. Unfortunately this style of workforce will ultimately reduce the graduate intake and perhaps Derecke Palmer's predictions could take effect!

BUT the resource industry is so cyclic that when discoveries wane and commodity prices improve so will the budgets and hence job prospects. Not being a soothsayer and being a complete optimist who has seen at least two of these cycles I'll believe the later.

Having acknowledged these problems it is good to note that the ASEG is still forging ahead. Before our own Conference and Exhibition year the ASEG has been a partner in two successful events. Both of these occurred in Sydney in February. The AEM International conference attracted over 270 delegates plus one Federal Senator and one Rogue Tasmanian politician who asked an in-depth question and unfortunately got some serious replies. The Federal Senator is currently in hot water over his coal interests and it was obviously his exposure at the conference that brought him to prominence. The Tasmanian poly' was an impostor, in fact a comedian, but probably would do an excellent job in parliament.

The conference was truly a success and brought together the aquirerers, the processors, the interpreters and to a limited degree the managers. A good mix of the Government, Industry and Academics from Australia and overseas provided a comprehensive coverage of the state the art in Airborne EM. The organization of the conference was a tribute to Brian Spies and his organizing committee. A majority of the papers presented will be published in the Editions 2/3 of Geophysics due in July. I believe that this work will be a reference volume by AEM practitioners for some time to come and a credit to our Society.

The Radiometric workshop was oversubscribed and required an overflow hall with a video link. I did not attend this meeting so I cannot attest to its quality but by all accounts it was a very worthwhile affair. The proceedings from the workshop are to be published in *Preview* soon.

The Federal Executive had its annual election on April 7th. As outgoing President I would like to thank all of the Executive Committee who have all worked hard in voluntary capacities to maintain a committed and vibrant society. I would also like to thank members of the Society including State Branch and Standing Committees representatives, contributors to *the Preview* and EG. They have ensured that we are a Society of high technical merit in geophysical exploration, which to me is a fundamental tenet.

S.N. (Nick) Sheard
ASEG Outgoing President

Executive Brief

Congratulations to Brian Spies and all the CRCAMET team for a very successful and professional conference on Airborne EM last month. I attended the conference and all the attendees I spoke with agreed it was cutting edge stuff. The format of the presentations gave plenty of time for discussion and some of the debates between companies and contractors were just as entertaining as Richard Vain MP! As a co-sponsor of the conference, our society was well promoted. We had many enquires about membership and plenty of complimentary copies of *Preview* were taken. Look out for some excellent publications in the July volume of *Exploration Geophysics*.

One of the tasks for the Executive committee this year is to investigate status of the many sub-committees of the society. All sub-committees will be reporting back to the Executive on a regular basis. The contributions of all members involved in these committees, present and past, is gratefully acknowledged. The status of each committee as we understand at the moment is:-

Publications Committee - alive and working well.

Conference Advisory Committee - Roger Henderson has just agreed to take on the job of CAC Chair since ex-chair Kim Frankcombe is tied up with the Perth Conference organisation. This committee is very active with the current Conference Organising Committees.

Standards Committee - this committee is only partly working.

Honours & Awards Committee - new members are being sought.

Corporate Affairs - No current activity and it is recommended that the committee be closed.

South East Asia - No current activity and it is recommended that the committee be closed.

Student Liaison Committee - still investigating....

Plenty of papers and posters have been received for the Hobart Conference and the draft technical program is complete. There will be one petroleum stream and two minerals/engineering streams. Booths are selling fast so if you want one you should get onto the PCO. The date of the Perth Conference will be around February or March 2000 and the venue is Burswood Dome.

The Financial Status of the society at 20 January 1998:-

Cheque Account (00800044)	$57,263
Cash Management Acct (00791483)	$79,355
Term Deposit (CBA Commercial Bill)	$158,000
Cash Managements (Sands)	$10,828
Term Deposit (Sands)	$40,000
NET CASH:	~ $345,446

Robyn Scott
Honorary Secretary

Personality Profiles

KYLA de CLIFFORD
CO-ORDINATOR FOR ASEG PUBLICATIONS
Jenkin Buxton Printers Pty Ltd

Kyla grew up in Donvale, Victoria, and went to Swinburne University to study marketing (1993). She deferred to go to Denmark where she studied and worked. She returned In 1995 to start work for Niche Media where she was the circulation co-ordinator looking after eight magazines. She was responsible for their marketing promotions every month and organising their distribution.

She retained this position for two years before accepting her current position at Jenkin Buxton Printers Pty Ltd, which includes her co-ordination of ASEG publications, where she is the first point of contact for advertisers.

She will be returning to finish her Marketing Degree in the second semester this year. In the meantime she will be doing a short marketing course for the next three months.

Kyla enjoys being in the spotlight and has friends in high places *(see photo)*.

She plays basketball, tennis and football (AFL), on the odd occasion that the boys let her join in! Kyla barracks for Geelong.

She spends as much of her spare time as possible down at Ocean Grove with her wonderful boyfriend, David, and their baby, Munga, who is an 18 month old Rottweiler!

New Federal Executive

President	Noll Moriarty
First Vice-President	Andrew Mutton
Second Vice-President	Wayne Stasinowsky
Hon Secretary	Robyn Scott
Hon Treasurer	Grant Asser
Preview Editor	Henk van Paridon
Committee	Nick Sheard, Koya Suto, Steve Hearn, Margot Whittall, Doug Price.

Treasurer's Report

As part of the continuing push towards ever greater heights of professionalism, the Federal Executive requested a budget for 1998. This will enable us to better monitor our financial performance throughout the year, and to formulate responsible longer-term commitments. As an example of the latter, a $30,000 annual contribution to the ASEG Research Foundation has been budgeted.

The Society's cash flow is substantial, the projected net revenue for 1998 being $271,000. Only about $100,000 of this is derived from members' subscriptions. Conference income is crucial and, based on the strength of recent conferences, a healthy surplus has been predicted from the Hobart conference! The other principal source of income is our publications. The budgeting process serves as a reminder of the debt the Society as a whole owes to those members who organise our conferences and produce our publications.

Despite its many advantages, a budget has one huge disadvantage: the Treasurer could be proven wrong! Accordingly, I am standing down as Treasurer, and we are seeking someone new to make the Society even more accountable.

Brief details of the 1998 Federal budget are as follows:-

INCOME	
Membership	$109,200
Hobart Conference	$ 50,000
Exploration Geophysics	$ 64,500
Preview	$ 39,100
Interest	$ 8,300
Total income	**$271,100**

EXPENDITURE	
Preview (excl. conf. edition)	$ 70,700
Exploration Geophysics (excl. conf. edition)	$ 57,400
ASEG Research Foundation	$ 54,000
Secretariat	$ 39,700
Accounting Fees	$ 16,600
Perth 2000 Conference (loan)	$ 10,000
Capitation	$ 9,600
Administration	$ 5,300
Development & Awards	$ 3,200
Total expenditure	**$266,500**

Peter Fullager
Hon Treasurer (Outgoing)

Preview Deadlines – 1998

June	**May 15**
August	**July 15**

Calendar Clips

1998

April 30
First call for papers SEGJ Fracture Imaging Symposium.

June 8-12
EAGE 98 Leipzig www.eage.nl

June 20-26
SEGJ/SEG Beijing. Beijing 98 Conference and Exhibition.

July 6
SEG/ASEG 4D Seismic 1 Day Course, Perth.

July 8
SEG/ASEG 4D Seismic 1 Day Course, Melbourne.

July 10
SEG/ASEG 4D Seismic 1 Day Course, Brisbane.

July 21-24
Western Pacific Geophysics Meeting, Taipei.

August 30 - September 2
West Australian Basins Symposium, Perth.

September 13-18
SEG Conference, New Orleans.

October 15-16
Cooper Basin Symposium, Adelaide.

October 28-30
Gas Habitats of SE Asia &Australasia, Jakarta.

November 8-12
Australian Society of Exploration Geophysicists 13th International Conference and Exhibition. Hobart, Tasmania, Australia.

December 10-12
SEGJ/SEG/ASEG 4th Int Symposium Fracture Imaging, Tokyo.

Details and more events on Page 36.

Sneak Preview

1998 will be a big year!

- *Results of Radiometrics Workshop.*
- *Review of Ian Jacks 4D Seismic Workshop.*
- *Conference Edition.*
- *Your contributions.*

Society Briefs

Corporate Membership Changes

The important role played by past and current Corporate Members in the ASEG is very much appreciated and acknowledged. The ASEG Federal Executive announced recently changes for the 1998 Corporate Membership, after seeking Corporate Members' views on the proposed changes late last year. The comments on the proposed changes were largely favourable. Following recent questioning by some companies, it is now apparent the reasons underlining the changes should be discussed by the Society as a whole.

Key factors considered by the Executive driving the changes were the lack of significant promotion within the Society of the Corporate Members and the need for an ensure and increased funding stream for the Research Foundation.

With respect to promotion, the Executive would like to see increased acknowledgment in the Society's publications of the Corporate Members and by (say) poster at the Conferences. An Internet hot link from the Society's web page and the Corporate Members would be established.

The Research Foundation, set up by the ASEG in 1989, promotes research in Applied Geophysics by providing grants at the Honours, Masters and Ph.D. level (see details on the ASEG web page). Generally there are 3-4 students sharing about $20-30,000 per year funding. The Foundation is keen to substantially increase the grants available. To date, funds for the Foundation have come from direct donations by the ASEG, SEG, some companies and individuals. It has been difficult for the Foundation to plan ahead, because funding for future years is not known.

In this age of need for technical and innovative geophysical leadership, the Executive would like to see the Foundation's prominence and relevance extensively upgraded. We wish to see more support for research activities, with a Foundation funding target of $80,000 per year. To start the ball rolling, the ASEG is donating $30,000 yearly to the Foundation.

In essence, the changes to Corporate Membership involve the creation of two types of Member – Corporate and Corporate Associate. Differences between the two types include the prominence of the Society's acknowledgment of the Member, amount of discount for advertising and number of copies of the publications received by the Member. From the set fees of $2,500 and $500 for Corporate and Corporate Associate members, the Society would forward $2,000 and $400 respectively to the Research Foundation. This donation is tax deductible for the Members. Thus the Foundation would receive increased regular funding. Corporate Members' suggestions for research topics are welcomed by the Foundation.

The Executive seeks comments from Corporate Members/Associates and individual members on the use of the name Corporate Associate. It has been suggested Corporate Associate may imply that member is not an active member. Possibly the name for the current Corporate Members could be enhanced (e.g. "Corporate Plus"?) and the Associate Member then called a Corporate Member. Furthermore, the amount of discount on advertising will be reviewed, although we have to ensure increasing costs of publication are recovered. Last year, increases in advertising fees were announced – note that these fees are still below those of comparable publications.

Finally, there is a perception that the Society has a large amount of funds from Conference "profits" and that Corporate Members should not therefore have to contribute to the Foundation. What is not appreciated is that these "profits" have been declared before all expenses associated with publication of the Conference Journal are incorporated. The overall profit is actually smaller. Refer to the 1998 ASEG Budget, tabulated in this edition, that shows the fine line between income and expenditure.

The Executive welcomes any comments on the changes to Corporate Membership. Please contact Noll Moriarty or Andrew Mutton.

This column is intended for news from Society members that will be of interest to others. Topics can be about personal, kindred society or company information. It will also act as a Stop Press. Please send in your briefs! Ed.

Noll Moriarty
President

ASEG Branch News

Queensland

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The year has started off with the February meeting, being the NSW branch AGM and the office bearers for the year will be Timothy Pippett as President, Dave Robson as Secretary and Katherine McKenna as Treasurer. The AGM was then followed by a very interested talk from Dr Brian Spies on the topic of "The Current Status and Future Direction of the CRC-AMET." He also gave an overview of the Airborne EM Workshop which had over 270 registrations.

At the March meeting, Nigel Jones gave a very informative talk on the work he undertook for a masters Degree in Groundwater Geophysics. As part of his studies Nigel did a hydrogeological investigation using aeromagnetic and ground electromagnetic data together with downhole resistivity and conductivity data to investigate mound springs in the Gunnedah basin of New South Wales.

The program for he next few months talks has not been put in place as the Preview goes to press but I can assure you there will be some very good soft and hard rock papers with a number of talks orientated at data acquisition. Please remember if you are in Sydney on the third Wednesday of a month, there will be an ASEG meeting being held at the Rugby Club Rugby Place (down near Circular Quay).

Timothy Pippett
NSW Branch President

ACT

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Treasurer: Bob Groves (08) 9370 1273/Fax: (08) 9370 1273

A new permanent mailing address for the WA Branch of ASEG has been established at:-
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South Australia

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Another relaxed start to the year for the South Australian branch. We held our AGM on the 26th of February and put a few new faces on the committee (and a few fine bottles of red away) Mike Hatch was elected as President, Samanda Bell as Vice President, Paul Washe as Treasurer and Andrew Shearer returns as Secretary. The committee looks to be fairly robust with 12 at-large members. The following were elected to the committee: Alan Aplleton, Nick Dunstan, Neil Gibbins, Bill Hedditch, Richard Hillis, Leslie Huggard, Rod Lovibond, Andy McGee, Andy Mitchell, Suzanne Roberts, Stephen Tomlin and Peter Wickens. We are all sorry (in a local sense) to see Mark Taylor head off to the greener pasture of Paris for a few years.

Victoria

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There was good attendance from the Victorian branch members for our March meeting (the first for the year) in which Richard Smith from Geoterrex gave an excellent presentation on "iSPI", the improved Source Parameter Imaging method. Richard also fielded some enthusiastic questions from the audience.

The SPI method (Thurston and Smith, 1997), is a technique which makes the interpretation of magnetic data significantly easier. Magnetic total-field data are distorted in shape as a consequence of varying magnetic inclination, declination and remnant magnetization. This distortion is removed on the local wavenumber images output by the SPI method. Depth estimates can therefore be obtained from these images independent of the magnetic inclination, the declination, the remnant magnetization, and also the dip and the strike of the structure. It is also possible to obtain dip and susceptibility estimates, but these require an assumption of no remnant magnetization. The advantage of the method is that interpretation is done from an image which makes the interpretation of a particular feature easier, as the context of each anomaly is clearer.

We would like to sincerely thank both Richard and Geoterrex for making time available to present ideas on this exciting field of research.

Our next meeting is the April AGM, in which we are also going to hear a presentation from Mark Dransfield on Potential Field Searchlights.

The 1997/1998 Victorian ASEG Committee are:-

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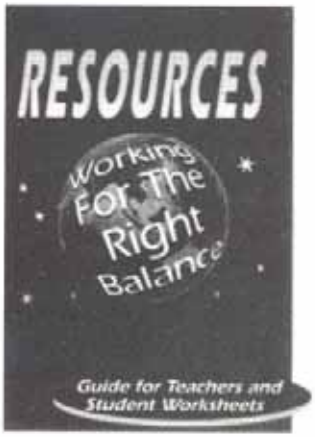
Preview Review



RESOURCES:

Working for The Right Balance

Published by:

Mines and Energy, South Australia

Do we know much more than high school students about the subjects we have not specialised in?, or are of special interest? A few years after school do we know more about Shakespeare, Roman history, vector algebra, chemical reactions, photosynthesis, the Australian Constitution, etc. than when we were students? As well as preparing the foundation for future specialisation, high schools provide, or at least should, a very wide range of basic knowledge of life and society. At this age children have the ability to absorb a great amount of information, and it forms the fundamental way of thinking for the rest of their lives. In this context, it is very appropriate for the educational package, "Resources: Working for the Right Balance", to aim at high school students. Furthermore, the product is informative for the general public to whom resource issues are not of day-to-day concern. I would commend the authors' effort and MESA's initiatives on these points.

"Resources: Working for the Right Balance" comes in a presentation box which is a little larger than A4 and about as thick as the Concise Oxford Dictionary. Why is it so big? Opening the box, you will find a video cassette and a CD-ROM in the left and a 290 page workbook in the right. More than half of the thickness is taken by the video cassette, and the size of the workbook is A4, which is ring-bound ready to open flat on your photocopier stage. "Resources: Working for the Right Balance" is, as the authors call it, a multi-media learning package.

The package covers eight topics: The Importance of Minerals; Exploration, Mining and Processing; Environment Management in Resource Industry; Using Resources from the Earth; Groundwater; Careers; Energy; and Finding the Right Balance. Each topic is contained in the video, CD-ROM and the workbook in the same structure so that the all three media can be used independently or jointly. The best way to use in the classroom is, perhaps, to watch the video first and then to reinforce it by discussions followed by the questions in the workbook. The CD-ROM can be used for a quick reference in the class room or homework, and it adds fun to learning. There is a game to identify commonplace objects and find the mines in Australia where their raw materials are extracted, but as the game advances the time allowed becomes too short to learn anything. (Perhaps I am not good enough at computer games.)

The video starts with scenes familiar to our daily life, and proceeds to the benefits we receive from the earth's resources. For some people, it may be a surprise to find so many familiar products are manufactured from mined resources. The scenes then move to exploration in the wilderness, developing and operating mines and some minerals processing. The viewers can see parts of Australia to which usual holiday trips may not take them, or from the different perspective of a light aircraft or at the wheels of a seismic vibrator. The scenery is generally beautiful so that just watching this video is pleasurable. Apart from the narrator, people we meet in both the video and on the computer screen are from the industry. It is nice to see our friends and colleagues.

Many aspects of the resource industry are covered in this extensive package. Geophysics and geology are well covered in the Exploration and Career Guidance sections. Roles of different specialists, companies and governments are explained well. Our environmental concern is emphasised in each section. It seemed to me the authors are very concerned (perhaps a little too much) about environmental issues. However, it is arguably necessary to improve the image of the industry at every opportunity, and such effort and concern are well justified. After all, mineral and fossil fuel resources are limited, and to manage and use them with a sense of balance should be an ultimate concern of our society.

The CD-ROM is a special feature of the package. Interactively accessed animated pictures briefly explain typical the genesis of ore deposits. In exploration, the student temporarily becomes a geologist, a geophysicist, or an exploration manager. They can follow exploration activities step by step: from planning the survey, operation, data analysis and economics. In planning, associated issues like Aboriginal claims, landowner liaison and environmental management are not forgotten. There are quizzes at the end of most sections to test what was learnt. Inevitably the processes are simplified for students. I wish our jobs were as easy as this!

Resources other than minerals and petroleum are covered as well. This includes groundwater and alternative energy sources. On the CD-ROM, a glossary icon is always provided in the lower right corner, as well as links from technical terms used in the text. The explanation of the words are plain and understandable. I noticed several American spellings in the Australian scene.

My friend, a primary school teacher, borrowed my copy and used it in his class room. He found that upper primary school children can understand and carry out sensible and stimulating discussions on the topics. He wrote to me:-

"The book provides a great lesson overview for each unit, and enables the teacher to walk students through the many issues associated with effective resource management. The video contains sections which compliment each unit, and are an excellent introduction to the issues each unit addresses. There is some obvious bias towards the mining industry, but it is not intrusive, and as a teacher, I consider the information is balanced and useful and emphasises the need to manage resources effectively".

My fear is that it may be too large a commitment within the time frame of the current curriculum for a teacher to show nearly three hours of video followed by discussion and workbook activities. This may take about one hour per week for one full term. Copies were distributed to every high school in South Australia. I hope these copies will not be sleeping on a shelf in the staff room.

Considering the quality, volume and work involved in the creation of the package, the price of $90 to schools and $150 to others is low. I would recommend this package to all schools and the general public. Mining companies, oil companies and geophysical contractors can use this to explain to their non-technical staff and visitors what their business is all about. I hope that a civic-minded organisation in the resource industry will donate this package to more schools and public libraries. Greater access to a wide audience will promote understanding of the resource industry's major challenge: the balance between our need for mining products and the maintenance of a healthy environment.

(Review by Koya Suto, Oil Company of Australia)

SEG Distinguished Lecture Series

Time Lapse Seismic (4D) in Reservoir Management

by Ian Jack, BP Exploration

***FREE* to all ASEG/SEG Members**

This course brings geoscientists up-to-date with the state-of-the-art in "time-lapse seismic" and enables them to assess the value and risk of this new technology.

It covers the rationale and driving forces behind time-lapse seismic by examining the limitations of existing methods of tracking fluid flow between wells. It examines those reservoir properties that change with time, and what can be observed on seismic data over elapsed time.

The repeatability of seismic data and the use of "legacy" data sets are discussed, together with a review of the seismic data acquisition schemes and data processing requirements for time-lapse analysis. The rock physics foundation for the data analysis and interpretation options are also described.

A selection of industry case-histories illustrates many of the above points. The participant will leave with an understanding of key success factors, key calibration requirements, and key uncertainties of time-lapse seismic in reservoir management.

Perth July 6, Melbourne July 8, Brisbane July 10.

For more information, contact local branches.

ASEG RF – Donations

ASEG RESEARCH FOUNDATION

Post to: Treasurer, ASEG Research Foundation
Peter Priest, Ste 3, 17 Hackney Rd,
Hackney SA 5069

NAME: .....

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COMPANY: .....

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ADDRESS: (for receipt purposes)

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ASEG RESEARCH FOUNDATION

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Obituary

VALE JOE WILLIAMS

Joseph Patrick Williams (1941-1998)

Joe Williams died at his home in Ipswich on 10th February 1998 after a long illness. He will be sadly missed by his family and many friends and colleagues. The following memories are assembled from information supplied by his wife Genie and friends/colleagues, Bob Smith, Mike Shalley, David Gust and Lloyd Hamilton.

Joe was born in Gulgong, New South Wales, on 10th November 1941 and spent his early years on his parents' sheep and wheat farm. In later years he often joked that he was a frustrated farmer - hence his great love of the outdoors. He completed his schooling at St. Stanislaus College, Bathurst in 1958 and went on to Sydney University where he gained a B Sc with majors in Geology and Geophysics in 1961. In those days Joe's first interest was Chemistry but he took Geology as an enforced extra and Geology/Geophysics soon became the total love and interest which he maintained all his life.

Joe joined the metalliferous section of the Bureau of Mineral Resources in Melbourne in 1962 and shared a flat there with Bob Smith and several others between field operations. Work included planning, leading and reporting on a variety of surveys throughout Australia. Examples were gravity and seismic at Tallebung, Kikoira, Cooktown and Mount Garnet. Joe also participated in the early evaluation of the IP method at Hoddle's Creek and Castlemaine. He conducted extensive surveys with magnetics, EM, IP, and SP at Mount Lyell and other areas. The Mount Lyell surveys contributed to the discovery of the Cape Horn orebody.

In 1965, at his sister's wedding in Sydney, Joe was attracted to the chief bridesmaid and was heard to mutter to his twin brother Tim (who was officiating at the wedding), "Who is that girl? I'm going to marry her". It was a genuine case of love at first sight, the truly authentic love that endures through thick and thin for a lifetime. They married the following year - the girl, of course, was Genie. At about that time the Geophysical Branch of the BMR moved to Canberra where Joe and Genie set up their first home. A family soon followed led by Matthew in 1967, then Rachel in 1968, John in 1969 and Simon (deceased) in 1971. Joe was always an immensely proud and devoted family man.

From 1967, as a Geophysicist Class 2, Joe conducted scale model tests on the Turam method and from that developed new interpretation procedures. Results of this and later work were presented at the first and second ICOGEO conferences in Sydney (1970 and 1973). The Turam model studies were published in the ASEG Bulletin in 1971. Joe also worked at Tennant Creek and Rum Jungle and moved to Darwin in 1969 to take charge of the uranium group there. He was also in charge of the seismic observatory, geophysical laboratory and field operations at Rum Jungle and South Alligator.

Joe left the BMR in 1970 and moved to Sydney as Chief Geophysicist for Australian Ores and Minerals, Carr Boyd Minerals and Hill Minerals. His work for this group in Tennant Creek contributed to the discovery of the Rover field which is a repetition of the Tennant Creek copper/gold field. He was later to become the Chief Geophysicist of Anaconda (Aust.) Inc. and spent a year or so as a consultant before joining QIT (now QUT) as a lecturer in Geophysics and Hydrogeology from 1983 to his retirement in 1995 due to illness.

During his twelve years in acadaemia Joe brought to his teaching a relevance founded on his extensive industry experience. He emphasised the practical aspects of his subjects and provided students with the valuable 'hands-on' experience they needed for their careers. Joe was an exceptional geologist as well as a good geophysicist and his contributions to the training of students earned him both popularity and respect.

In 1987 Joe completed a M App Sc in Geophysics from QIT. Entitled 'Upward Continuation of Magnetic Intensity Profiles' the research was of great practical and scientific value and a testament to his intellectual brilliance. His love of learning and his desire to contribute to the advancement of his chosen scientific field was reflected in his move to undertake PhD studies. Although unable to complete this degree due to his early retirement, his efforts were noted and admired by students and staff. Joe's honesty and open friendliness, coupled with his sharp wit and love of a good story, endeared him to us all.

Joe was prominent in the early day of the Queensland local branch of the ASEG and was a regular attendee at meetings until his illness. He was also a member of the 1992 Conference Organising Committee where he served on the Technical Papers Committee.

Retirement and illness did not dull Joe's interest in the pursuit of scientific knowledge. He continued his work on the remanent magnetisation of batholiths and published a short review article in the April '97 issue of Preview. God bless you Joe. We will miss you and remember you.

Obituary

VALE LYNN McNEILLE HASTIE

Lynn passed away on 2nd December, 1998, aged 60 after a final battle with cancer. His warm personality and ability as a scientist will be remembered with fondness and regret for the loss by his colleagues in Geophysics and in The Physics Department of The University of Queensland. His research in magnetotellurics together with his ability and wide knowledge of micro-processors, computing and signal processing earned him the deep respect of all those who sought the benefit of his advice. To the end he was concerned about the continuation of the work he had initiated in magnetotellurics and C.S.A.M.T. and for those research associates and graduates who participated in this research his demise is deeply felt.

He was born in Rockhampton, graduated with B.Sc. (Hons) from The University of Tasmania in 1961, then joined the Bureau of Mineral Resources as a Geophysicist (1961-64). After completing a Masters (1966) and then a Ph.D. (1971) in Physics at the University of Toronto, Canada, he returned to Australia and in 1972 joined the Physics Department of The University of Queensland.

From an early interest at Toronto in earthquake rupture, publishing on dislocation models and surface deformation, research was continued at Queensland with the Geophysics group established by F.D. Stacey on anelasticity and stress measurements.

In 1973 he became interested in electromagnetic prospecting techniques, particularly magnetotelluric and audio magnetotelluric methods. In so doing he became an excellent exponent of signal processing techniques which he brought to bear in his teaching of this subject as might be recollected by quite a number of geophysics and physics graduates.

A big problem in obtaining accurate impedance estimates in MT and AMT is the variability of the results due to variability in the source. An analysis by his research team of source signals from a recording station he established near Ipswich, Queensland showed that the inaccuracy was due to the non-stationarity of these signals. This led to the development of a non-stationary time series method of analysis with a consequent improvement in the signal to noise ratio. Source signal problems eventually converted him to the controlled source method (CSAMT.). For this he developed a switched mode power amplifier which could handle any frequency and waveform in the band width 0 to 10000Hz generated using a computer. As this work expanded he received support from ARGC, NERDDC, MIM and AGL. In the words of a colleague '...His approach to the field was definitely unique and innovative, but not yet accepted widely, largely due to unfamiliarity in the community...'

In depth sounding applications he worked on data sets from Papua New Guinea and the Bowen Basin. His field work in the Bowen Basin was memorable as, in the experience of any geophysicist, in the field the unexpected can happen. From a former research student —

'One night we learnt the importance of careful selection of measurement sites. After retiring for the night it started to rain, which is usually of no consequence except that we had camped on the flood plain adjacent to a creek and woke up at 3am to find ourselves floating on our air mattresses in six inches of water. The true character of an individual is revealed in such circumstances, and Lynn worked as hard as anyone to recover the waterlogged equipment and camping gear.

Lynn taught me that field work depends on trade secrets of practical significance revealed here for the first time but known to many such as the fact that cockatoos eat any coloured wire except black, that cows will chew through any wire laid on the ground except solid steel cored wire or that a Ford transit van can go where no Ford transit van has gone before.'

Lynn was a great supervisor, dedicated, always helpful and cared for his students. He is survived by his wife, Margaret and sons Callum and Marcus.

Sydney Hall

Multi-channel Gamma-ray Spectrometric Correction and Calibration Techniques

By Martin Schneider, DFA

This paper was presented at the recent Gamma-ray Spectrometry Workshop and has been edited for inclusion in Preview. In particular many of Figures have been omitted. Interested readers should contact the author for more information.

Corrections

Historically, the main impediments to the routine use of multi-channel radiometric corrections have been:-

- the time and space required to record raw spectra in real time;
- the difficulty in obtaining calibration data required to derive the spectra and;
- coefficients needed for data processing.

The rapid advances in instrumentation and computer systems used for data acquisition has eliminated the first restriction and improvement in processing algorithms has turned what was once a problem of research proportions into one that can be carried out with care in a reasonable amount of time and hence at a reasonable cost. Over the last few years, the corrections routinely performed in the spectral domain have been:-

- livetime/deadtime normalisation from counts to counts per second;
- energy calibration;
- cosmic and aircraft background removal;
- radon background removal;
- Noise Adjusted Singular Value Decomposition (NASVD) smoothing.

Figures 5a and 5b show a raw spectrum from a single 1 second sample that has had NASVD smoothing applied, the result being a differential increase in the signal to noise ratio dependent upon the count rate in the raw spectrum. Each of the photopeaks is more clearly resolved due to precise definition of the shape above the Compton continuum. This enables operations involving peak location and calculation of the area under a peak to be performed with much greater confidence using less stacking of samples. Less stacking results in better quality multi-channel corrections, especially the calculation of the amount of radon present for the spectral ratio technique.

Whilst these corrections have a noticeable effect on an individual spectrum, it is the effect upon groups of spectra such as lines, flights and whole surveys that is of most interest if these methods are to be useful and practical. One example of the benefits of multi-channel corrections can be seen in the results obtained from the routine processing of 8,500 line km of helicopter aeromagnetic and radiometric survey data flown in 1997 covering part of a 1:100,000 sheet in south eastern Australia. The survey parameters were:-

- 200 metre flight line spacing;
- 80 metre terrain clearance;
- Exploranium GR820 spectrometer with 16.8 litres of downward looking detector;
- 45 metre sampling interval.

The topography of the survey area was mountainous, ranging from 135 to 1210 metres above sea level. The terrain clearance achieved over this topography was very uniform and close to the desired level of 80 metres, except for two areas. This uniformity more than satisfies the underlying assumptions of the spectral ratio method for radon removal described by Minty in 1992 and 1997.

A series of images were prepared (not shown) in which each of the International Atomic Energy Agency (IAEA) windows Total count, Potassium count, Uranium count, and Thorium count before and after multi-channel corrections have been applied. The raw images depict the IAEA windows that were recorded in real time by the spectrometer and the processed images depict the IAEA windows after the raw spectra have been:-

- livetime corrected;
- energy calibrated;
- cosmic and aircraft background removed;
- radon background removed;
- rewindowed.

It is quite evident that the the Uranium and Total count data has been improved substantially from the real time window data, primarily due to the removal of radon while the potassium and thorium data show fewer significant changes. Similar improvements have also been observed in other datasets processed using the same software and methodology. These include:-

- 54,000 line km of data from the same group of surveys;
- 81,000 line km of data from the same type of spectrometer installed in a (different helicopter;
- 38,500 line km of data from fixed wing surveys using a different type of spectrometer;
- 20,000 line km of data from other fixed wing systems.

Figures 11 to 14 are a series of images which show the same data with NASVD smoothing applied at the beginning of the multi-channel processing stream. The improvement in the Uranium and Thorium data is dramatic, whilst the higher count rate windows of Total

count and Potassium show a lesser but still beneficial change. In detail (figures 15a and b) we typically observe the enhancement of weak features previously obscured within the background noise to a level where gridding techniques are able to better correlate between flight lines resulting in a more coherent view of the data overall. Other images produced show the combined benefits of the increase in signal to noise ratio generated by the NASVD smoothing and the removal of radon using the spectral ratio technique. The raw profile shows each of the 4 IAEA windows from a survey line strongly affected by radon (which is evident as a raised base level in the Uranium and Total count data) and with the typical noise levels expected from an airborne system with a small detector volume. The processed profile shows the same line with a much reduced noise envelope in all 4 windows and base levels close to zero for all 4 windows. Each pair of raw and processed window representations shows a reduction in the absolute count rate due to the subtraction of the three backgrounds (cosmic, aircraft and radon) and a reduction in the noise envelope due to the NASVD smoothing.

Calibration

The calibration data required for routine multi-channel processing can be obtained from 3 sources:-

- tests flown prior to or during a survey;
- historical test results;
- the survey data itself.

The cosmic and aircraft background spectra are obtained from the conventional multi-level high altitude tests flown for deriving the cosmic and aircraft backgrounds in each of the 4 IAEA windows. Instead of performing 4 linear regressions (1 for each window) 256 linear regressions are performed (1 for each channel in the spectrum). The result is 256 aircraft background constants which becomes the 256 channel aircraft background spectrum and 256 cosmic channel multipliers which becomes the 256 channel cosmic spectrum. Spectra (not shown) were derived from cosmic tests undertaken specifically for the helicopter surveys. The shape of these spectra conform closely to those published by Minty in 1992 and when summed over the channel range corresponding to the 4 IAEA windows, the amplitudes of the aircraft background spectrum agree favourably with those computed by independent regressions from the windowed data recorded in real time.

Cosmic and aircraft background spectra derived from the NASVD smoothed version of the same raw test data were produced. These spectra are smoother yet the aircraft background values are of similar amplitude to those of the raw test results. It is reasonable to conclude that the test results which have been processed using the NASVD smoothing method provide the best cosmic and aircraft backgrounds for removal from survey data as they contain the least amount of noise.

The radon spectrum can be obtained from test lines flown either at low altitude over water or at high altitude away from ground response provided that radon is present. However, as it is not possible to predict with sufficient certainty whether radon will be present in an area these tests do not guarantee that a radon spectrum can be found.

Two alternative solutions to this dilemma can be used:

- generate the radon spectrum from the low level survey data by differencing techniques outlined by Grasty and Minty in 1995;
- use an existing radon spectrum from another installation.

The radon spectrum used for processing the helicopter survey data was one generated from the AGSO fixed wing installation for a nominal height of 80 metres terrain clearance. Since the spectral ratio method of radon removal relies on the relative amplitude of each of the peaks used in the correction we need only assume that the shape of the radon spectrum remains consistent between installations for a given terrain clearance. To date we have no calibration data to support or refute this assumption, but we do have processing results that seem to work based on this assumption. It is hoped that this example helicopter survey dataset can be used to test the method of generating a reliable radon spectrum from the survey data sometime soon in the future.

Conclusions

From these examples we can conclude that presently:

- Multi-channel processing can be performed routinely on large survey data sets regardless of the type of survey platform and spectrometer in a realistic time frame and at reasonable cost.
- Multi-channel corrections improve data quality particularly when radon is present.
- NASVD smoothing using multi-channel spectra substantially improves the signal to noise ratio of the data, particularly in areas of low count rate.
- Cosmic and aircraft background calibration spectra can be derived reliably from conventional test data.
- Radon calibration spectra from one well calibrated system can be used to process data from another system.

Future developments

Selective recombination of spectral components to eliminate particular sources of systematic noise or undesirable signal from the multi-channel spectra such as man made sources of gamma radiation.

Use of amplitude and component information from the NASVD smoothing method for classification and interpretation of soil and rock geochemistry.

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Minty, B.R.S., 1992. Airborne gamma-ray spectrometric background estimation using full spectrum analysis: Geophysics, Vol 57, No 2, p279-287.

Minty, B.R.S., 1997 Multichannel Models for the Estimation of Radon Background in Airborne Gamma-ray Spectrometry: In Press.

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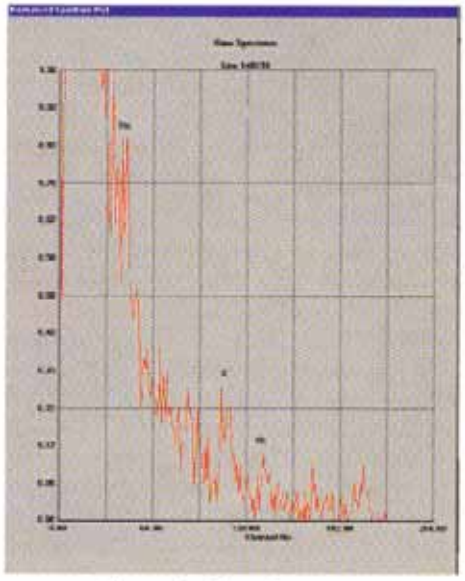

Figure 5a. Raw Spectrum.

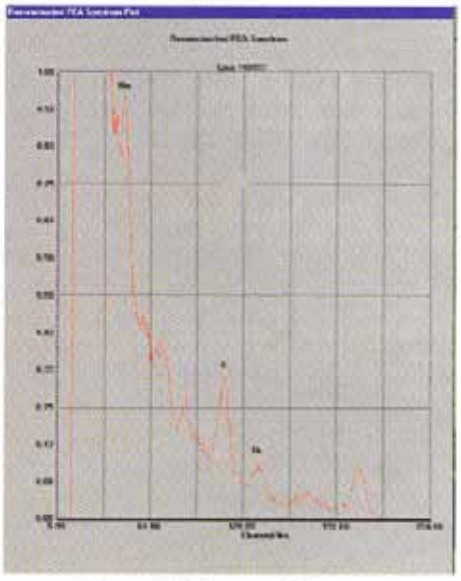

Figure 5b. Processed Spectrum.

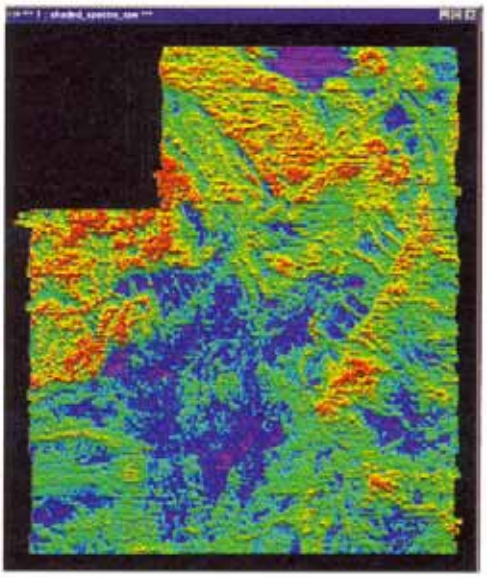

Figure 11a. Raw Total Count.

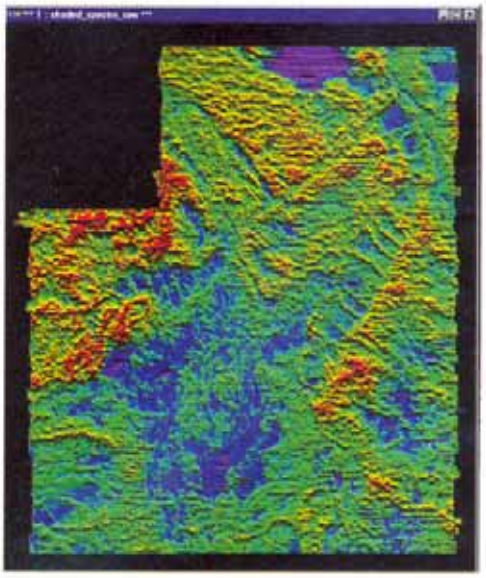

Figure 11b. Processed Total Count.

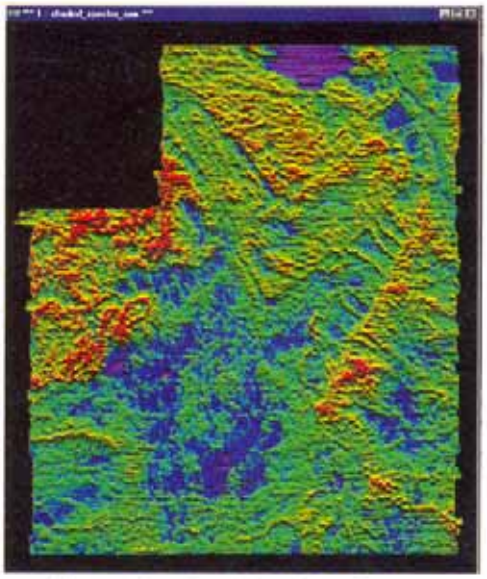

Figure 12a. Raw Potassium Count.

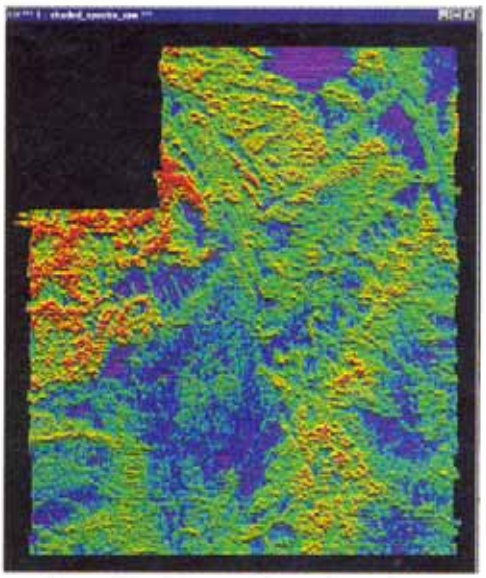

Figure 12b. Processed Potassium Count.

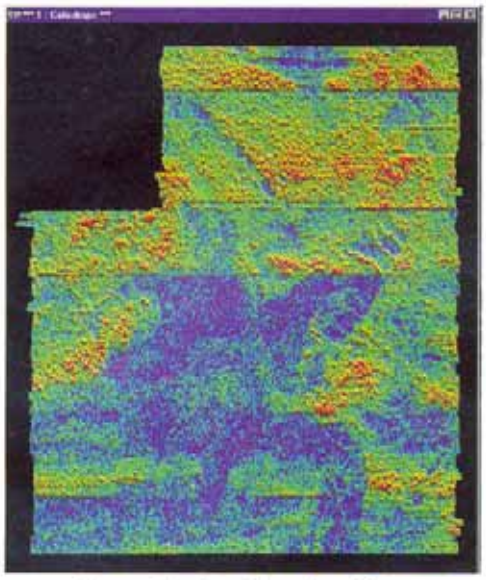

Figure 13a. Raw Uranium Count.

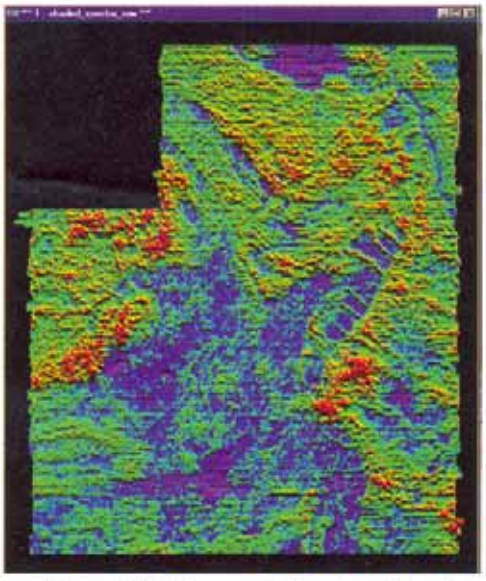

Figure 13b. Processed Uranium Count.

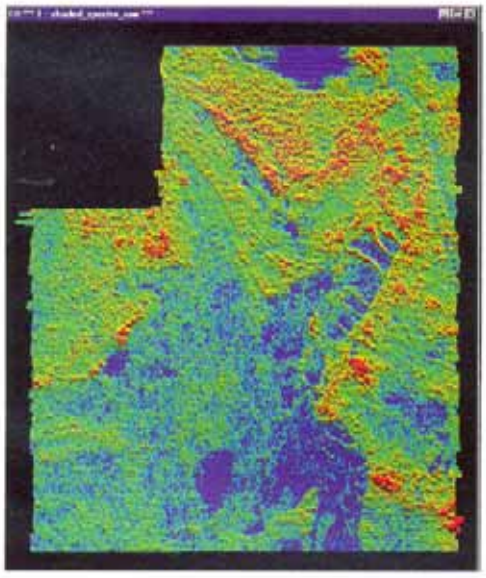

Figure 14a. Raw Thorium Count.

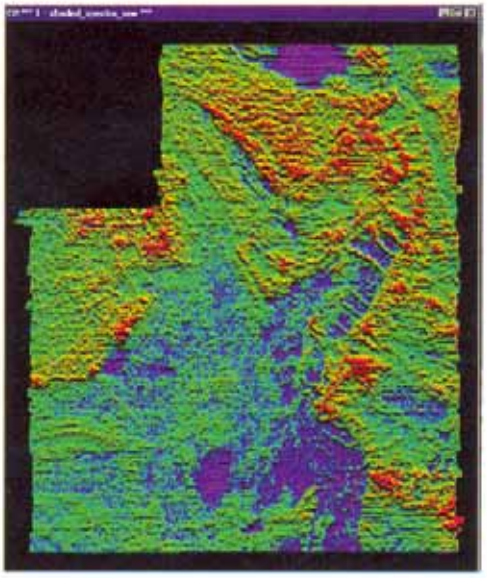

Figure 14b. Processed Thorium Count.

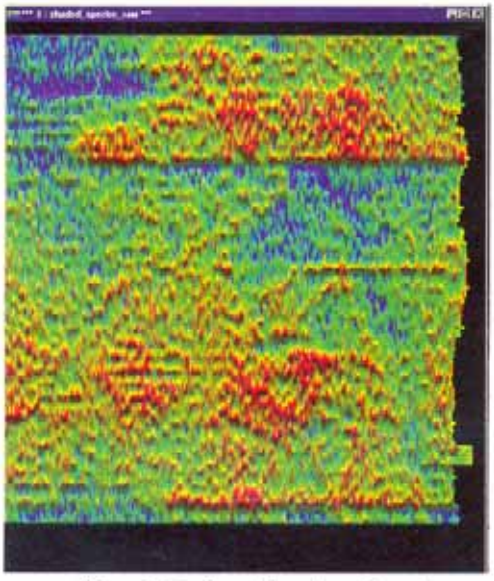

Figure 15a. Raw Uranium Count.

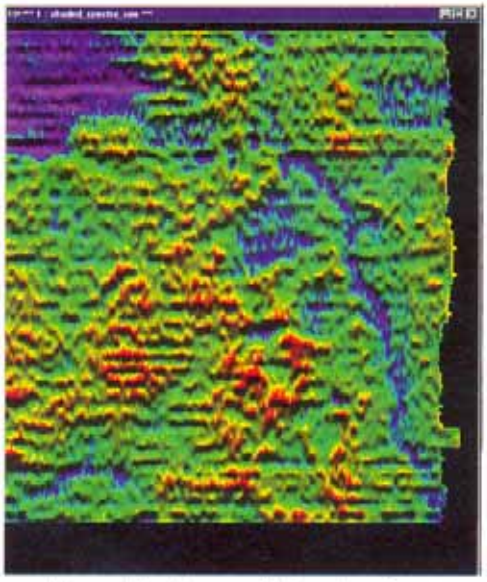

Figure 15b. Processed Uranium Count.

Sequence stratigraphy: Basic elements, concepts, and terminology

J.W. Mulholland, Thomasson Partner Associates, Denver, Colorado

Reprinted from the Leading Edge

The elements of "sequence stratigraphy" had been around long before it acquired its modern name, and those elements had their own terminology, familiar to most geologists and geophysicists (depositional cycles, unconformities, beds and bed sets, laminae and laminae sets, etc.). The publication of Exxon's stratigraphic technology with its own unique language at once both excited the geologic community and irritated many who disliked the proliferation of new terminology for long-held concepts. With time the objections faded, perhaps because as the new language became more widely used it became more familiar, and perhaps because the new language signaled new ideas, and it was a useful way to distinguish new from old.

The concept of globally synchronous unconformities created by eustatic lowering of sea level, and the preservation of those unconformities across a continent was reported by Lawrence Sloss in 1963. Sloss identified six cratonic sequences (named Sauk, Tippecanoe, Kaskaskia, Absaroka, Zuni, and Tejas) and their bounding unconformities. Peter Vail, a doctoral student under Sloss, took the concepts with him to Exxon Production Research Company where he had access to thousands of miles of offshore seismic data where unconformity-bounded depositional sequences were often strikingly evident. Vail refined his ideas, and together with his colleagues, by the early 1970s had developed terminology for the architecture of sequences, tied the depositional patterns to dated well and outcrop sections, matched the depositional patterns (cycles of coastal onlap) to postulated sinusoidal sea level fluctuations, and produced a technique to identify and date strata in virgin basins where only a seismic line was available.

Apparently believing this technology had leaked and was already widely known, Exxon consented to its publication in AAPG Memoir 26 in 1977 (see "Suggestions for further reading"). In fact, very few knew much about sequence stratigraphic concepts and the Memoir delighted scientists and thrilled the academic community, which had new grist for its publication mill. Two additional landmark publications soon followed: Sealevel changes: An integrated approach by C.K. Wilgus et al. (SEPM Special Publication 42, 1988), with additional conceptual papers and examples from continental basins, and Siliclastic Sequence Stratigraphy in Well Logs, Cores, and Outcrops: Concepts for High-Resolution Correlation of Time and Facies by J. C. Van Wagoner et al. (AAPG Methods in Exploration Series,

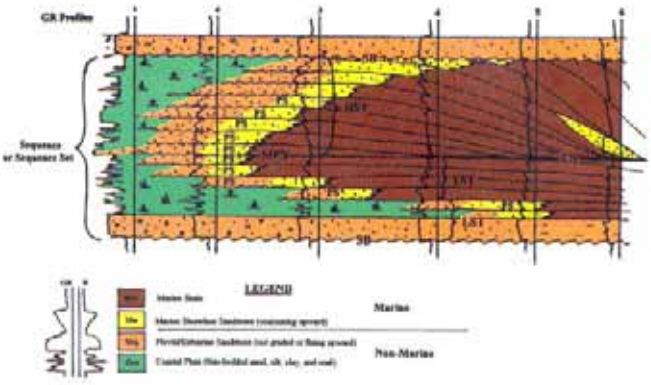

Figure 1. Schematic diagram to illustrate components of a sequence which includes a significant basal unconformity, or sequence boundary (SB). HST = highstand systems tract. TST = transgressive systems tract. LST = lowstand systems tract. MFS = maximum flooding surface, also called the condensed section (CS). PS = parasequence. Well log profiles are illustrated by stylized gamma ray (GR) curves and a resistivity (R) curve.

No. 7, 1990), with details of how sequence stratigraphic concepts were applicable at the scale of wells, core, and outcrops. In short order sequence stratigraphy-related publications exploded into the professional literature so that today a reference list would fill dozens of pages.

One not familiar with sequence stratigraphy will ask, "Why is it useful?" The answer is that it is an unparalleled exploration tool for oil, gas, and coal as well as a production tool for reservoir development. It works for both elastic and carbonate systems. For geophysicists it provides techniques for chronostratigraphic interpretation of seismic lines that provide (1) the ability to age-date to at least the period level seismic strata in previously unexplored basins, (2) more accurate facies identification in unknown strata, (3) identification of probable source-rock intervals and the location of probable reservoir facies, and (4) development of both tectonic and sedimentation histories of new basins or basins where data are sparse or limited in areal extent. For geologists, as stated by Van Wagoner et al., its application will result in (1) more accurate surfaces for mapping and facies correlation, and (2) higher-resolution chronostratigraphy for improved definition of plays, especially stratigraphic traps. Continuing to paraphrase Van Wagoner et al., it also will yield a more effective method for (1) evaluating sandstone continuity, (2) predicting reservoir, source and sealing facies, (3)

projecting reservoir trends into areas with limited data, (4) identifying stratigraphic traps, and (5) ex tending the life of older producing fields. Perhaps the real dividend has been that geologists and geophysicists exposed to the technique and its results are energized, excited, and infused with new ideas for tired basins and plays, usually resulting in increased discoveries and addition of new reserves.

The rest of this paper will review concepts and terminology. Readers are cautioned that this is a complex topic and this overview is a far from exhaustive treatment. The cited publications will provide a more indepth introduction to the details and theory and lead the reader into consideration of the numerous published studies now available.

General concepts

H. W. Posamentier et al. (in an article in SEPM Special Publication 42), defined sequence stratigraphy as "the study of rock relationships within a chronostratigraphic framework wherein the succession of rocks is cyclic and is composed of genetically related stratal units (sequences and systems tracts)." Behind this statement lie a number of assumptions and general concepts:

- Marine sedimentation patterns are controlled by changes in relative sea level.
- Relative sea level is controlled by eustasy, subsidence, tectonics, and sedimentation rate. On trailing-edge continental shelf environments, eustasy is of primary importance. In epeiric basins tectonics may overshadow the role of eustasy. Subsidence and sedimentation rate are commonly of secondary importance and are commonly assumed to be processes operating at constant rates (but, of course, they do not).
- Sedimentation patterns controlled by sea level have distinct geometries (systems tracts) that are easily recognized on seismic lines, well-logs, well-log cross-sections, outcrops, and cores.
- On passive margin shelves, as these geometries are eustatically controlled, they are similar worldwide. Once the geometry has been calibrated in a familiar area, it can be used as a correlation tool to identify and date seismic strata elsewhere.
- The building blocks of a depositional sequence are laminae and laminae sets, beds and bed sets, parasequences and parasequence sets, systems tracts, sequences and sequence sets. Sequences are commonly bounded above and below by unconformities (also termed sequence boundaries), which record a fall in relative sea level.
- Sequence stratigraphy may be applied at several scales, and in this sense it is fractal in nature (meaning that at any scale sequences have the same characteristics). Phanerozoic history is comprised of first-order eustatic sequences. First-order sequences are called mega-sequences by B. U. Haq et al. (in SEPM Special

Publication 42) and are equivalent to the cratonic sequences of Sloss. Eras are comprised of second-order eustatic sequences (supersequences of Haq et al.). Seismic stratigraphy normally is concerned with third-order sequences (1-5 MY duration), and it is this level that is the subject of AAPG Memoir 26. Geologic studies of well-log cross-sections, outcrops, and cores deal with third, fourth (105 years duration) and fifth-order (104 years duration) sequences, and these are the subject of Van Wagoner et al.

Terminology

Sequence stratigraphy has been defined above. Additional terms are quoted below from Posamentier et al. There is insufficient space in this article to expound on these terms, which are filled with meaning that can only be fully understood by study of the basic literature suggested at the conclusion of this article. Future articles in this series will, however, expand on these concepts. Figure 1 illustrates some of these features.

- "Sequence: A relatively conformable succession of genetically related strata bounded at its top and base by unconformities and their correlative conformities. It is composed of a succession of systems tracts and is interpreted to be deposited between eustatic-fall inflection points." Note that a sequence is terminated by a fall in sea level.
- "Systems tract: A linkage of contemporaneous depositional systems (L. F. Brown Jr. and W. L. Fisher, in AAPG Memoir 26). Each is defined objectively by stratal geometries at bounding surfaces, position within the sequence, and internal parasequence stacking patterns. Each is interpreted to be associated with a specific segment of the eustatic curve..."
- "Depositional System: A three-dimensional assemblage of lithofacies, genetically linked by active (modern or inferred (ancient) processes and environments (delta, river, barrier island, and so on) (Brown and Fisher)."
- "Parasequence: A relatively conformable succession of genetically related beds or bedsets bounded by marine-flooding surfaces or their correlative surfaces (Van Wagoner, at SEPM's 1985 Midyear Meeting)." Note that a parasequence is terminated by a rise in sea level. Parasequences are generally below the resolution of most seismic data, but their bounding surfaces produce reflections that are time-stratigraphic seismic events.
- "Unconformity: A surface separating younger from older strata, along which there is evidence of subaerial erosional truncation (and, in some areas, correlative submarine erosion) or subaerial exposure, with a significant hiatus indicated." Unconformities are time-stratigraphic surfaces, are readily identifiable on seismic lines due to the underlying truncation and overlying onlap relationships, and are associated with a fall in relative sea level. Regional unconformities are also called sequence boundaries.
- "Condensed Section: A thin marine stratigraphic interval characterized by very slow depositional rates (<1-10 mm/yr) (Vail et al., AAPG Memoir 36, 1984). It consists of hemipelagic and pelagic sediments, starved of terriginous materials, deposited on the middle to outer shelf, slope, and basin floor during a period of maximum relative sea-level rise and maximum transgression of the shoreline (T. S. Loutit, et al., SEPM Special Publication 42). Seismic interpreters will recognize the condensed section as the "downlap surface" on seismic profiles.
- "Accommodation: The space made available for potential sediment accumulation (M. T. Jervey, SEPM Special Publication 42)."

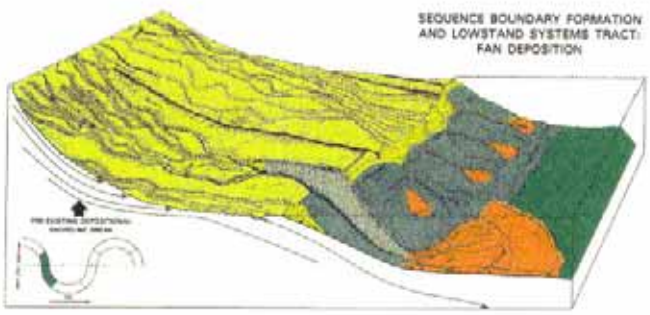

Figure 2. Sequence boundary formation. (Figures 2-5 are from Siliciclastic Sequence Stratigraphy in Well Logs, Cores, and Outcrops: Concepts for High-Resolution Correlation of Time and Faces by J. C. Van Wagoner, R. M. Mitchum, K. M. Campion, and V. D. Rahmanian, © 1990 by AAPG. They are reprinted by permission of the American Association of Petroleum Geologists and by Datapages, Inc.)

Growth of a sequence

Sequence stratigraphy is necessarily an understanding of geologic processes. The terminology above gives us tools to describe the processes that produce sequences and the components of which a sequence is constructed. By going through the development of a sequence process by process and component by component (process-response modelling), we gain an understanding of the basic model and some insight into the variations possible. The following description is abbreviated, and readers who seek a better understanding are encouraged to consult the suggested readings.

Sequences are controlled by changes in relative sea

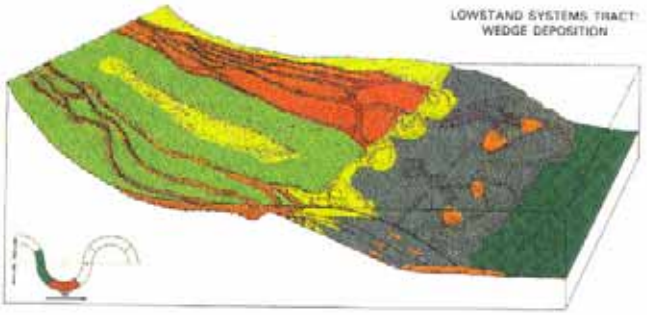

Figure 3. Lowstand systems tract (reproduced from Van Wagoner et al.).

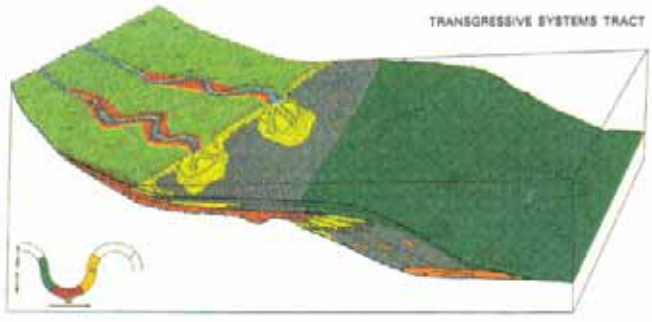

Figure 4. Transgressive systems tract (reproduced from Van Wagoner et al.).

Figure 5. Highstand systems tract (reproduced from Van Wagoner et al.).

level, and as they are bounded top and bottom by unconformities, they necessarily begin with a lowstand of sea level. The lowstand exposes the continental shelf, or in an epeiric sea, the shallower portions of the sea floor, to subaerial exposure and erosion (Figure 2). This erosion may be slight or it may include valleys up to several hundred feet in depth.

At lowstand (Figure 3), sediment transported down valleys is delivered at the shoreline to form estuarine and beach environments or is carried off the shelf edge into deep water to form seafloor fans or lowstand wedges in the angle between floor and slope.

As sea level rises, the shoreline transgresses across the erosional surface and the locus of deposition shifts inland (Figure 4). Because sediment is transported from land to sea, discrete depositional packages, called parasequences, are developed. Beach parasequences typically coarsen upward and in the progradational direction change facies from coastal plain (coal and clay) through marginal marine (sandstone) to offshore marine (shale). As sea level rises, successive parasequences are built, but each begins and ends further landward than the one preceding it. The result is a stack of parasequences having a "retrogradational stacking pattern," characteristic of the transgressive systems tract. Valleys normally fill first (the lowstand systems tract), beginning with fluvial sands, overlain by estuarine or bayhead delta facies, and finally filled to overflowing with shoreface parasequences (the transgressive systems tract).

As the rate of sea level rise begins to slow, the sediment volume delivered to the shore is just sufficient to fill the accommodation space, and the parasequences stop retreating and build upward, creating an "aggradational stacking pattern." As sea level reaches its highstand, the shelf is now under fairly deep water and is starved for sediment. A condensed section is deposited, consisting of a thin layer of black shale composed of mostly pelagic and hemipelagic debris. On seismic lines it appears as a downlap surface, and on well logs it will commonly be a thin radioactive shale (the "hot shale" marker of many cross-sections). The condensed section, also known as the maximum flooding surface, is an excellent source rock.

As sea level begins its accelerating downward movement, sediment delivery outpaces available accommodation, and the streams have to flow farther and farther seaward to deposit their load (Figure 5). Consequently, the parasequences thus created migrate seaward, forming "progradational stacking patterns," characteristic of the highstand systems tract. Offshore, the accommodation space greatly exceeds the volume of silt and clay being delivered, and depositional patterns take on downlapping sigmoidal patterns, thinning and wedging out atop the condensed section.

Eventually sea level falls below the base level of the streams at the shore line, and they begin eroding into their own delta/shoreface deposits. The highstand systems tract becomes fully exposed as sea level reaches a new lowstand, a surface of erosion is created, and the upper sequence boundary is in place, ready to receive the next sequence.

Frequently this ideal cycle is incomplete. Where tectonic effects are prevalent, the highstand systems tract may never develop, as uplift forces a retreat of the shoreline and creates a premature upper sequence boundary. Alternatively, uplift may be sufficiently prolonged that once-complete sequences are truncated deeply, with removal of most of their highstand systems tract. It is not uncommon in the Rocky Mountain basins to see stacked lowstand systems tracts without any evidence of transgressive or highstand systems tracts. It is also possible to observe sequences with little or no transgressive systems tract development (one thin parasequence, or the condensed section lying directly on the sequence boundary) but with a fairly complete highstand systems tract. Variations on the model, especially at the scale of fourth- and fifth-order sequences, are many, and interpreters must be sensitive to the possibilities.

Conclusion

Sequence stratigraphy has come of age, and it is a tool every explorationist must master. It is essential for regional and local exploration studies, for seismic evaluation, and for reservoir evaluation. While carbonate sequence stratigraphy has not been emphasized here, it is equally important. (I feel that carbonate geologists were doing sequence stratigraphy well before it became known as such, because carbonate strata are clearly cyclic

and depositional environments are very sensitive to sea-level fluctuations. The concepts and language of sequence stratigraphy, however, has imposed a more systematic framework to carbonate stratigraphy.)

Future articles in this series will speak in more detail about the elements of sequences, methods of interpretation for geologists and eophysicists alike, and provide applications and examples. To build on one's understanding of sequences, it is important to thoroughly understand all the elements of stratal architecture. In this light, future articles will focus on such topics as sequence architecture (boundaries, systems tracts, and facies), the parasequence and its elements (lamina, beds, boundaries, depositional environments and facies), the condensed section and biostratigraphy, systems tracts and stacking patterns, sequence scale (orders, time spans, and causes), tectonism versus eustasy, carbonate sequence stratigraphy, principles of seismic interpretation, principles of log correlation, core and outcrop interpretation, exploration applications, production applications, many examples, including some that contrast pre- and post-sequence stratigraphy interpretations and the benefit gained by the new insight, and an overview of some specialized topics such as the value of sequence stratigraphy in coal, lacustrine , and eolian environments, photostratigraphy, and computer simulation. All these discussions will have the common themes of process (sedimentary, tectonic, eustatic, erosional), response (deposition or erosion), and our interpretation (depositional environment, facies patterns, rock successions, diagenetic response, hydrocarbon habitat).

Suggestions for further reading. Although universally known as AAPG Memoir 26, this breakthrough publication is officially titled Seismic Stratigraphy-Applications to Hydrocarbon Exploration and was edited by C. E. Payton. Sloss's fundamental work was archived in "Sequences in the cratonic interior of North America" (GSA Bulletin, 1963). Vail's own "Seismic stratigraphy interpretation procedure" can be found in the Atlas of Seismic Stratigraphy (AAPG, 1987).

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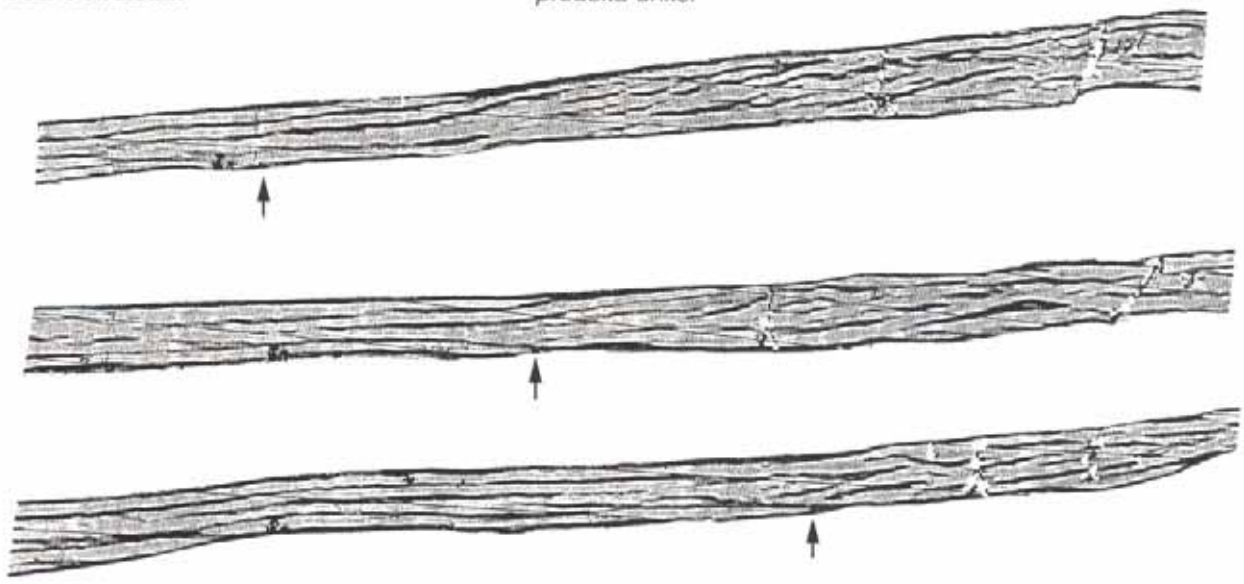
Seismic Window

with

Rob Kirk
BHP Petroleum

Geometries! These three 2D lines are from the Carnarvon Basin and each about 2km long and 2km apart. Note the basal event terminating from left to right at the arrow. This could be a submarine fan or basal transgressive sand? which is covered by the fine grained prograding Cretaceous prodelta units.



Hohmann Award

First G.W. Hohmann Award to Misac Nabighian

The first recipient of the G.W. Hohmann Award is Misac Nabighian, recently retired from Newmont Exploration and presently teaching electromagnetics and potential fields at the Colorado School of Mines. Misac is a well-known and highly respected figure in the electromagnetics community, responsible for the "smoke ring" analogy that brought transient electromagnetics down from the realm of higher mathematics to readily understandable intuitive physics. Misac was awarded SEG honorary membership in 1987, and has published widely on exploration geophysics.

The G.W. Hohmann Award is a new award available to students, researchers, or faculty, for excellence in electrical geophysics. The award is administered by the G.W. Hohmann Memorial Trust for Teaching and Research in Applied Electrical Geophysics. Established in 1992, the Trust has raised over seventy thousand (US) dollars through personal donations and special events. The Trust is intended to be a lasting and active memorial to Gerald W. (Jerry) Hohmann, a scientist and teacher. Jerry was an outstanding leader in the theory and application of electrical geophysics. At the University of Utah he trained a new generation of geophysicists, who have gone on to apply electrical techniques in mineral, hydrocarbon, environmental and regional geophysics.

Other Trust activities include an annual GWH Memorial Undergraduate Scholarship, and the GWH Memorial Graduate Fellowship. These awards will be administered through the SEG scholarship program. The Trust also has the long-term goal of establishing an endowed chair in Jerry's name in electrical geophysics at a major research university. To make donations to the Trust, or for further information, please contact GWH Memorial Trust, c/- Stanley H. Ward, 2004 Highland Drive, Anacortes, WA 98221, USA.

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Conferences

AEM 98 - "A Roaring Success"

AEM 98, the International Conference on Airborne Electromagnetics, put Australia firmly on the map as the focus for worldwide research into improving and promoting the use of airborne electromagnetics for mineral exploration and environmental studies.

A total of 280 people from 18 countries attended the conference to discuss the state of the art in airborne EM acquisition, processing and interpretation and its application in the areas of mineral exploration, geological mapping and ground-water studies. The conference was organised by the Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET) and the ASEG, and served as a showcase for the achievements of Australian researchers.

There were 75 oral and poster presentations spread over the three-day period February 23-25, interspersed with discussion and panel sessions, as well as a small exhibition area with booths from the 11 financial sponsors. Near-perfect weather and an idyllic location at Manly Beach in Sydney no doubt contributed to the success of the conference.

The Federal Minister for Resources and Energy, Senator Warwick Parer, opened the conference, and was followed by the Executive Director of AGSO, Dr Neil Williams, who gave the keynote address.

"The minerals industry makes a huge contribution to the Australian economy," Senator Parer said. "For these contributions to be maintained we need to ensure that Australia remains an attractive place to invest, and that the technologies are available for efficient and effective exploration."

Senator Parer said a large proportion of the costs of exploration is spent on drilling. "If drilling costs can be reduced by improving the methods of defining drilling targets then the industry will become more effective. In Australia this means being able to 'see through' the weathered surface layers that cover more than 70 per cent of the continent and identifying the prospective rocks beneath."

Welcome by Conference Chairman, Brian Spies; followed by opening address by Federal Minister for Resources and Energy, Senator Warwick Parer (seated); and keynote address by Dr. Neil Williams, Executive Director of AGSO.

Icebreaker reception in exhibition area.

Thus the emphasis on airborne EM, a technique that originated almost 50 years ago. Responsible for at least $10 billion of mineral discoveries in Canada, a country geologically blessed by recent glaciation, the technique has been seriously challenged by Australia's thick and variable conductive regolith cover. Research in the 1970s and 1980s showed that ground time-domain electromagnetics could effectively overcome many of the exploration problems in Australia, but airborne EM has been relatively ineffective.

CRC AMET, a collaborative joint venture between CSIRO, AGSO, the Geological Survey of W.A., World Geoscience Corporation Ltd, AMIRA, and Curtin and Macquarie Universities, was established in 1992 to address these issues. The Centre has research programs in airborne EM hardware, modelling, processing and geological interpretation.

The conference attracted virtually all the key players from around the world (30% of conference attendees were from overseas). Sessions covered hardware, processing, interpretation and applications, with detailed and at times lively discussion of the potential benefits and limitations of AEM as currently practiced. It is clear that:-

(i) the environmental market is driving improvements in accuracy and resolution,

(ii) a broad frequency bandwidth is essential to extracting 3-D quantitative information from AEM,

(iii) market demand is very price sensitive, and

(iv) what is needed most of all is a major new discovery attributable to airborne EM.

Although there appeared to be a greater appreciation of the geological information content of AEM, most attendees said that geological mapping was the role of government, and the major industry need was to use AEM for direct targeting.

The conference pioneered several "firsts" for Australian geophysicists: 2-minute (rigidly enforced) poster introductions, 15-minute technical presentations, and a surprise speaker for the conference dinner who promised to "introduce legislation in Parliament to restrict, and ultimately revoke, the domestic licences of so-called Australian firms exploring overseas in order to encourage them to invest in Australia" and to "levy retrospective tuition costs from Australian scientists benefiting other countries". It took the many of the audience some time to realise the talk was in jest.

Technical papers from the conference are currently being reviewed and edited for a special AEM 98 edition of *Exploration Geophysics* to be published later this year.

A follow-on workshop on Recent Developments in Gamma-Ray Spectrometry, organised by AGSO and the ASEG, was held on Thursday, February 26. The workshop attracted a 'full house' of 99 delegates, with an additional 26 seated downstairs in the disco watching the proceedings via a video hook-up. Most of the presentations were on new statistical methods for the reduction of noise in multichannel gamma-ray spectra. These methods are producing stunning improvements to the quality of processed multichannel data. Other topics covered at the workshop included the downward continuation of airborne gamma-ray spectrometric data, and multichannel spectral fitting methods. A full write-up of the workshop will appear in a later edition of Preview.

Brian Spies
Chairman,
Organising Committee

Acknowledgements

The conference owes its success to the efforts of the Organising Committee (David Fitterman, Peter Sengpiel, Greg Newman, Julian Vrbancich, Markku Peltoniemi, Alex Becker, Ben Sternberg, Peter Woodgate, Julian Vrbancich, Scott Holladay, John Slade, Richard Smith, Roger Henderson, Steve Kilty, Peter Diorio, Nick Sheard, Bob Smith, Jovan Silic, Philip McInerney, Peter Williams and Phil Klinkert), and also to the financial support from the principal financial sponsor Geoterrex-Dighem Pty Ltd, and the major sponsors ASEG, AGSO, CSIRO Exploration and Mining, Encom Technology Pty Ltd, Geo Instruments Pty Ltd, GPSAT Systems, High-Sense Geophysics Ltd, SIAL Geosciences Inc, Universal Tracking Systems Pty Ltd and World Geoscience Corporation Ltd; with special thanks to the conference secretariat, Well Done Events, and staff and students of CRC AMET.

Steve Mudge, Nick Sheard, John Bishop and Frank Morrison (U.C. Berkeley) on the lookout for the cocktail waitress.

Surprise speaker at the gala dinner, the Hon, Richard Vain QC MP (see text for details).

Australian Society of Exploration Geophysics

HONOURS AND AWARDS

13th Conference and Exhibition

During the ASEG conference three award categories are presented to members who merit recognition for distinguished service to the Society and to exploration Geophysics. These honours are:-

ASEG Gold Medal – for distinguished service to geophysics.

Honorary Membership – for distinguished contributions to the profession of Exploration Geophysics.

Grahame Sands Award – for innovation in Applied Geophysics It is made to a person or persons who has or have been responsible for a significant practical development of benefit to Australian applied geoscience. This could be in the field of instrumentation, data acquisition, interpretation or theory.

With the conference being between November 8-12 it is now time to call for nominations for these awards. Any member of the Society is eligible to nominate applicants by including a seconder and by sending three copies of relevant documentation to:-

Chairman Honours and Awards Committee,
22 Kurraba Road,
Neutral Bay,
NSW 2089

Application will close on September 8, 1998.

Industry Briefs

ER Mapper Announces Free ER Viewer

Perth Australia, February 1998 – **Earth Resource Mapping, the developer of ER Mapper, is extremely pleased to announce the release of ER Viewer.**

ER Viewer allows you to view and manipulate images on your desktop.

Since ER Viewer is Microsoft compliant it integrates seamlessly onto your existing desktop. It will allow you and your customers to view ER Mapper data and algorithms whilst also handling TIFF, GeoTiff, BMP and HDR images.

Due to ER Mapper's unique Algorithm technology (which forms the image engine of ER Viewer), ER Viewer is capable of viewing an image of *any* size and resolution. ER Viewer is also capable of 'Real Time' roaming and zooming. To accelerate the growth in the use of digital data ER Viewer is freely available to users and data suppliers alike.

Alistair Maclenan, Vice President of Earth Resource Mapping, said "ER Viewer represents a tool of substantial benefit to the market place as a whole, whether it is used by commercial clients, data suppliers or educational establishments it will promote the use of geospatial data to a vast audience."

David Hayward, Director of Development at Earth Resource Mapping, commented, "We expect ER Viewer to become the de-facto standard in viewing packages used by suppliers of raster-based data because of the combination of large file size handling and algorithm support."

ER Viewer can be downloaded from the ER Mapper web site at: **www.ermapper.com**. For organisations that wish to distribute ER Viewer with their data please contact the relevant regional ER Mapper office or email: queries@ermapper.com for further information.

The ER Mapper integrated mapping software is supported by a network of 352 resellers world wide.

New Faces Added to Consultants Group

Two new faces have recently joined the Flagstaff Geo-Consultants Partnership, strengthening both the geophysical and geological arms of the group

Shanti Rajagopalan, formerly with Rio Tinto, brings additional specialist skills in the interpretation of gravity, magnetic and radiometric data.

Alaster Edwards, currently with BHP Minerals in London and northern Eurasia, will be joining at the end of May, and brings geological project generation, management and GIS skills (and fluent Russian language!) to the Melbourne-based but internationally oriented partnership.

Contact: Flagstaff Geo-Consultants
Ph 61 3 9421 1000
Email: flagstaff@compuserve.com

Unipulse

Three new projects funded at Monash

The Department of Earth Sciences at Monash University is delighted to announce success in gaining ARC funding for three new geophysics research projects. The funding is granted for collaborative projects involving both Industry and the University.

Prof. Jim Cull received $90,000 pa for three years for "Seismology for Block Caving Management", a project which will develop seismic monitoring and analysis to forecast the advance of the caving front in underground mining operations. ISS Pacific Pty Ltd and Northparkes Mines Ltd are the Industry partners.

Michael Asten received $85,000 pa for two years for "Borehole Electromagnetic Prospecting for Weak Conductors". This project will develop the magnetometric method and interpretation methodology for time-domain EM methods applied to the particular problems of sphalerite-galena ore-body search. Four international Mining companies (MIM, North, Pasminco and BHP are collaborators.

Peter Betts gained a grant to develop a targeting strategy for Olympic Dam style ore deposits. Research will focus on understanding the key structural elements associated with the formation of the giant Mesoproterozoic Olympic Dam copper-uranium deposit in South Australia, and will involve a team of personnel from Monash and Western Mining Corp in an integrated study of geophysics and structural geology.

The three projects have created additional opportunities for graduate students at Monash University, which will add to a future resource of geoscientists having both academic qualifications and experience with Industry.

ASEG Workshops

THE 13TH ASEG CONFERENCE, HOBART, NOVEMBER 1998

A number of pre-conference workshops are being planned and will include the following:

FRIDAY 6TH NOVEMBER

3D Workbench for Potential Field Interpretation (1 day), Presenters: Dr Clive Foss and Dr David Pratt
This is a hands-on workshop aimed at geoscientists with some previous experience in data analysis and interpretation of potential field data for either mineral or petroleum exploration.

The Airborne Gamma Ray Spectrometric Method (1 day), Presenter: Dr. Brian Minty
This course is suitable for both existing practitioners and those new to gamma-ray method. The course will cover both conventional and multichannel processing methods.

Near surface Seismology (1 ½ days), Presenter: Dr Don Steeples
This one-and-a-half-day course provides background to help professionals with near-surface applications to the following methods: Basic high-resolution seismic theory; Instrumentation: sources, seismographs, sensors; Seismic refraction, including fan shooting and generalised reciprocal method (GRM); Seismic reflection, including CDP and common offset; Surface waves, including spectral analysis of surface waves (SASW); Three-component data, field procedures, and modeling; Seismic data integration and interpretation, including pitfalls and case histories.

SATURDAY 7TH NOVEMBER

Presentation and Interpretation of TEM Data (1 day), Presenter: Peter Gidley
This is a hands-on workshop aimed at both experienced and novice users of Transient Electromagnetic (TEM) survey data. Course attendees will use the latest versions of EM Vision and EM Flow software will be used with illustrative examples.

How to choose an Airborne EM system (1/2 day), Presenter: Dr James McNae, and others.
This workshop will explore the intricacies of choosing an optimal airborne (or ground) EM system, and will delve into controversial claims and counter-claims of EM practitioners.

3D Visualisation for Mineral Exploration Geophysics (1/2 day), Presenter: Dr Brian Spies, and others.
The workshop aims to evaluate the application of existing 3D visualisation packages to modern mineral exploration geophysics data (including magnetic, gravity, EM, Electrical, airborne, surface and borehole) and their integration with geological, mine, and GIS packages.

VSP Interpretative Processing: Theory and Practice (1 ½ days), Presenter: Dr Ronald C Hinds
The emphasis of the workshop will be on the practical acquisition concerns and that the processing is shown in a clear and practical way. Interpretation case studies that encompass the exploration play, geology, surface seismic, logic of the VSP interpreter/processor; and results that reflect in detail the advantage to oil explorationists will be presented and discussed.

SUNDAY 8TH NOVEMBER

ER Mapper as a desktop exploration tool (1 day), Presenter: Dr Abdullah Mah
ER Mapper is a widely used visualisation tool by explorationists. It is used with a variety of data types. In this workshop Dr. Mah will demonstrate how to effectively use ER Mapper to process Landsat TM, Radiometrics and Magnetics data to create interpretable images. The workshop will concentrate on how to integrate these data types, along with vector information, to aid identification of potential exploration areas.

Transient and Induced Variations in Aeromagnetics (1 day), Presenter: Dr Charles Barton
The purpose of the workshop will be to discuss the problem of interference by high frequency natural (and induced variations of the geomagnetic field in high-resolution aeromagnetic surveys).

Further details will be included in the next Conference brochure, or can be obtained from the Conference Secretariat (Tel: 03 9690 6744, Fax 03 9690 7155)

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Calendar of Events

1998

April 30
First Call for Papers, Abstract submission, SEGJ 4th Int Symposium. Preferred format for abstracts (400-500 words) is email sent to <segj4th@gsjart.gsj.go.jp>. See details below

Jun 20-26
SEG /SEG Beijing Beijing 98 Conference and Exhibition
For further details:
www.seg.org

July 6 – Perth
July 8 – Melbourne
July 10 – Brisbane
SEG Distinguished Lecture Series. Time Lapse Seismic (4D) in Reservoir Management. Check with your Local Branch for Venues.

July 21-24
AGU, 1998 Western Pacific Geophysics Meeting, Taipei.
For further details:
200 Florida Avenue
Washington DC, 20009, USA
Tel: 1 202 462 6900
Fax: 1 202 328 0566
Email:
meetinginfo@kosmos.agu.org
www.agu.org

Aug 30-Sept 2
Western Australian Basins Symposium. Hyatt Regency, Perth.
For further details:
Karen Webster,
C/o WAPET.
For registration details visit
www.pesa.com.au

Sept 13-18
SEG Conference New Orleans
For further details:
www.seg.org

Oct 15-16
Cooper Basin Symposium. AMF Adelaide. SA Dept. of Primary Industry and Resources.
For further details:
c/o Staffords Conference Management,
PO Box 232,
Kensington Park SA 5068
Tel: 08 8364 1005
Fax: 08 8332 8810
Email:
enquiries@staffords.on.net

Oct 28-30
Gas Habitats of SE Asia & Australasia,Jakarta,Indonesia Indonesian Petroleum Association
For further details:
Tel: 62- 21 5273663
Fax: 62-21 5219063
email ipa@cbn.net.id ,
www.ipa.or.id

November 8-12
Australian Society of Exploration Geophysicists 13th International Conference and Exhibition. Hobart Tasmania Australia
For further details:
ASEG Conference Secretariat,
93 Victoria Avenue, Albert Park VIC 3206
Tel: +61 3 9690 6744
Fax: +61 3 9690 7155
email: wsm@latrobe.edu.au

Dec 10-12
SEGJ/SEG/ASEG 4th Int Symposium Fracture Imaging Tokyo. The technical sessions will cover "Fracture Detection, Imaging, and Characterization" and "Underground Heterogeneity".
For further details:
The Society of Exploration Geophysicists of Japan
San-ei Bldg., 2-2-18
Nakanagome, Ota-ku
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Phone/Fax: +81-3-3774-5858
http://wwwsoc.nacsis.ac.jp/segj/meeting/is4/.
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