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FRONT COVER

PAC-750 aircraft with turbine engine flying over trees (image courtesy of Thomson Aviation).

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Ann-Marie Anderson-Mayes

At 3:32 am on 6 April 2009, an earthquake of magnitude 6.3 struck the city of L'Aquila, located approximately 100 km east-north-east of Rome. Three hundred and nine people died in the quake with a further 1500 people injured, and 65 000 people were temporarily displaced. It is probable that this event has been displaced in our minds by more recent, larger earthquake events in New Zealand and Japan. However, the L'Aquila quake is back in the news because in late September of this year, the trial of six leading Italian scientists and one government official commenced, with the prosecution bringing charges of manslaughter due to negligence for the earthquake-related deaths. News of the trial has prompted a number of *Preview* readers to write to me expressing concern regarding the implication of this case for all geophysicists.

There has been widespread condemnation for these indictments in the global scientific community, including statements from the American Geophysical Union and the American Association for the Advancement of Science. An open letter originating from Italy's National Institute of Geophysics and Volcanology (INGV) was signed by over 5000 scientists. These documents all point to the fact that science is not yet able to pinpoint the time, location and strength of a future earthquake. The INGV letter states 'The scientific community involved in earthquake science urges the Italian government, local authorities and decision makers in general, to be proactive in establishing and carrying out local and national programs to support earthquake preparedness and risk mitigation rather than prosecuting scientists for failing to do something they cannot do yet – predict earthquakes'.

The quote above is really the key to this case. An excellent article in *Nature* (Volume 477, pp. 264–269) by Stephen S. Hall states, 'Irrespective of the verdict, the episode has been a painful tutorial about the importance of clear public communication when potential disasters loom'. In L'Aquila, the conversation in the local media became a discussion of whether a significant earthquake *would or would not* take place, instead of focussing on earthquake preparedness and risk mitigation given that a significant earthquake *could* happen.

So, where does this leave Australian geophysicists? Being very careful about what they say I suspect. Levity aside, this is one of the sobering outcomes of this case. Enzo Boschi was President of the INGV in Rome at the time of the quake and is one of the Italian scientists now on trial. He is quoted in Hall's *Nature* article as saying, 'When people, when journalists, asked my opinion about things, I used to tell them, but no more. Scientists have to shut up'. And this at a time when we are all being urged to be better science communicators. For example, in Cribb and Sari's book *Open Science* (see review in *Preview*, Issue 146, p. 41) we are told, 'For science and technology to deliver full value to society, they must be accessible to as many people as possible and their messages must be easily understood'.

And perhaps therein lies the problem – making our science 'easily understood'. Sometimes, in meeting the requirements for a quick sound bite or an easily digestible article in the mainstream press, the true complexity of a scientific story is lost. In Italy, residents of L'Aquila felt reassured by a press conference only days before the 6 April earthquake that there was nothing to worry about. All the scientists now standing trial are clear that they never stated that a major earthquake would not occur, but that there was nothing to suggest that the hazard level was any higher than normal (remembering that this is a high-risk area anyway). And so perhaps this case is a reminder that in a highly litigious world, we do need to be careful about the way we communicate our scientific findings. But rather than choosing to say nothing at all, perhaps it is better to work on making our message as clear as possible. And this is especially important when our findings have implications for managing risks and hazards.

If you have a view on this very important topic, please send me an email (preview@mayes.com.au) and we will publish your comments in the next issue of *Preview*.

Some facts about fracture stimulation

The resource industry is again receiving attention and unwarranted criticism, this time for hydraulic fracture stimulation. Fracture stimulation is not directly related to the work of many exploration geophysicists, but I think that all geoscientists can help explain to the public some of the facts and myths related to fracture stimulation, and perhaps turn the current belief and fear-driven media feeding frenzy on fracture stimulation into an evidence-driven public debate. I offer here some background facts that may be helpful and my opinion on a workable solution.

A good place to start is with the design of an oil or gas well: assume this page is a scaled cross section of the earth with an 'average' 2500 m vertical shale gas well running from the top edge of this sheet to the last line of text. The target hydrocarbon reservoir would be thinner than the last line of type, and shallow aquifers used for town and irrigation supply will normally lie above the title line for this column. Let's consider how those shallow aquifers might be contaminated:

- Can frac fluids leak *directly* from the well into the aquifer? Not likely without a hole in the steel casing that lines the well bore, and that hole would show up immediately as a significant pressure loss during the frac job.
- Can frac fluids leak up the annulus between the casing and the borehole? That annulus is filled with cement and then pressure-integrity tested, so this too is very unlikely.
- But can't the frac job itself create a conduit from the reservoir to the shallow aquifer? This hydraulically created fracture is usually less than 10–30 m high. It normally does not grow higher than this because the high pressure frac fluids will find a lower-stress lithology and stay in it by growing horizontally, not vertically. Vertical fluid movement would require crossing repeated high-stress barriers, which is like water running uphill.

Now it is relevant to point out the important difference between shale gas frac jobs (mostly in North America so far) and coal seam gas frac (CSG) jobs in Australia. CSG reservoirs are shallower than shale reservoirs. The shallowest CSG target might be at 300 m, not the average 2500 m shale well discussed above. This is getting uncomfortably close to aquifers used by towns and for irrigation.

Now let's examine some facts. There have been about 1.5 million fracture stimulation treatments performed since 1947, mostly in North America. There have been about 2500 frac jobs performed in Australia, with about half of those done in deep Cooper Basin targets. Today in North America, approximately 80–90% of all new onshore wells receive multiple fracture stimulation treatments.

The fracture stimulation industry claims that despite the above 1.5 million frac treatments, there has not yet been a documented case of aquifer contamination. The industry's detractors will say that there have been cases of contamination, but these cases are settled out of court with cash payments and non-disclosure clauses.

The New York Times recently found and published the details of one of these out-of-court settlements, a case in Pennsylvania in the late 1980s. In this case (according to preliminary court documents) frac fluids were found in a shallow aquifer above a deep fracture stimulation treatment. And in this case, the frac fluids were able to travel the 'impossible' vertical distance from the target reservoir to shallow aquifer because – unbeknownst to the frac operator – there was an improperly abandoned gas well near the frac treatment well. This improperly abandoned well provided an easy conduit for vertical movement of frac fluids.

What does the above case prove? This case of contamination required a rare set of cascaded errors in well abandonment and regulatory oversight, but it still does not provide a case where a stimulated fracture provides a conduit between a hydrocarbon reservoirs and surface aquifers.

What about frac chemicals and the flaming kitchen tap shown in the documentary film 'Gas Land'?

The flaming kitchen tap seen in 'Gas Land' is caused by a well known phenomenon (well known to coal geologists) explained by Langmuir isotherms. A Langmuir isotherm plot shows how much natural gas will be released from a coal seam as the water pressure in that coal seam is lowered. This is not a rare phenomenon; it is happening by design in tens of thousands of coal seam gas wells in Queensland. And if a rancher completes his water well in a coal seam his water will produce water plus gas as the water pressure is lowered. This is why proper regulation prohibits water wells from drawing water from a coal seam.

Aren't there toxic chemicals released in fracture stimulation?

Yes. The fluids used in fracture stimulation are 99.5% water, but the remaining 0.5% are chemicals that can be harmful and do require regulation. One example: bacteria and algae growth in frac fluids is a potential problem, and biocides are used to preclude that. Biocides are also used for the same reason in public water supplies. I'd like to know that a safe level of biocides are used in my tap water – and if there is ANY chance that frac fluids might leak into aquifers, it would be good to know that the frac fluids do not exceed that safe concentration of biocide(s).

I very recently heard a provider of fracture stimulation saying they are switching from chemical biocides to UV radiation treatment – just as many home owners use in a spa bath. I don't know if this switch from low-level biocides is required from a public risk point-of-view, but this switch could be very important in the court of public opinion.

Perhaps the most attention worthy chemical used in fracture stimulation is a 'friction-reducing agent'. Friction-reducing agents make it easier to quickly pump millions of litres of fluids through the frac pumps, pipes and the well casing. These are hydrocarbon lubricants and go by the acronym BTEX, which is short for benzene, toluene, ethylene and xylene.

I have mixed feelings towards BTEX use in frac fluids. When I fill my car with

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petrol, I'm putting BTEX (among other things) in the tank without *undue* risk to humans and the environment. Shouldn't it be safe to inject BTEX into a *hydrocarbon* reservoir? But I know from experience that uncombusted BTEX fumes make me feel ill, and I understand that exposure to BTEX can cause cancer. Therefore, I would not be comfortable with BTEX in my water supply, even at small concentrations.

Fracture stimulation is an important part of CSG development in Australia, and CSG development is the lowest-cost path of lessening our use of coal and lowering our CO_2 emissions. A sensible solution to the frac stimulation debate would be to allow regulated fracture stimulation using current chemicals and current well design *as long as the frac job is not within 100 m vertically of a shallow permeable fresh water aquifer.* If a frac job gets any closer than 100 m to an aquifer, then it is not unreasonable to ask that the frac job be banned OR that all frac fluids meet food and drinking water quality standards – something that is very doable.

Dennis Cooke
Email: dennis.a.cooke@gmail.com

Research Foundation Update

The Research Foundation was pleased to receive applications to support seven research projects commencing this academic year. Congratulations go to the successful students and their supervisors. After careful consideration and ranking by the technical committees, and also taking account of our financial resources, the Foundation has agreed to support five projects as detailed below.

Project: RF11M01
Title: Constrained magnetic modelling of the Wallaby gold deposit, Laverton, Western Australia
Institution: University of Western Australia
Student: Sasha Banaszczyk
Degree: B.Sc (Hons)
Supervisor: Professor Mike Dentith
Awarded: $5,000

Project: RF11M02
Title: Removing the effects of sensor rotation from EM measurements: a critical need for low-frequency AEM
Institution: RMIT University
Student: Terence Kratzer
Degree: PhD
Supervisor: Professor James Macnae
Awarded: $8,000 (Year 1), $9,200 (Year 2), $1,200 (Year 3) = $18,400 (total)

Project: RF11M04
Title: Modelling down-hole induced polarisation based on the Centenary gold deposit, WA
Institution: University of Western Australia
Student: Jarrad Lachlan Trunfull
Degree: B.Sc (Hons)
Supervisor: Professor Mike Dentith
Awarded: $4,000

Project: RF11P02
Title: Computational rock physics, seismic wave propagation and imaging in complex anisotropic media
Institution: University of Western Australia
Student: James Deeks
Degree: PhD
Supervisor: Professor David Lumley
Awarded: $8,000 (Year 1), $8,000 (Year 2), $8,000 (Year 3) = $24,000 (total)

Project: RF11P03
Title: Seismic anisotropy analysis for estimating reservoir fractures and stress
Institution: University of Western Australia
Student: Lisa Gavin
Degree: PhD
Supervisor: Professor David Lumley
Awarded: $8,000 (Year 1), $8,000 (Year 2), $8,000 (Year 3) = $24,000 (total)

We wish all these students well with their research and look forward to hearing about the results of their work at the completion of their studies.

Phil Harman, ASEG RF Chairman

New members

The ASEG extends a warm welcome to 17 new members to the Society (see table). These memberships were approved at the Federal Executive meetings held on 28 July and 25 August 2011.

Name	Organisation	State/Country	Member Grade
Craig John Ballington	Queensland University of Technology	QLD	Student
Majid Beiki	CSIRO	NSW	Active
Kyle Robert Blay	CSIRO Materials Science & Engineering	NSW	Associate
Daniel Burton	James Cook University	QLD	Student
Ristch Camille	Macquarie University	NSW	Student
Daniel Robin Eden	Curtin University of Technology	WA	Student
Robert Neil Finnegan	University of Western Australia	WA	Student
Matthew Goldman	Geological Survey of QLD	QLD	Active
Gustavo Hinestrosa	University of Sydney	NSW	Student
Joanna Jago	GroundProbe Geophysics	WA	Active
Emma Louise Johnson	University of Newcastle	NSW	Student
Michael John Nelson	GroundProbe Geophysics	WA	Active
Thomas Phillips	Inova Geophysical	USA	Associate
Ludovic Ricard	CSIRO	WA	Active
Andrew Michael Roberts	Southern Geoscience Consultants	WA	Active
Brent Walker	Macquarie University	NSW	Student
Marlene Woligroski	Southern Geoscience Consultants	WA	Active

We would also like to welcome **Thomson Aviation Geophysical Survey** as a new corporate member of the ASEG. Thomson Aviation offers the highest resolution airborne magnetic, radiometric and digital terrain data available. Advanced acquisition techniques, combined with the best available instruments and in-house processing using the latest software, ensure the best value for money data sets in the industry. Thomson Aviation have over 18 years experience in low level operations and can offer fixed wing and helicopter systems for both domestic and international projects.

The latest addition to Thomson Aviation's fleet of fixed-wing geophysical aircraft is a PAC 750. This aircraft is manufactured in New Zealand and powered by a PT6-34 turbine engine, giving it improved performance over similar piston-engined aircraft. In particular, it has superior climb performance which enables it to maintain close terrain following and in some cases it can do as well as a helicopter. Its features provide for high safety standards, which is always of paramount concern for Thomson Aviation. Its high power-to-weight ratio provides for a big payload. Thus, for example, it is able to carry twice the normal radiometric detector volume, or 66 L. The PAC 750 was obtained deliberately to provide an excellent platform for geophysical operations and this has proved to be the case in practice. The installation of a magnetometer boom and the consoles for magnetic and radiometric measurement were easily accommodated and the compensation quickly achieved. Already, several clients of Thomson have experienced the excellent data quality produced by the PAC 750. Also, its size and payload allows for the future addition of other methods than the current high-resolution magnetic and radiometric installations. More information about this expansion will be available soon.

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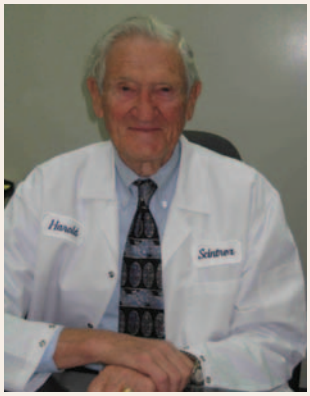
Harold O. Seigel, PhD, O.C.: 1924–2011



Dr Harold O. Seigel, renowned exploration geophysicist, entrepreneur, mentor and Officer of the Order of Canada, passed away on 13 July 2011, in Toronto, Ontario after a short illness, to the great sadness of the global geophysical community. His sudden departure ended an extraordinary career that spanned over six decades.

Harry was born and raised in Toronto. In 1943, Harry, then a first year math and physics undergrad at the University of Toronto, was invited by Lachlan Gilchrist to join a geophysical field crew conducting a magnetic survey north of Lake Huron. Geophysics appealed to Harry's loves of science, discovery and nature, and he had the necessary skills to make meaningful contributions. His PhD thesis on the application of induced polarization for mineral exploration, completed in 1949 at the University of Toronto, included results of the first full-scale field testing of this new method over a porphyry copper deposit in Arizona.

After completing his PhD, Harry spent the next four years working for Newmont in Arizona, collecting and analyzing data and refining the mathematical theory of the IP response, before returning to Toronto in late 1952. The beauty of the desert was firmly set into Harry's heart, and, in later years, he and Marilyn spent the winters in Tucson.

In 1953, a group of geophysicists based mostly in the Toronto area formed the Canadian Exploration Geophysicists Society (KEGS), with Harry as the founding chairman. Harry's active support of KEGS continued through the next 58 years, and he was one of the founding directors of the KEGS Foundation in 1999. In 1987, he served as Chairman of the Exploration '87 conference.

In 1956, Harry started his consulting company, Seigel Associates. He merged this company with E. J. Sharpe Instruments in 1967 to form Scintrex Limited. He remained active at Scintrex until several days before his death.

Over the course of an extremely productive and successful career, Seigel was directly involved in at least nine significant mineral discoveries, authored over 20 patents and published over 40 papers. He was honoured with many awards, including the Canadian Geophysical Union's J. Tuzo Wilson Medal in 1985, a Distinguished Service Award for the Prospectors & Developers Association of Canada in 1987, the A.O. Dufresne Award from the Canadian Institute of Mining, Metallurgy and Petroleum in 1988 and SEG's Maurice Ewing Medal in 1995. In 1995, Seigel was inducted into the Canadian Mining Hall of Fame, and, in 1997, he was appointed as an Officer of the Order of Canada.

Harry also found time to volunteer at the University of Toronto, for which he was awarded the Arbor Award for Outstanding Personal Service to the University in 2002. His legacy at the University of Toronto continues with the Harold O. Seigel Graduate Scholarship, awarded by the Department of Physics for graduate studies in Applied Geophysics. Also in 2002, Harry received a Commemorative Medal in honour of the Queen's Golden Jubilee in recognition of his achievements and distinguished service.

In the late '60s, Seigel recognized significant business opportunities for western geophysical technology in China. He participated in the first Canadian Trade Mission to China in 1972, impressing the Chinese hosts by conversing in Mandarin. He made many return trips to China until 1989, establishing solid relationships for Scintrex in China that continue today.

The challenge to develop effective electrical geophysical methods in Western Australia's highly conductive overburden drew Seigel to Kalgoorlie in 1967. The use of high power transmitters and gradient arrays contributed to the discovery of the Mt Windarra nickel deposit in 1968, and the subsequent Poseidon Nickel boom.

While walking over the Kanowna salt lake in 1968, Harry conceived a method to measure the magnetic rather than electric field on induced polarization surveys in areas of conductive cover. Subsequently, the Magnetic Induced Polarisation method contributed to several significant discoveries across Australia including Elura ('72), South Mt Keith ('77), Sandy Flat ('79) and Mt Pleasant ('83).

Harry was special among his peers in the geophysical business, combining a solid understanding of scientific theory, and engineering with ambition and business acumen. He was a lifelong entrepreneur and scientist who relished the challenge of exploration. Under his guidance, Scintrex focused efforts on instruments that could be successfully commercialized. Many other ideas remain undeveloped. Less than two weeks before his death, Harry spent the morning at Scintrex discussing the potential of magnetic induced polarisation for exploration in the western Athabasca Basin, Saskatchewan.

Harry's love of nature and enthusiasm for outdoor activities were evidenced by his passion for hiking. He was incredibly fit and took the lead on most hikes regardless of the terrain. Those of us who walked with him through the hills north of Toronto or the canyons near Tucson would be humbled the next morning when Harry showed no apparent signs of soreness, while we limped through the day. Our last hike was on 8 May 2011. As usual, Harry was in good shape the next day while the rest of us suffered.

Harry's interests went well beyond geophysics, business and hiking. He was a dedicated and proud husband, father and grandfather. He spoke several languages, travelled extensively and loved music, culture, history and people. He treated everyone equally, respectfully and fairly.

Harry is survived by his wife, Marilyn, his son Joel Seigel, two daughters, Laurie Beckerman and Marcie Seigel, and four grandsons, Mathew, Jordan and Kyle Seigel and Jacob Beckerman.

Chris Nind, with help from Tony Howland-Rose, Norm Paterson, Jerry Roth, Laurie Reed, the Seigel family and the Scintrex alumni.

Nominate a colleague for an ASEG Honour or Award for 2012

NOMINATIONS CLOSING SOON

The ASEG acknowledges the outstanding contributions of its individual members both to the profession of geophysics and to the ASEG, through the presentation of the Society's Honours and Awards across a range of categories. The next Awards are scheduled to be presented at the ASEG Brisbane Conference from 26–29 February 2012.

The ASEG awards are made through nominations of the membership at large, as well as through State and Federal executives. All members are invited to submit nominations according to the 'Nomination Procedure' set out below. Some of the awards carry considerable prestige in the eyes of the ASEG and therefore require some documentation to support the nomination. Please contact the Committee Chairman, Andrew Mutton, if you require further guidelines on what is required.

Recipients selected from these nominations will be presented with their award at the forthcoming Brisbane conference.

Details of the award categories appeared in the previous issue of *Preview* (Issue 153, p. 9). They are:

- **ASEG Gold Medal**
- **Honorary Membership**
- **Grahame Sands Award**
- **Lindsay Ingall Memorial Award**
- **Early Achievement Award**
- **ASEG Service Awards**

Nomination procedure

Any member of the Society may nominate applicants. These nominations are to be supported by a seconder, and in the case of the Lindsay Ingall Memorial Award by at least four geoscientists who are members of an Australian geoscience body (e.g. GSA, AusIMM, AIG, IAH, ASEG or similar).

Nominations must be specific to a particular award and all aspects of the defined criteria should be addressed. To gain some idea of the standard of nomination expected, nominees are advised to read past citations for awards as published in *Preview*. If required, proforma nomination forms are available from the Chairman, Andrew Mutton.

Nominations including digital copies of all relevant supporting documentation are to be sent electronically to:

Andrew Mutton
Chairman, ASEG Honours and Awards Committee
Email: andrew.mutton@bigpond.com

The deadline for nominations is 15 December 2011.

Australian Capital Territory

A number of events and presentations have kept members of the ACT Branch busy and entertained during the past few months.

Branch President, Ron Hackney, attended the annual Awards Ceremony for ANU's College of Physical and Mathematical Sciences on 6 June. At the ceremony, he presented the local Branch's 2010 'Prize for Geophysics' to Hannah Keal for the best results in the Research School of Earth Science's second-year geophysics course.

After a post-IUGG train/bus trip from Melbourne, Tien Grauch and Jeff Phillips (USGS, Denver) stopped in Canberra on 14 July to share lessons in understanding magnetic anomalies over faulted layers and thoughts on potential-field inversion for constructing and testing geological models. Tien showed that rather than being related to chemical processes modifying the magnetic properties of a fault, the juxtaposition of layers with differing magnetic properties is often sufficient to explain anomaly patterns across faulted layers. Jeff gave a useful overview of the benefits and deficiencies of different inversion techniques that can be used to aid the construction of geological models.

On 28 July, Federal President, Dennis Cooke, was poached and brought to Canberra. Kept from a FedEx meeting, he instead gave a timely and informative presentation to a joint ASEG/PESA audience on the "shale gas revolution". Recognising the significance of this revolution, more than 40 people came to hear Dennis' views on the rapidly changing perception of shales as a gas reservoir. Dennis also provided a good overview of where Australia is at. It seems that we need to move beyond the current status of dominantly vertical drilling and we can still do more with 3D seismic for drill targeting and assessment of geohazards.

During a purple-patch in mid August, we hosted back-to-back talks by Rick Blakely (USGS, Menlo Park) and Clive Foss (CSIRO, Sydney). Rick gave a presentation on 18 August to almost 60 people outlining the use of gravity and magnetic data to link active back-arc and fore-arc faults in the Cascadia subduction zone. Rick not only showcased the benefits of curvature, tilt and Euler deconvolution for mapping active faults, but he also highlighted how the Cascadia earthquake map is a proxy for population density (more earthquakes = more people)!

On 19 August, Clive Foss talked to an audience exceeding 30 people on integrated magnetic field and paleomagnetic studies. The goal of this work is to provide tools to help interpreters deal with oft-ignored remanence. Clive gave an overview of these tools and a soon-to-be-released database containing information (including anomaly images) on remanent anomalies in Australia.

A final point of note is that ASEG member and SEG Pacific South Honorary Lecturer, Richard Lane, presented a Distinguished Geoscience Australia Lecture on 31 August. Richard summarised the impact of his richly rewarding lecture tour around South Pacific countries and shared his insight into the current and future of potential field modelling with his GA colleagues.

Ron Hackney

ASEG News

New South Wales

In July, we held the NSW branch annual dinner. This year it was held at the Belgian Beer Café in the city. Much Belgian beer, the odd bottle of red and many mussels were consumed. Profound geophysical discussion is rumoured to have occurred and a great time was had by all.

In August, Ken Witherly from Condor Consulting gave a talk on the evolution of the use of geophysics in the search for blind volcanic-hosted massive sulfide (VHMS) deposits in the Abitibi greenstone belt in Quebec Canada. Ken spoke about how geophysical technologies have contributed significantly to numerous discoveries of VHMS deposits in the Abitibi greenstone belt since the 1950s when airborne EM technologies were first commercialized. Ken noted that since the mid-1980s however, the discovery rate has dropped drastically even with major improvements to geophysical processes involved in deposit formation and the geochemical signatures associated with deposits. Ken noted that at the regional scale, to develop new Greenfields areas, new data sets such as high resolution gravity need to be acquired and assessed along with traditionally acquired EM and magnetics. Many questions ensued and much discussion about current exploration methodologies.

In September, Bruce Dickson spoke about the geophysical indicators of global climate changes. Bruce outlined how geophysical measurements are the most direct indication of changes occurring across the globe due to the warming climate. Bruce spoke about some of the satellite radar, gravity and radiation measurements and the magnitude of changes that are occurring to the ocean, icecaps and the atmosphere. Bruce even digressed to speak about some isotopes and spoke a bit about the philosophical consideration on the scientific method and extrapolation of trends. Much discussion followed Bruce's talk.

An invitation to attend NSW Branch meetings is extended to interstate and international visitors who happen to be in town at that time. Meetings are held on the third Wednesday of each month from 5:30 pm at the Rugby Club in the Sydney CBD. Meeting notices, addresses and relevant contact details can be found at the NSW Branch website.

Mark Lackie

South Australia

The South Australia and Northern Territory Branch has had a busy couple of months. On 22 August we welcomed Julien Muenier from CGG Veritas who presented the 2011 SEG/EAGE Distinguished Instructor Short Course (DISC). Thirty-eight people attended the full day workshop at the Adelaide Convention Centre.

Our annual wine tasting event was held at Cos Restuarant in early September 2011. Look out for the order form on p. 36 in this edition of *Preview*, and on the website.

Future speakers include Dr Stephan Thiel from the University of Adelaide. Stephan will be presenting his work on magnetotellurics in South Australia with a focus on geothermal exploration.

Our annual Industry night will be held in October and our annual student night in November.

The SA branch holds technical meetings monthly, usually on a Tuesday or Thursday night at the Coopers Alehouse begining at 5:30 pm. New members and interested persons are always welcome.

Please contact Philip Heath (philip.heath@sa.gov.au) for further details. If you are an ASEG member and are not receiving emails please ensure your contact details are up to date by contacting aseg@casm.com.au.

Philip Heath

Victoria

On Wednesday 27 July the ASEG Victorian Branch hosted a technical presentation at the Kelvin Club in Melbourne's CBD entitled **'The shale gas revolution in North America and how it might impact Australia (and you!)'** by ASEG national president Dr Dennis Cooke - Program Manager, Unconventional Resources at the University of Adelaide's Australian School of Petroleum. Attracting a healthy turnout of about 20 geoscientists, Dr Cooke's talk addressed the problems associated with extracting hydrocarbons from shales, canvassing economic viability, shale favourability, drilling and fracturing stimulation technologies and pattern versus sweet spot drilling. Needless to say Dr Cooke's talk gave rise to a lively discussion during question time, inevitably broaching current public concern about this technique.

On Thursday 4 August ASEG Victorian branch members enjoyed a very fine evening of micro-brews, nibbles, and cross-disciplinary banter at the Midwinter Social Evening at the Portland Hotel in Melbourne's CBD. The event, which was a joint meeting of the Victorian branches of PESA, SPE and ASEG, was, as always, a great success.

On Monday 15 August the ASEG Victorian Branch hosted the 2011 SEG/EAGE Distinguished Instructor Short Course (DISC): **'Seismic Data Acquisition from Yesterday to Tomorrow'**, presented by Julien Meunier, CGGVeritas, at the Victoria Hotel, 215 Little Collins Street, Melbourne. This well-received workshop, comprising 18 participants, commenced with an historical account of seismology and its rapid evolution into a valuable exploration tool. Through presentation and course manual, Julien provided a comprehensive description of seismology instrumentation and underlying theory within a practical context. Although discussing some survey design, Julien paid particular attention to consideration of signal and noise – identifying the latter to be either source generated or ambient.

John Theodoridis

Geoscience education turns around at Australian universities

Dr Trevor Powell
Former President, Australian Geoscience Council
tpowell@grapevine.net.au

This article first appeared in the Aug/Sept 2011 issue of PESA News Resources (No. 113). Preview *thanks PESA for permission to republish the article.*

In 2007 in response to increasing concern among the member societies about the health of tertiary geoscience education in Australia, the Australian Geoscience Council (AGC) undertook a survey of Australian universities with 'geoscience departments' to establish an Australian Geoscience Tertiary Education Profile 2007 (AGTEP 2007). Following the initial impact of the Global Financial Crisis, the resumption of the resources boom and the associated skills shortages, it is timely for the survey to be repeated and updated. AGTEP 2010 provides an up to date stocktake of tertiary geoscience education in Australia and the general capabilities of tertiary geoscience institutions. The full report can be accessed at www.agc.org.au.

The principal conclusion of this survey is that the status of geoscience and geoscience education has improved substantially over the last three years (2008–2010) with a marked growth in enrolled students and academic teaching staff reversing the decade-long decline to 2007. In the 2007 survey there had been an increase in enrolment particularly in levels 1 and 2 in some universities and this has now extended to all levels, particularly at the Honours level, and in many institutions (Figure 1). The situation of geoscience in Australian universities is stronger now than at any time over the past 15 years.

Seventeen universities (Table 1) have the capacity to teach geoscience as a major in their undergraduate programs with an additional university offering an earth science major as part of an environment degree. Of these, six maintain distinct geoscience schools. In the remainder, the geoscience discipline is amalgamated into schools of 'earth, geography and environmental science' or schools of 'physical sciences'. The consequence for the structure of the undergraduate majors on offer varies. Some schools have created 'geoscience degrees' from a blend of physical geography or environmental courses and traditional 'solid earth science' courses. Others have maintained a clear distinction between degree types.

Table 1. Australian universities offering Earth Science degrees

University	School	Geoscience staff*
University of Adelaide	School of Earth and Environmental Science Australian School of Petroleum	34.8
Australian National University	Research School of Earth Sciences	72
University of Ballarat	School of Science and Engineering	4.6
Curtin University	Department of Applied Geology Department of Exploration Geophysics	38.9
James Cook University	School of Earth and Environmental Sciences	17
Macquarie University	Department of Earth and Planetary Sciences	14
University of Melbourne	School of Earth Sciences (includes ocean, atmospheric sciences)	35.6
Monash University	School of Geosciences	22.7
University of New England	School of Environmental and Rural Science	2.5
University of Newcastle	School of Environmental and Life Sciences	13.1
University of New South Wales	School of Biological, Earth and Environmental Sciences	16
University of Queensland	School of Earth Sciences	26.6
Queensland University of Technology	School of Biogeoscience	10.5
University of Sydney	School of Geosciences (includes geography, environmental sciences)	25.5
University of Tasmania	School of Earth Sciences	31
University of Western Australia	School of Earth and Environment	43.4
University of Wollongong	School of Earth and Environmental Sciences	16

**Includes teaching and research staff in geoscience only at the time of the survey.*

Contrary to expectations arising from the 2007 survey, geoscience is still being taught as a component of 'environmental science degrees' at the Universities of Canberra and La Trobe and to a lesser extent at University of Technology Sydney. At Flinders University, an earth science major is offered as part of an environment degree. At RMIT University, an Honours course in Physics-Geophysics is offered to eligible physics or engineering students.

The extent to which course work is undertaken for the completion of an Honours degree varies slightly with institution. Eight universities participate in the Minerals Short Course Program at Honours underwritten by the Minerals Tertiary Education Council (MTEC). All institutions offer MSc by research, but there are several MSc degrees being offered predominantly by course work with a lesser component allowed for a dissertation or thesis. These coursework degrees are often specifically aimed at training candidates in the knowledge and techniques required for employment in industry.

In addition to normal curriculum reviews, several universities have taken specific, or are planning specific steps to meet the needs of potential employers by addressing the core skills requirements of graduates:

- they have made (or are in the process of making) specific teaching appointments in resource geosciences;
- they have remodelled courses to meet core skills requirements and the evolution of disciplines including field geology, digital geology, minerals geoscience and petroleum geoscience;

- placements in industry as part of a course of study; and
- provision of specific options and specializations in majors.

Increasingly, sharing of specialist teaching at the Honours and Masters level is becoming more common, active and systematically organized as follows:

- the national Minerals Tertiary Education Council (MTEC) program where eight institutions teach courses into the Minerals Short Course Program;
- three universities collaborate to deliver the MTEC Minerals Geoscience Masters program;
- the Sydney Universities Consortium of Teaching Geology and Geophysics – Honours Course Electives run by the Sydney metropolitan universities; and
- the Victorian Institute of Earth and Planetary Sciences Honours Program run by Melbourne, Latrobe, Monash and Ballarat.

Nationally, student enrolments as measured by Equivalent Full-Time Student Load (EFTSL) have increased 25% over the past 3 years accelerating the level of growth recorded in AGTEP 2007 of 20% over the previous 5 years (Figure 1). Most universities show increases at all levels while others are static, or have decreased in enrolments at some levels.

A major difference from the previous survey has been the substantial growth in the numbers of Honours students (Figure 1), which have increased nationally by 73% to 265 over the period 2008–2010 compared with the 9% decrease in the previous 5 years and the 60% decrease in the 15 years leading up to 2007. However there is a wide variation between institutions.

There is also a wide variation in student load. The total EFTSL across all levels ranges from 53 to in excess of 350 with 12 (10 in 2007) universities having total EFTSL values above 100 and seven (two in 2007) universities in excess of 150 of which two have values above 250. There are five (seven in 2007) universities with values below 100 of which one (two in 2007) has a value below 55.

Whereas in AGTEP 2007 it was not possible to discern any significant trends in postgraduate degrees, the addition of 3 years of data clearly shows some major changes (Figure 2). The output of MSc/MPhil degrees by research has declined by over 50% while the output of MSc degrees based on coursework has seen a dramatic increase, which appears to be accelerating – up 250% in 2010 compared with 2007. In the five years leading up to 2007, the output of PhD degrees had remained generally static, but since 2007 there has been a decline of about 15%.

In 2010, 256 academic staff are engaged in some level of teaching of geoscience in Australian universities whilst there are a further 183 staff engaged in research with no formal teaching commitments. The numbers in 2007 were 170 and 187 respectively. The dramatic difference is dominated by significant change in reporting from the ANU following internal re-organisation. Removing the ANU, nationally there has been an increase in 22 (13%) staff engaged in teaching while the number of research positions has increased by 18 (13%).

Consistent with the increase in teaching positions among the 'geoscience' schools, there are now eight (three in 2007) schools with more than 12 teaching positions, five (12 in 2007) with 8–12 teaching positions, and four (four in 2007) with fewer than eight teaching positions. The EFTSL per teaching academic ranges from below 5 to 20. There are four institutions below 10 (six in 2007), six between 10 and 15 (seven in 2007), and six above 15 (three in 2007).

The combination of teaching and research positions (Table 1) shows a wide range in capability between the 'geoscience' universities with two having in excess of 40 geoscience positions, four having between 30-40 positions, three having 20–30 positions, six having between 10 and 20 positions, and two having fewer than 10 positions.

The survey shows that the Australian institutions vary widely in their viability as teaching institutions although there has been a general strengthening of 'geoscience schools' as student numbers have increased. There is evidence of considerable effort to meet the work force requirements of graduates both at the undergraduate and MSc levels. Funding pressures remain in some institutions. In others the rapid increase in student numbers, although sometimes accompanied by expansion of teaching staff, is causing an increase in teaching loads at a time of turnover of the 'baby boomer' generation of academics. The decline in PhD output must have a financial impact on departments and, if it continues, must be a concern for the

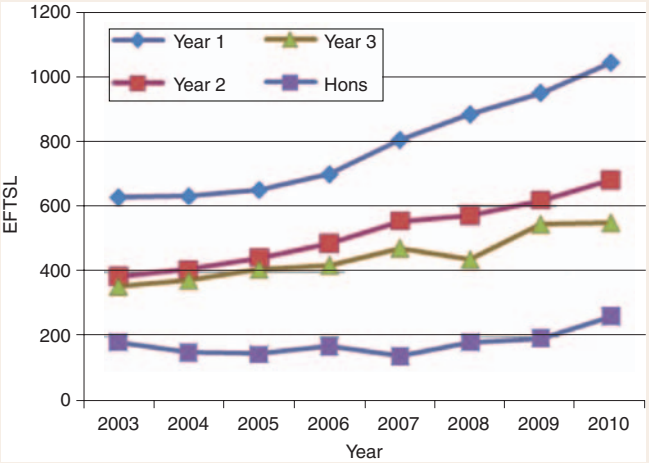


Fig. 1. *Trend in Equivalent Full-Time Student Load (EFTSL) in geoscience at Australian universities 2003–2010.*

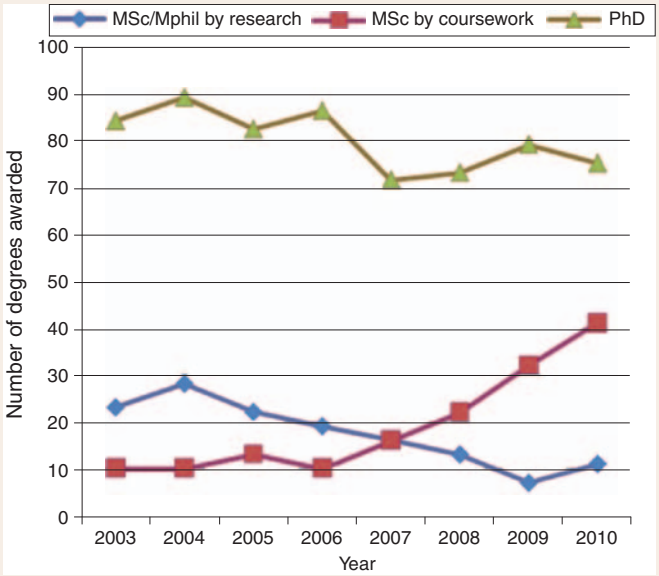


Fig. 2. *Output of higher geoscience degrees in 15 Australian universities 2003–2010.*

long-term viability of geoscience research in Australian universities.

The question asked in the report on AGTEP 2007 remains highly pertinent: 'What is the minimum economic department size that is sustainable in the longer run?' This has to take consideration of government funded student load, fee paying students, academic staff numbers, service teaching to other degrees, external funding for teaching, and research funding. As this survey once again demonstrates these considerations vary from institution to institution and are not easily compared. This is rendered more complex by the changes in the funding arrangements for universities.

In general the position has improved substantially since 2007, but it remains a truism that a critical mass of teaching and research capability that creates a vibrant and attractive educational experience is fundamental to retaining tertiary geoscience educational opportunities in Australia. This survey shows that some larger schools with wide capability are growing from strength to strength, whilst others with lesser capability are static or reducing.

ASEG 2012 22nd ASEG International Conference and Exhibition News Update (07)

The COC is pleased to announce that BHP Billiton has come on board as the Platinum Sponsor. While the company hardly needs any introduction it is worth noting their continued and continuing support for both our society and our profession.

We are now only 5 months out from the conference with Early Bird registration to close on 15 November. At the time of writing, the Technical Committee is extremely busy reviewing nearly 200 abstracts. Thanks to all those who volunteered (and those who didn't but are doing it anyway).

In a departure from previous conferences we will be giving extended time to more keynote speakers. The workshop programme will include opportunities for geophysicists at every stage of their career. The provisional list of Conference Workshops to take place on either Sunday 26 February or Thursday 1 March 2012 is listed below. You can register your interest on the website (see below).

Petroleum/Energy

- AVO Inversion by Brian Russell
- Operational Seismic Sequence Stratigraphy by Robert Kirk
- Microseismic Monitoring by Peter Duncan
- Geothermal Exploration by Cameron Huddlestone
- Coal Bed Gas by Scott Thompson
- Seismic Imaging: A Review of the Techniques, their Principles, Merits and Limitations by Etienne Robein (EAGE Education Tour)
- A Practical Overview of Seismic Dispersion by Chris Liner (SEG DISC)

Minerals

- Electromagnetics by Douglas Oldenburg
- Natural Electromagnetic (Magnetotelluric) by Bob Smith

Industrial workshops on Minerals (presenters to be confirmed)

- Intrepid Geophysics
- Mira Geoscience
- Ikon Science

Last but not least, the social programme has been finalised with the traditional ice-breaker and conference dinner being the highlights. The exhibition area, scene of many past pleasantries, will be full again as only 13 booths remain to be sold.

If you have a corporate conference or local geological/geophysical meeting I ask that you help promote ASEG2012. A PowerPoint slide, conference poster and conference email signature are all available to download in the media area of the website.

Please visit our website at www.aseg2012.com.au.

Co-Chairs: Wayne Mogg and Andrea Rutley
Technical: Binzhong Zhou
Sponsorship: Ron Palmer
Exhibition: John Donohue
Finance: Noll Moriarty
Workshops: Koya Suto
Publicity: Henk van Paridon
Social: Janelle Kuter

Henk van Paridon

Outstanding Plenary Program arranged for 34th IGC in Brisbane

The 34th IGC Scientific Program will feature a daily Plenary Session in which distinguished speakers will give invited presentations on major contemporary themes in the geosciences. These plenary themes are closely aligned with particular Themes and Symposia in the scientific program and are intended to promote discussion and debate during the Congress.

1. The Earth and man: living with a restless Earth

An increasing proportion of the world's population, especially in developing countries, are potentially at risk from natural hazards. This plenary will examine how man's interaction with the Earth's natural processes has shaped human society and how man has adapted to living in close proximity to natural hazards such as volcanoes, earthquakes, tsunami and floods.

Iain STEWART (UK) – A geologist and broadcaster who holds a chair in Geoscience Communication at Plymouth University. A well known presenter of several major BBC television series about the planet (*Journeys from the Centre of the Earth*; *Journeys into the Ring of Fire*; *Earth: The Power of the Planet*; *Earth: The Climate Wars, How Earth Made Us*). His latest landmark BBC series examines how plants have helped shape Earth's history.

Renato SOLIDUM Jr (Philippines) – Director of the Philippine Institute of Volcanology and Seismology, the Philippine government organization mandated to monitor and warn, assess hazards and risk, conduct research and development, and formulate awareness and preparedness plans to events related to volcanoes, earthquakes and tsunami.

2. What does the geological record tell us about the Earth's past climates in relation to projected climate change?

This plenary will overview the current data and projections relating to global climate change and examine the evidence

from the geological record of past climate change. It will consider rates of climate change, sea levels, CO_2 levels and temperatures, geosphere–biosphere feedbacks and climate sensitivities, and explore what this might mean for the Earth's climate in the future.

Tim NAISH (New Zealand) – Director of the Antarctic Research Centre at Victoria University of Wellington and Principal Scientist at the New Zealand Crown Research Institute, GNS Science. He is a paleoclimatologist focussed on reconstructing past global sea-level changes from continental margin geological records and participated in 9 expeditions to Antarctica and helped found ANDRILL, an international Antarctic Geological Drilling Program.

Will STEFFEN (Australia) – Executive Director of the ANU Climate Change Institute at the Australian National University (ANU), Canberra and serves on the Multi-Party Climate Change Committee (MPCCC) and as a Climate Commissioner. His research interests span a broad range within the fields of climate change and Earth System science, with an emphasis on incorporation of human processes in Earth System modelling and analysis.

3. Energy in a carbon-constrained world

The plenary will review the drivers for change to a low-carbon energy future and examine the range of energy sources potentially available but with particular focus on the geo-sources of energy (fossil fuels, geothermal, nuclear, hydro). It will consider the resource base, accessibility, extraction and use, technological and other limitations, and the environmental impacts of use of the various energy sources available now and the in the medium term.

Lord Ron OXBURGH (UK) – Member of the House of Lords UK Parliament, served as chairman of The Shell Transport and Trading Company until its unification with Royal Dutch Petroleum, and a graduate of the Universities of Oxford and Princeton. He has taught geology and geophysics at the Universities of Oxford and Cambridge and was a visiting professor at Stanford University, the California Institute of Technology and Cornell University.

Scott TINKER (USA) – His passion is education. He is actively engaged in building bridges between academia, industry and government. His latest educational project is a major documentary film on global energy. Scott has developed a vision for America's energy future and concludes that energy security – available, affordable, reliable and environmentally sustainable – must drive energy policy.

Sally BENSON (USA) – Director of the Global Climate and Energy Project in the Department of Energy Resources Engineering at Stanford University. She has worked at Lawrence Berkeley National Laboratory in a number of capacities, including Division Director for Earth Sciences. She was a coordinating lead author on the 2005 Intergovernmental Panel on Climate Change Special Report on Carbon Dioxide Capture and Storage.

4. Resourcing tomorrow: meeting the needs of a growing population

This plenary will review the future demand and availability of groundwater and mineral resources. By 2050 the world's population will exceed 9 billion with well over half living in urban areas. This will require more natural resources, especially minerals, energy and water, than used in the past, and present challenges for the discovery of resources and new extraction technologies.

Leader of Chinese Delegation – Future resource demand: a perspective from China.

Eduardo LEDSHAM (Brazil) – Vale's Executive Director for Exploration, Energy and Projects Management. He is the Chairman of the Board of two energy companies: VSE and VEL. He developed his professional career at Vale, which he joined in 1986.

Steve GORELICK (USA) – Runs the Global Freshwater Initiative at Stanford University where he is the Cyrus F. Tolman Professor in the Department of Environmental Earth System Science. One of his major research focus areas is analysis of water-supply sustainability in developing nations, including multi-year projects that have evaluated urban-agricultural competition for surface water and groundwater resources.

5. Digital Earth – The information explosion

The digital revolution and explosion of information is shaping the future direction and application of the earth sciences. Rapid advances in real time monitoring and measurement, web technologies and in data transfer are making geological and geospatial data increasingly global, accessible and instantaneous and therefore useful for purposes beyond which they were originally collected.

Thomas CUDAHY (Australia) – Director of the Western Australian Centre of Excellence for 3D Mineral Mapping. He has over 25 years of research experience with CSIRO in Perth in developing optical remote and proximal technologies for mineral resources exploration and development, especially hyperspectral mineral mapping at visible to thermal infrared wavelengths.

Laura WALLACE (New Zealand) – Senior Scientist at GNS Science in, New Zealand. Her primary research interests are in using GPS techniques to understand tectonic processes. In particular, she applies GPS methods to gain new insights into slow slip events at subduction zones, tectonic geohazards and plate boundary zone deformation.

Kristine ASCH (Germany) – Head of the Geological Information Systems and Maps unit at the Federal Institute for Geosciences and Natural Resources. She is Chair of the IUGS Commission of Geoscience Information, leads the Europe Subcommission of the Commission of the Geological Map of the World and coordinates building the Geoscience Information in Africa (GIRAF) network.

For more information, go to the IGC website: www.34igs.com.

David Denham

National Rock Garden: Celebrating the Geological Heritage of Australia

Concept

Australia's prosperity over the past 200 years has depended substantially on the geological makeup of the continent and its margins. This economic dependence on the continent's geological legacy is likely to continue well into the future. It therefore seems appropriate that due recognition be given to Australia's geological heritage by establishing a tribute in the nation's capital, Canberra, alongside other national monuments and institutions.

Displays of specimen rocks are established in a number of locations around the world; examples include the exhibition sites in St Johns, Canada, and the Science Museum in Helsinki, Finland. The latter is the example that spawned the present project following the 2008 International Deep Seismic Profiling Symposium at Saariselkä well inside the Arctic Circle. The Finns take great pride in displaying the richness of their spectacular glaciated Precambrian geology and its resources. This geological heritage is there for all to see in parks in the middle of Helsinki. Australia has an even greater reason to recognise and celebrate its geological legacy.

After consideration of a discussion paper among members, the Geological Society of Australia (GSA) adopted the concept of a national rock specimen display in the form of a park/garden in Canberra containing specimens from around the country. It is believed that such a display of rock specimens from across a whole continent will be a world first. The rock garden/park will be open to the general public and demonstrate the richness and diversity of Australian geology in every State and Territory.

It is proposed that this Australian tribute takes the form of a National Rock Garden on the north-western shores of Lake Burley Griffin, Canberra (see Figure 1). In a very real sense the National Rock Garden will bring together elements from every corner of the country.

A site has been gazetted by the Commonwealth Government and will share infrastructure such as roads, amenities blocks, pathways, shelters, car and bus parking with the neighbouring Lindsay Pryor National Arboretum currently being redeveloped as a tourist and educational destination by the National Capital Authority (NCA).

The 6 hectare site of the National Rock Garden is currently gently sloping grassland (see Figure 2), ideal for the development of pathways, rock specimen sites and public amenities. There are views from the site towards Lake Burley Griffin and Black Mountain. It is expected that there will be a central focal point, explanatory geological information and amenities for tourist and educational purposes. Construction of the entrance driveway from traffic lights on Lady Denman Drive by the ACT Government is now nearing completion.

Rock specimens

National Rock Garden specimen rocks will be selected on the basis of criteria that reflect the project aims, namely, to recognise, acknowledge and celebrate Australia's rich geological heritage and demonstrate to present and future generations of Australians the diversity of the rocks and minerals that contribute so significantly to the nation's landscapes, heritage and prosperity.

Rock specimens will be large (10–20 tonnes), realistically collectable, sufficiently robust for transport and long-term survival in the Canberra environment, and they must meet more than one of the following selection criteria.

- **Educational value and public/ tourist interest** – Specimens must be inherently interesting to the public and of significant educational value.
- **Nationally recognised/iconic** – Specimens should be readily associated with nationally significant locations, or cultural, industrial, economic or scientific heritage.
- **Story line/history** – Specimens should have a fascinating story to tell vis-a-vis Australian social history, scientific interest, industrial/economic importance and indigenous cultural tradition.
- **Interest/appearance** – Specimens should have an intrinsically interesting rock type, shape, colour or texture. The collection must include a balance of rock types, age, resources and structures, covering the length and breadth of the continent.

Specimens, where possible, will have a face cut and polished to reveal internal colours, textures and structures.

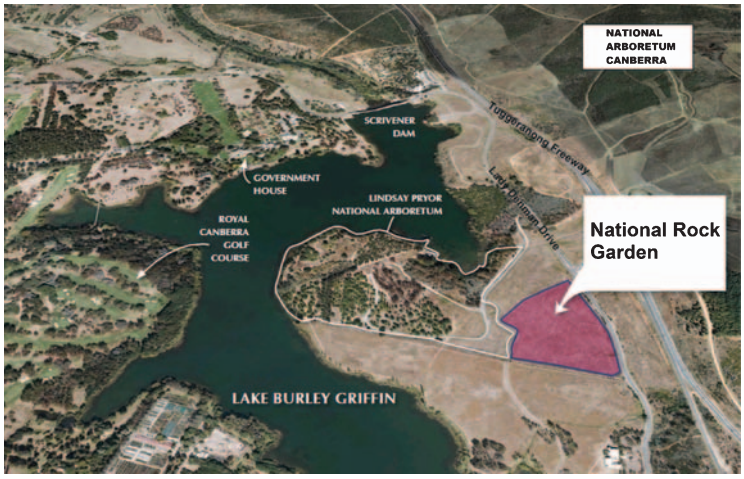


Fig. 1. *Map image of western Lake Burley Griffin, Government House and the Scrivener Dam showing the location of the National Rock Garden site.*

Fig. 2. *The National Rock Garden site looking towards central Canberra and the Captain Cook Memorial Fountain on Lake Burley Griffin.*

Gathering 15–20 tonne rock specimens from around the continent is going to be hard job. Just getting agreement on a representative collection of 100 specimens is going to be hard too. However, GSA has established working groups in each State and Territory to help with this task.

Landscape design

In the first half of 2011 the GSA combined with the University of Canberra to sponsor a landscape design competition for 27 3rd year students including four scholarship students from Canada. Some excellent designs and ideas were produced that may well be incorporated in a final professional design within the next six months (see Figure 3 for an example).

Fig. 3. *Design concept by University of Canberra student Louise Thomassin with pathway networks for rock specimens within different geological periods.*

National Rock Garden Trust

The GSA still has a long way to go in the business of constructing the National Rock Garden. Serious sponsorship funding is being sought from industry, governments and institutional organisations. The Society is entered on the Register of Environmental Organisations and is therefore endorsed by the Australian Taxation Office as a Deductable Gift Recipient. A National Rock Garden Trust has been established. The National Rock Garden Steering Committee includes representatives from Geoscience Australia, Questacon, the National Museum of Australia and the Australian Geoscience Council helping the GSA. Let's hope we can transform this National Rock Garden concept into reality in the next few years.

ASEG help and assistance

The Geological Society welcomes the support for the concept received from the Australian Society of Exploration Geophysicists (ASEG). ASEG members can help by being proactive in 'spreading the word' among colleagues throughout the resource industry, government and institutions. In Canberra we see many examples of monuments and memorials to many aspects of Australia's social history. Let's now also demonstrate to the world the richness of Australia's natural history and geological foundations and how they have shaped human history on this continent. This project presents a golden opportunity for the resource industries, governments, institutions and individuals to sponsor an outstanding national tribute to the basis of Australia's prosperity and social history.

Doug Finlayson
GSA and ASEG Member
Member of the National Rock Garden Steering Committee

Daishsat helicopter crashes in WA

The ASEG community was saddened to learn of the recent crash of a Daishsat Robinson R44 helicopter at Mingah Springs Station, about 200 km north of Meekatharra in Western Australia. The crash on Saturday 3 September claimed the life of 37-year-old pilot Matthew Wilson. The 23-year-old operator, Hugh Caren from Ireland, suffered serious injuries but is said to be recovering well.

The helicopter was undertaking a gravity survey as part of the continuing program of geophysical data collection under the Exploration Incentive Scheme in Western Australia. The Australian Transport and Safety Bureau is investigating the crash, but the investigation will not be complete before July 2012.

Matthew Wilson was a contract pilot for Daishsat. Managing Director David Daish said, 'Matt was a highly experienced pilot who first flew solo in an aircraft at 11 years of age. His skill and professionalism were greatly admired by his colleagues on the survey. He will be sadly missed by all who knew him.'

Hugh Caren is a graduate of the University of Dublin and has been working for Daishsat for four months. 'Hugh survived the crash and is recovering well – despite multiple fractures and internal injuries his first words to me immediately after the accident were "I think I'm ok" – they must breed them tough in Ireland', said David Daish.

The ASEG extends its warmest sympathy to Matthew Wilson's family and wishes Hugh Caren well in his continuing recovery.

Takeovers by giants continue

Rio Tinto acquires Riversdale Mining

Riversdale Mining Limited, with a market capital of approximately $4 billion was removed from the official list of the ASX on 7 July 2011, following the compulsory acquisition by Rio Tinto Jersey Holdings 2010 Limited.

Riversdale's main operations were in Africa, with three major coal projects. These are:

1. ***Benga Project*** in Mozambique, which is a joint venture between Riversdale (65%) and Tata Steel Limited (35%). Identified on the Benga Licence are coal resources of 4.0 billion tonnes and a coal reserve of 502 million tonnes. Construction of Stage 1, which will produce an estimated 5.3 Mt per year, has started and is expected to be completed in the second half of 2011.
2. ***Zambeze Project***, also in Mozambique, has an estimated coal resource of 9 billion tonnes. It is similar in structure to Benga with 22 coal seams outcropping over a strike length of 14 km across the northern portion of the tenement. Riversdale was negotiating with Wuhan Iron and Steel Corporation and the China Communications Construction Company to development the Zambeze Project.
3. ***Zululand Anthracite Colliery***, in South Africa, which is an operating underground anthracite mine located in the Zululand coalfield of northern Kwa-Zulu Natal. The 'run of mine' coal production was 753 433 tonnes for the year ended 30 June 2010. It has an estimated mine life of 13 years.

This is another strategic acquisition by Rio Tinto, to provide access to the Chinese coal market.

Barrick Gold swallows Equinox

Equinox Minerals Limited, with a market capital of approximately $7 billion, also vanished from the ASX in July 2011, when it was compulsorily acquired by the Canadian giant Barrick Gold Corporation. Equinox was an international mining company, dual listed in Canada and Australia. Its main interests were operating its 100% owned large scale ***Lumwana copper mine*** (20 million tonnes of ore per year) in Zambia, one of the largest new copper mines to be developed globally over the past decade and the construction of the ***Jabal Sayid Copper-Gold*** project in Saudi Arabia.

This is another example of giant multi-nationals swallowing not-so-small companies operating in Africa. Does this indicate a long term decline in business for the ASX in the resources sector?

Update on Geophysical Survey Progress from the Geological Surveys of Queensland, Western Australia, New South Wales, Tasmania and Geoscience Australia (information current at 19 September 2011)

Tables 1–3 show the continuing acquisition of gravity, airborne magnetic and radiometric data, and airborne electromagnetic data over the Australian continent.

Current surveys are in New South Wales, Queensland, Tasmania and Western Australia. All surveys are being managed by Geoscience Australia.

This issue reports three new gravity surveys in the Eucla Basin of Western Australia (see Figure 1). The three surveys will collect 14 703 gravity readings on a 2.5 km regular grid.

Table 1. Airborne magnetic and radiometric surveys

Survey Name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km^2)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
South Officer 1 (Jubilee)	GSWA	Thomson	1 Jun 10	180 000	200 m 50 m N–S	32 380	100% complete @ 22 Jun 11	TBA	148 – Oct 10 p23	TBA
South Officer 2 (Waigen – Mason)	GSWA	Thomson	28 Jun 10	113 000	400 m 60 m N–S	39 890	100% complete @ 5 Jan 11	TBA	148 – Oct 10 p24	QA/QC of final data in progress
North Canning 4 (Lagrange – Munro)	GSWA	Aeroquest	20 Sep 10	103 000	400 m 60 m N–S	36 680	100% complete @ 23 Jun 11	TBA	148 – Oct 10 p26	TBA
Grafton – Tenterfield	GSNSW	GPX	16 Jun 11	100 000	250 m 60 m E–W	23 000	58.5% complete @ 18 Sep 11	TBA	151 – Apr 11 p16	TBA
West Kimberley	GSWA	Aeroquest	29 Jun 11	134 000	800 m 60 m N–S Charnley: 200 m 50 m N–S	42 000	21.2% complete @ 18 Sep 11	TBA	150 – Feb 11 p20	TBA
Perth Basin North (Perth Basin 1)	GSWA	Fugro	11 Jun 11	96 000	400 m 60 m E–W	30 000	39.0% complete @ 18 Sep 11	TBA	150 – Feb 11 p20	TBA
Perth Basin South (Perth Basin 2)	GSWA	Fugro	22 Mar 11	88 000	400 m 60 m E–W	27 500	62.5% on 18 Sep 11	TBA	150 – Feb 11 p20	Survey on hold until October
Murgoo (Murchison 1)	GSWA	Thomson	28 Feb 11	128 000	200 m 50 m E–W	21 250	58.0% complete @ 18 Sep 11	TBA	150 – Feb 11 p20	TBA
Perenjori (Murchison 2)	GSWA	GPX	TBA	120 000	200 m 50 m E–W	20 000	TBA	TBA	150 – Feb 11 p21	Expected to commence January 2012
South Pilbara	GSWA	GPX	TBA	136 000	400 m 60 m N–S	42 500	TBA	TBA	150 – Feb 11 p21	Expected to commence October 2011
Carnarvon Basin North (Carnarvon Basin 1)	GSWA	GPX	24 Jul 11	104 000	400 m 60 m E–W	32 500	54.8% complete @ 18 Sep 11	TBA	150 – Feb 11 p21	TBA
Carnarvon Basin South (Carnarvon Basin 2)	GSWA	GPX	TBA	128 000	400 m 60 m E–W	40 000	TBA	TBA	150 – Feb 11 p21	Expected to commence October 2011
Moora (South West 1)	GSWA	Aeroquest	13 Jun 11	128 000	200 m 50 m E–W	21 250	45.1% complete @ 18 Sep 11	TBA	150 – Feb 11 p22	TBA
Corrigin (South West 2)	GSWA	GPX	TBA	120 000	200 m 50 m E–W	20 000	TBA	TBA	150 – Feb 11 p22	Expected to commence November 2011
Cape Leeuwin – Collie (South West 3)	GSWA	Fugro	25 Mar 11	105 000	200/400 m 50/60 m E–W	25 000	70.2% complete @ 18 Sep 11	TBA	150 – Feb 11 p22	Survey on hold until October.

Table 1. *Continued*

Survey Name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Mt Barker (South West 4)	GSWA	GPX	24 Apr 11	120 000	200 m 50 m N–S	20 000	12.7% complete @ 18 Sep 11	TBA	150 – Feb 11 p22	Survey on-hold until February 2012
Offshore East Coast Tasmania	MRT	Fugro	28 Feb 11	30 895	800 m 90 m E–W	19 570	100% complete @ 21 Apr 11	TBA	150 – Feb 11 p23	Data released via GADDS 27 July 2011
Galilee	GSQ	Aeroquest	11 Aug 11	125 959	400 m 80 m E–W	44 530	9.3% complete @ 18 Sep 11	TBA	151 – Apr 11 p15	TBA
Thomson West	GSQ	Thomson	14 May 11	146 000	400 m 80 m E–W	52 170	52.1% complete @ 18 Sep 11	TBA	151 – Apr 11 p15	TBA
Thomson East	GSQ	Thomson	14 May 11	131 100	400 m 80 m E–W	46 730	52.1% complete @ 18 Sep 11	TBA	151 – Apr 11 p16	TBA
Thomson Extension	GSQ	Aeroquest	22 Jun 11	47 777	400 m 80 m E–W	16 400	100% complete @ 10 Aug 11	TBA	151 – Apr 11 p16	TBA

TBA, to be advised.

Table 2. Gravity surveys

Survey name	Client	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Galilee	GSQ	IMT	3 May 2011	6400	2.5 km regular	TBA	100% complete @ 10 Jul 11	TBA	151 – Apr 11 p15	TBA
Thomson	GSQ	Daishsat	1 Apr 11	7670	2.5 km regular	TBA	100% complete @ 30 Jun 11	TBA	151 – Apr 11 p15	TBA
Peak Hill – Collier	GSWA	Daishsat	29 Jul 11	9100	2.5 km regular	56 140	35.1% complete @ 3 Sep 11	TBA	153 – Aug 11 p18	TBA
Kimberley Road Traverses	GSWA	Daishsat	8 Aug 11	7560	400 m station spacing along 2700 km of gazetted roads	TBA	76.6% complete @ 11 Sep 11	TBA	153 – Aug 11 p20	TBA
Eucla Basin SW	GSWA	TBA	TBA	3798	2.5 km regular	TBA	TBA	TBA	This issue (Figure 1)	TBA
Eucla Central	GSWA	TBA	TBA	5704	2.5 km regular	TBA	TBA	TBA	This issue (Figure 1)	TBA
Eucla Basin East	GSWA	TBA	TBA	5201	2.5 km regular	TBA	TBA	TBA	This issue (Figure 1)	TBA

TBA, to be advised.

Table 3. Airborne electromagnetic surveys

Survey Name	Client	Contractor	Start survey	Line (km)	Spacing AGL Dir	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Central Australian Palaeovalley	GA	Aeroquest	End Sep 11	5000	1000 m and tie lines at 30 km	4113	TBA	TBA	152 – Jun 11 p24	TBA

TBA, to be advised.

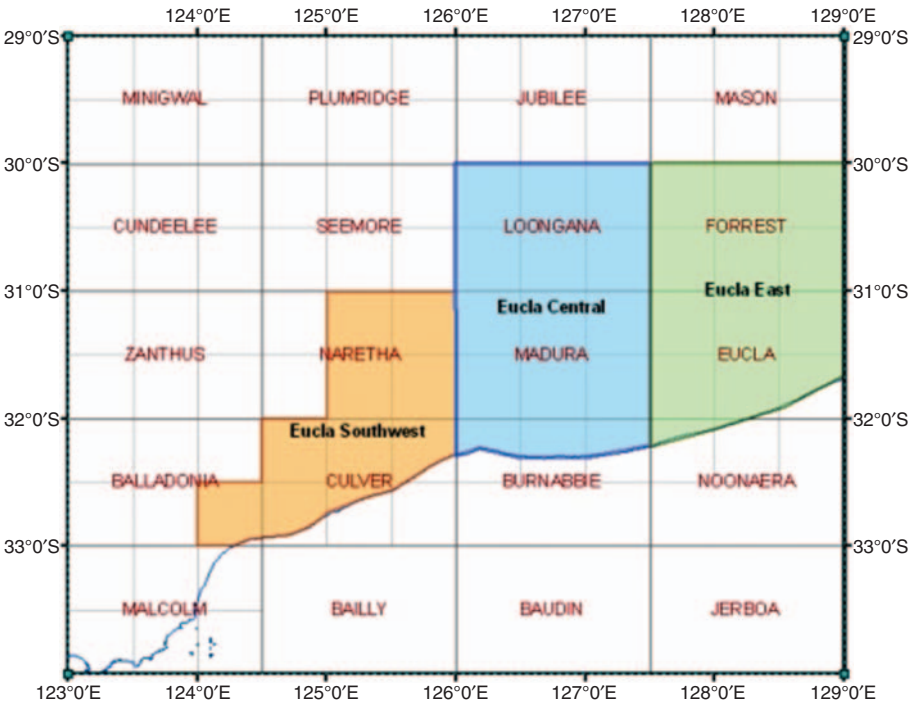


Fig. 1. *Location diagram for the Eucla Southwest, Eucla Central and Eucla East gravity surveys in Western Australia.*

GSQ reports that the Thomson and Galilee gravity surveys completed in July 2011 are undergoing final data checks and are now expected to be finalised in September. Gravity data will be publicly released when quality control processes are completed. Also, the Thomson and Galilee airborne magnetic and radiometric surveys are continuing in central and south-western Queensland. Wet weather delayed the start of these surveys by up to three months and data collection is now expected to continue until December 2011.

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Temperature interpretation and modelling for geothermal applications: GeoTemp

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One of the fundamental parameters controlling the viability of any geothermal project is the temperature of the reservoir. At the early exploration stage, it is unlikely that accurate temperature data will be available. To estimate it, engineers rely mainly on temperature data such as wireline temperature logs, drill stem tests, repeated formation tests and bottom hole temperatures, usually arising from geographically sparse measurements, often from shallow depths or having low reliability. The reservoir temperature distribution is intrinsically related to the thermal characteristics of the rock and the local fluid flow. Different thermal regimes such as conduction, advection and conduction with heat production could take place, depending on the local geology and hydrogeology. This work defines an integrated data analysis workflow for temperature interpretation, modelling and estimation based on the interpretation of geophysical wireline logs, core sample measurements, geology and hydrogeology. This workflow is packaged into the software GeoTemp.

Keywords: Temperature, thermal characterisation, interpretation, modelling, predictions, thermal conductivity, heat flow.

Motivations

Exploration for geothermal energy resources aims to locate and evaluate potential geothermal reservoirs in economically viable locations. To proceed to a thermal characterisation for temperature prediction at depth, we rely on existing thermal related data. The existing temperature data sources include bottom hole temperature, drill stem test and repeated formation test temperature and wireline temperature logs. The first sources are generally geographically and vertically sparse (often only a few data points for the whole depth of a well) and of low reliability (usually gathered through petroleum exploration rather than geothermal characterisation). Wireline temperature logs are extremely rare for deep wells (e.g. petroleum wells) but fortunately are more common for shallow wells (water monitoring and mining bores). An extensive temperature logging

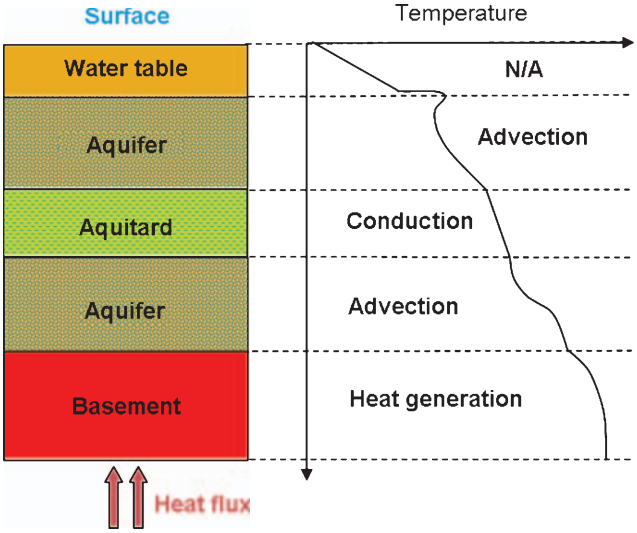


Fig. 1. *Thermal regime and temperature by formation.*

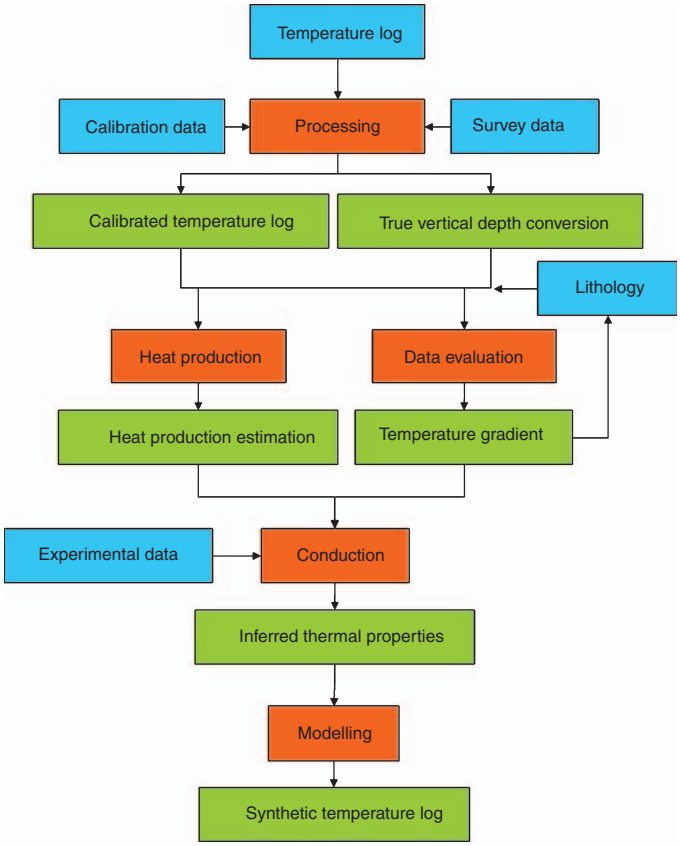


Fig. 2. *GeoTemp framework for thermal reservoir characterisation. Blue boxes represent input data, orange boxes represent the modules and green boxes represent output data.*

campaign is currently being undertaken in Australia by Geoscience Australia (Kirkby *et al.*, 2011). PressureDB provides a database of temperature data from petroleum wells (PressurePlot, 2007). Thermal conductivity data are rare. By early March 2011, for Western Australia, only 36 measurements of thermal conductivity were publicly available for the Perth Basin (HDRPL, 2008) and 50 measurements for the Canning Basin (HDRPL, 2009). These measurements were done on cores from petroleum wells situated in several Western Australian basins.

Heat is transported inside rocks by a combination of processes such as conduction, advection and radiation, defining the thermal regime. At a first approximation, for mildly heterogeneous formations, the thermal regime can be assumed to be constant. Therefore, thermal characterisation of a stratigraphic sequence could be achieved by assessing thermal regimes for each formation. Figure 1 presents a schematic of hydrogeological stratigraphy with associated thermal regimes.

To proceed towards temperature prediction at depth, quality control of the available data is required prior to any interpretation or modelling.

In this work, we present a software workflow for the processing, quality control, interpretation and modelling of temperature data and the quantitative extrapolation and interpolations of temperatures for geothermal reservoir engineering purposes. The software tool used, GeoTemp, accepts standard input files and exports pictures in common formats for reporting.

General framework

GeoTemp aims to set a protocol for inferring underground temperature and estimating rock thermal parameters based on the analysis, interpretation and modelling of temperature logs. It comprises six components corresponding to the six different stages of the process: Processing, Data viewing, Data evaluation, Heat Production, Conduction and Modelling.

Each module is independent of the other, however they are linked by an integrated framework that facilitates the workflow from processing to interpretation and then to modelling with prediction. The modules accept widely used file formats and well defined input/output files (Ricard and Chanu, 2011). For example, the LAS file format is used for wireline temperature logs. This format was defined by the Canadian Well Logging Society (http://www.cwls.org/las_info.php).

Figure 2 shows the GeoTemp workflow for temperature logs analysis.

Each module incorporates straightforward procedures for loading and interpreting the data with visualisation of intermediate and final results which may be exported for reporting purposes.

GeoTemp modules

Processing

GeoTemp Processing handles calibration of the temperature data, depth conversion from Measured Depth (MD) to True Vertical Depth (TVD) and quality control of the gamma-ray and local temperature gradient.

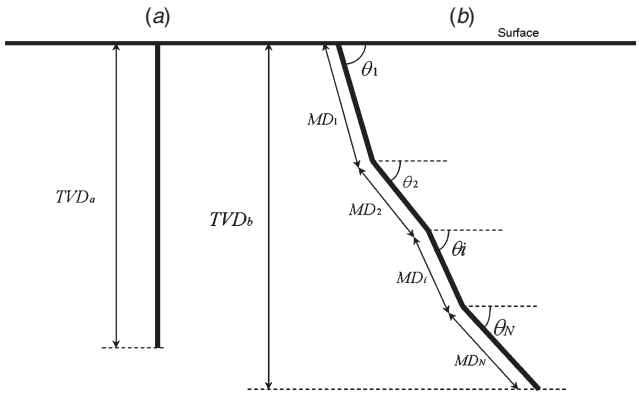


Fig. 3. *Measured Depth and True Vertical Depth for (a) a vertical well and (b) a deviated well.*

Every temperature probe has a natural drift over time, so regular temperature calibrations need to be performed and temperature data must to be corrected for drift. The GeoTemp Processing module gives the user the ability to calibrate the temperature data using a set of calibration data.

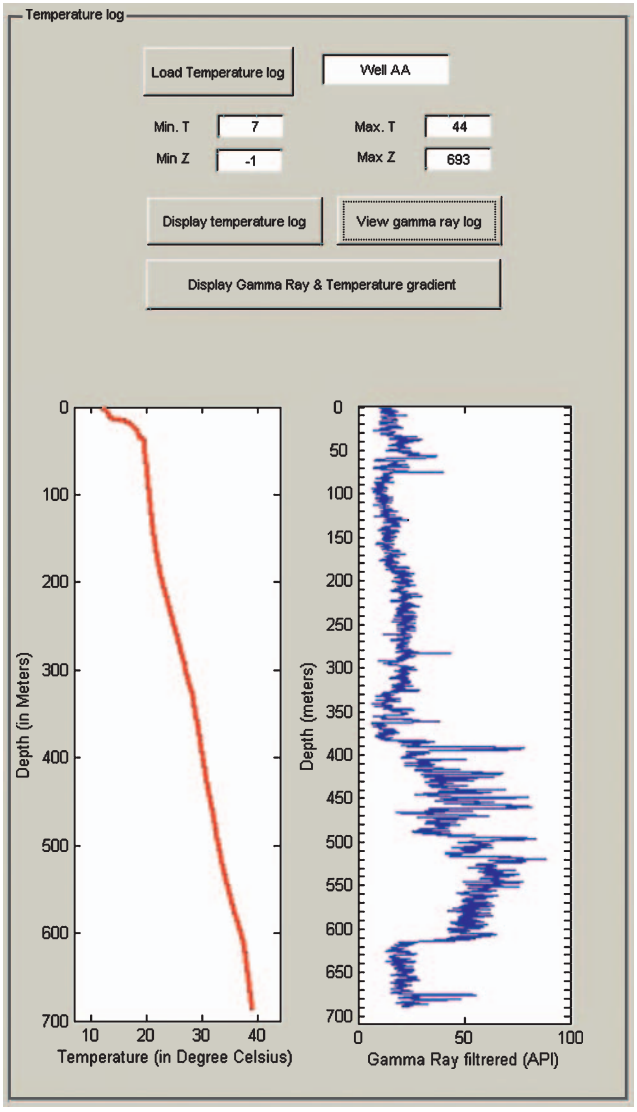


Fig. 4. *Temperature log frame screenshot.*

A second functionality of GeoTemp Processing is the ability to correct the depth from Measured Depth (MD) to True Vertical Depth (TVD) by loading temperature log (.LAS file) and survey data (.XLS file) in the True Vertical Depth Calculations frame (see Figure 3). As wells are not often strictly vertical but the temperature analysis is performed, as a standard, in true vertical depth, a conversion from Measured Depth (MD) to True Vertical Depth (TVD) is required. Using survey data, GeoTemp Processing allows the user to convert the depth from MD to TVD (see Figure 3).

The link between Measured Depth and True Vertical Depth is expressed as follows:

$$\mathrm{TVD} = \sum_{i=1}^{N} \mathrm{MD}_i \sin(\theta_i) \qquad (1)$$

where TVD is the True Vertical Depth in metres, and for each deviated segement i, MD_i is the Measured Depth in metres and θ_i is the angle in degrees.

A third functionality of GeoTemp Processing is the quality control of gamma ray and local temperature gradient data (see Figure 4) and the ability to display these for reports. These features allow the user to inspect the temperature and gamma-ray data in detail.

Viewer

GeoTemp Viewer allows the user to load and display several temperature logs at once (see Figure 5). By plotting several temperature logs at once, the user can easily compare the temperature logs.

Evaluation

The third component provides the tools to perform quality control of the temperature data, check the consistency of the temperature, lithology and gamma ray data, evaluate thermal regimes by formation, and finally calculate the temperature gradients by formation (see Figure 6). This module is designed to interpret thermal profiles with respect to a vertical conduction model.

It allows the viewing of the temperature and gamma-ray data by formation and therefore checks the consistency between formation tops and gamma-ray markers. If inconsistency is noted, formation tops can be adjusted. Once formation tops and gamma-rays are consistent, linear temperature gradients can be calculated by formation. In the case of vertical heat conduction with no heat production, the temperature profile obeys:

$$T(z) = T_0 + q_0 \sum_{i=1}^{N} (\Delta z_i / \lambda_i) \qquad (2)$$

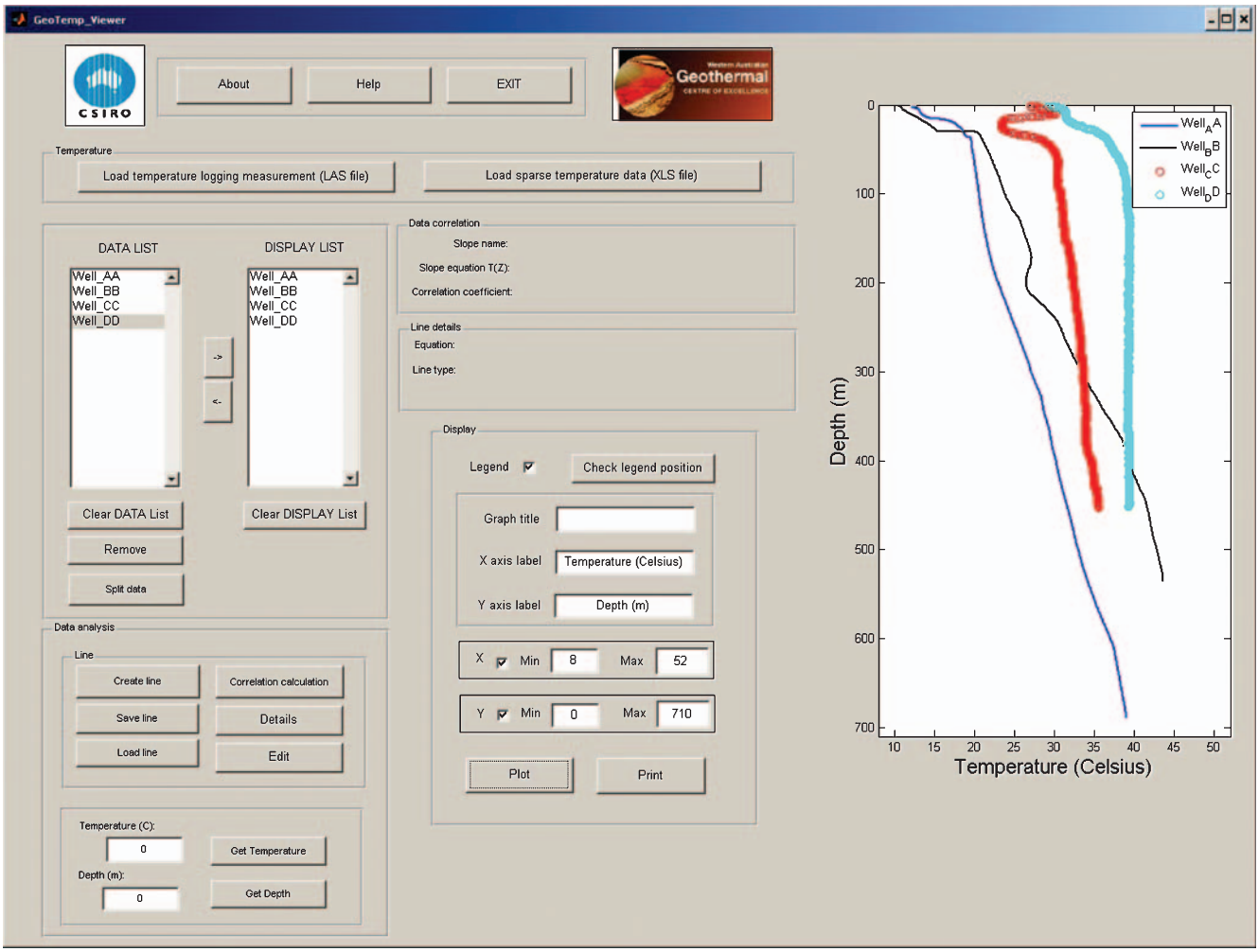


Fig. 5. *Viewer module screenshot.*

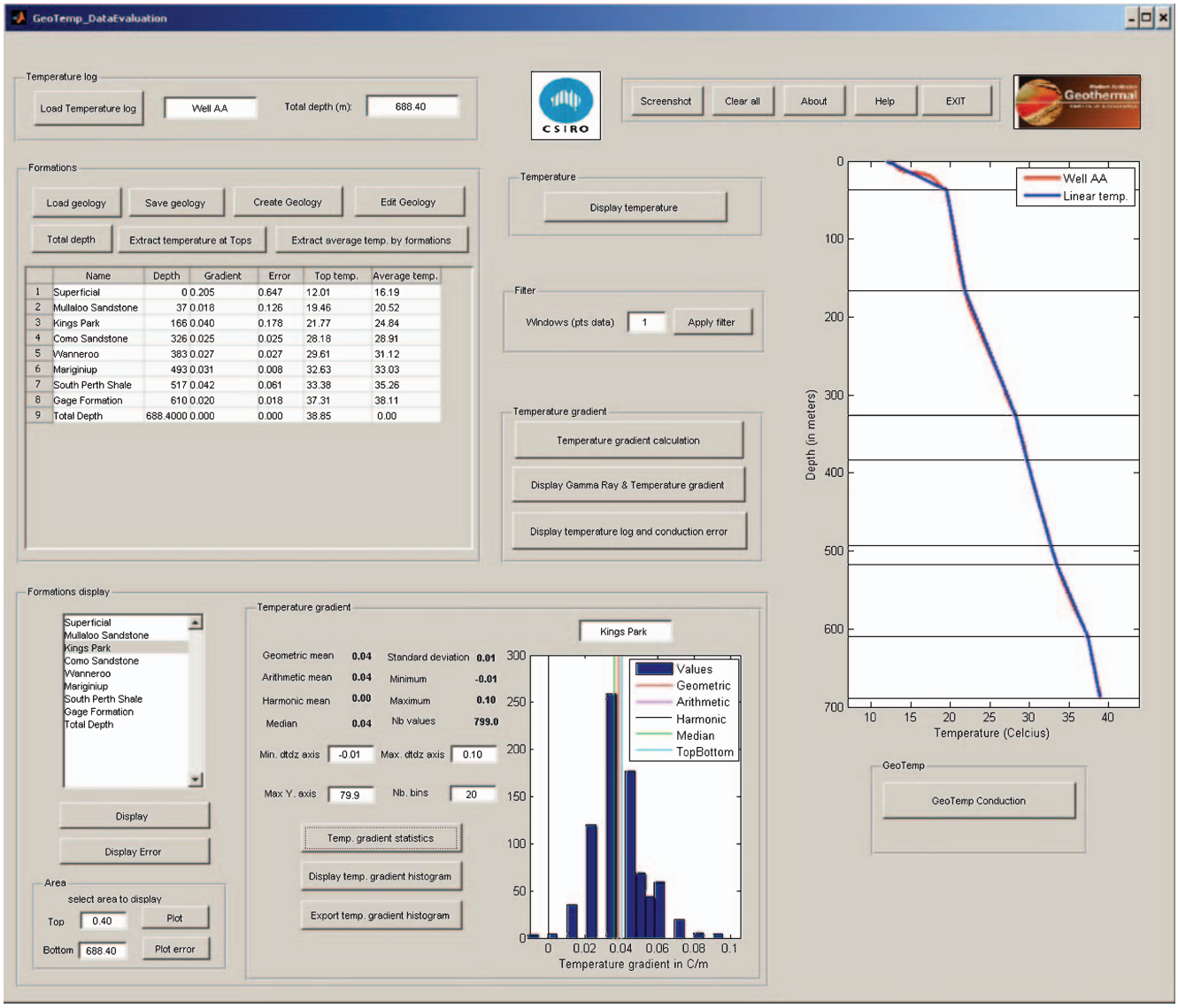


Fig. 6. *Data evaluation module screenshot.*

where T is temperature, T_0 is surface temperature or another reference temperature, q_0 is the constant heat flow density, z is depth below ground level and λ_i is thermal conductivity in the depth interval Δz_i (Kutasov, 1999).

For each formation, a normalised quadratic error between the linear temperature gradient and the real temperature data is calculated to quantify the suitability of the conductive thermal regime assumption. If the quadratic error is relatively small, to be determined by the user, then the vertical conduction assumption is accepted.

Heat production

The rate of radiogenic heat generation within rocks is related to the quantity of radioactive material present, the rate of decay and the energy of the emitted particles. Gamma-ray spectrometers provide the most direct method for measuring the abundance of uranium, potassium and thorium in rock (Beardsmore and Cull, 2001). The estimation of heat production rate by formations (Figure 7) is done from the gamma-ray wireline log using the empirical equation:

$$A = 0.0158(\mathrm{GR} - 0.8) \quad (3)$$

where A is the heat generation count in μWm^{-3} and GR is the gamma ray count in API units.

Conduction

Assuming a vertical conduction regime, a conductive interpretation of temperature logs can be performed using GeoTemp Conduction (Figure 8). In this module, the temperature gradient combined with experimental thermal conductivity measurements can be used to calculate the vertical heat flow and double-check the consistency of thermal conductivity, vertical heat flow and temperature gradient.

Modelling

The sixth component focuses on conductive modelling and temperature prediction at target reservoir depth (Figure 9).

Interpreted parameters such as thermal conductivities by formation, vertical heat flow and temperature at a given depth are used to calculate a synthetic temperature log.

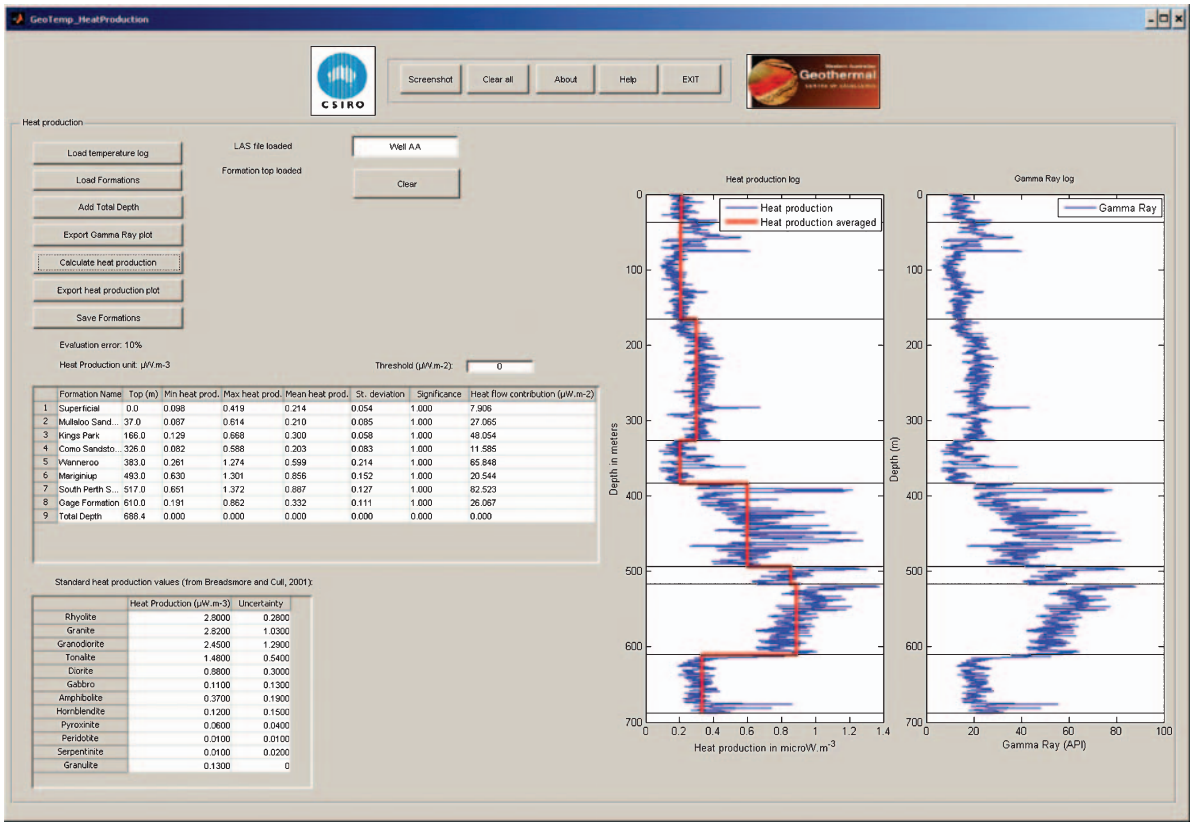


Fig. 7. *Heat production module screenshot.*

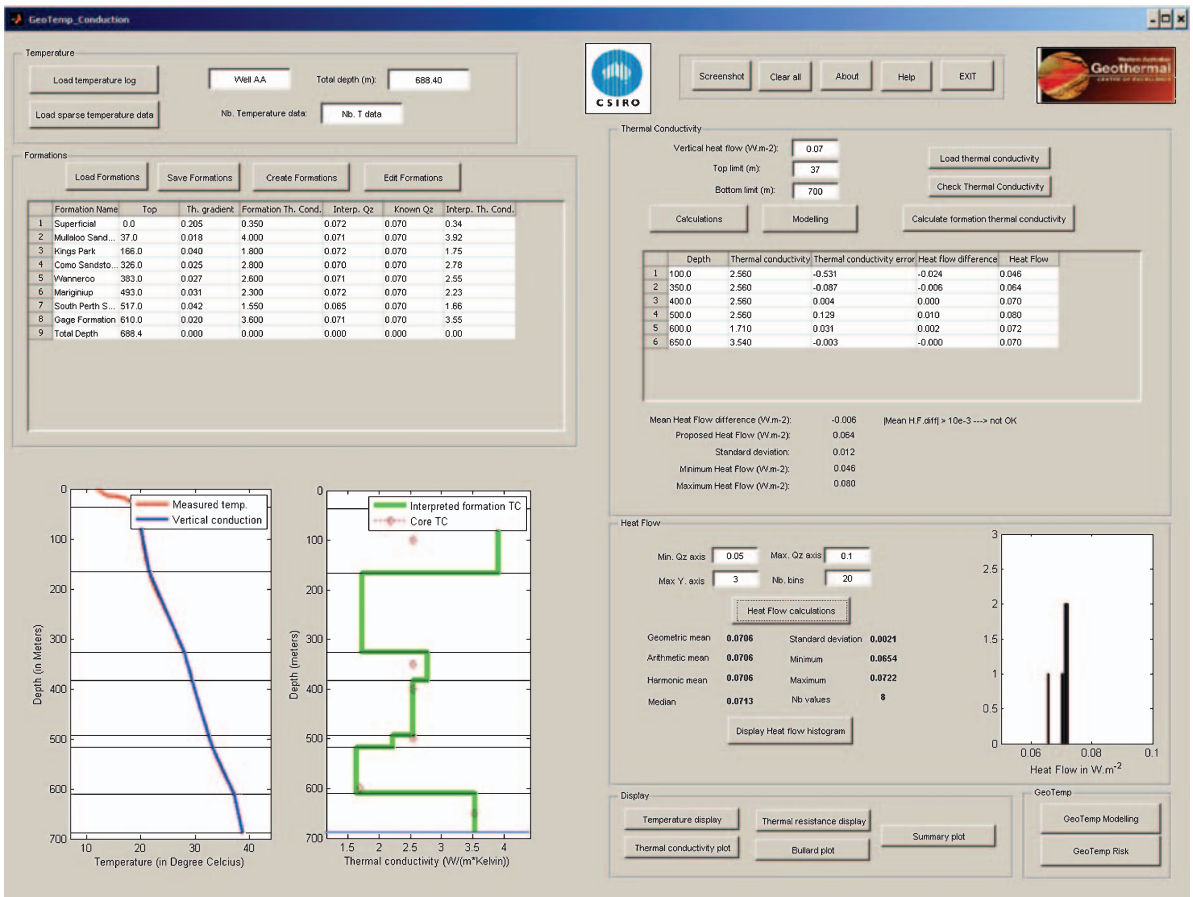


Fig. 8. *Conduction module screenshot.*

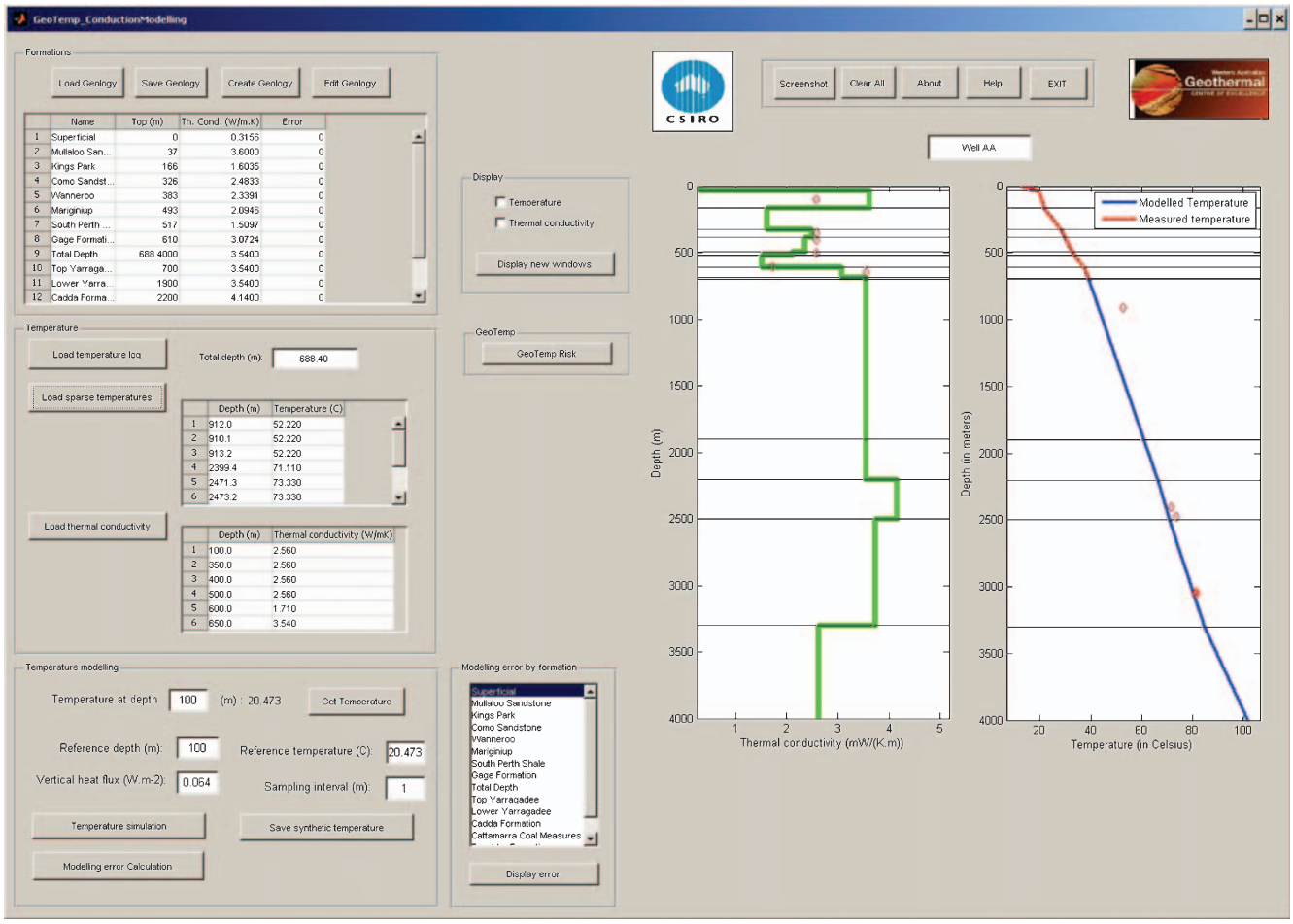


Fig. 9. *Modelling module screenshot.*

Normalised quadratic error between the real and the synthetic temperature logs is calculated for quality evaluation of the interpretation/modelling process. Temperature predictions can be made for depths below the supporting measurement data if vertical heat conduction is assumed.

References

Beardsmore, G. R., and Cull, J. P. 2001, Crustal heat flow a guide to measurement and modelling, Cambridge University Press. ISBN: 0 52179289 4 hardback.

HDRPL 2008, Geothermal energy potential in selected areas of Western Australia (Perth Basin): A report prepared for the Department of Industry and Resources, Western Australia. Hot Dry Rocks Pty Ltd, Report DOIR0060108.

HDRPL 2009, Geothermal energy potential in selected areas of Western Australia (Canning Basin): A report prepared for the Department of Mines and Petroleum, Western Australia. Hot Dry Rocks Pty Ltd, Report DOIR0681008.

Kirkby, A. L., Gerner, E. J., Budd, A. R., Weber, R. D., Meixner, A. J., and Champion, D. C. 2011, Heat flow data collection for the Australian continent: Support for an emerging geothermal industry, in: Middleton, M. and Gessner, K. (eds.) West Australian Geothermal Energy Symposium Abstracts, v. 1: p. 13.

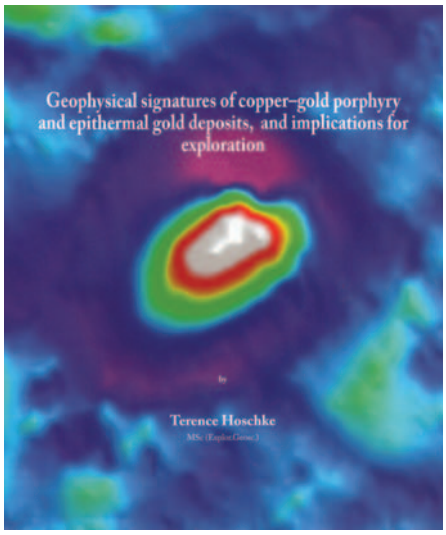
Kutasov, I. M., 1999, Applied geothermics for petroleum engineers, Elsevier Science. ISBN: 0 444 82887 7.

PressurePlot 2007. http://www.pressureplot.com/

Ricard, L. P., and Chanu, J.-B. 2011, GeoTemp 1.0: User Manual, WAGCOE/CESRE report in preparation.

Geophysical Signatures of Copper-Gold Porphyry and Epithermal Gold Deposits, and Implications for Exploration

by Terence Hoschke
Publisher: CODES, 2011, 46 pp.
RRP: $35 (paperback)
ISBN: 978-1-86295-625-4



The ARC Centre of Excellence in Ore Deposits (CODES) at the University of Tasmania produces a series of special publications. These are the result of major research efforts of authors from CODES and the School of Earth Sciences. This latest CODES publication by geophysicist Terence Hoschke outlines and discusses the geophysical data from a number of porphyry and epithermal deposits from the Pacific rim, including Batu Hijau, Elang, Grasberg, Alumbrera, Martabe, Yanacocha, Pajingo and Waihi. The author has worked for Geopeko, North Limited, Normandy, and is currently employed as principal geophysicist with Newmont. He has worked on porphyry exploration in Indonesia and more recently, a number of epithermal systems. This work was submitted (in June 2010) in partial fulfilment of the requirements for MSc (Exploration Geoscience) at the University of Tasmania.

Porphyry copper deposits are currently the largest source of copper ore. Although they are low-grade, the deposits constitute important sources because they may be worked on a large scale at low cost. Geologically, the deposits occur close to or in granitic intrusive rocks that are porphyritic in texture.

Geophysical Signatures of Copper-Gold Porphyry and Epithermal Gold Deposits, and Implications for Exploration is a paperback measuring 21 × 25 cm, and its 46 pages contain a good balance of text and diagrams. It has the look and feel of a practitioners hand book rather than a scholarly treatise. The writing is clear and concise, and the author has managed to avoid using too much technical jargon.

The introduction starts with a brief background. It is assumed the reader already has a working knowledge of porphyry and epithermal systems, not to mention geophysical methods. The aim of the study is to relate the geophysical responses to the geological and particularly, the alteration properties of the deposits. Most of these deposits are located in the western Pacific. The literature review notes the lack of examples of the geophysical characteristics of gold-rich porphyries. A discussion follows concerning the magnetic response and electrical properties over gold-rich porphyries and epithermal deposits. Unlike the Copper-Molybdenum porphyry deposits, gold-rich porphyries have an association of mineralisation with magnetite. The predicted magnetic response over the different alteration zones and the role of remanence in increasing or decreasing the anomaly strength is covered. The IP response of a porphyry system is generally related to the sulphide distribution. Reference is made to the Lowell and Guilbert (1970) model of a porphyry copper system, and unpublished work by Adi Maryono based on Indonesian deposits. The potassic, phyllic and propylitic alteration zones of the deposit are discussed including their impact on the measured response.

Chapters 2 to 4 present a number of case studies. Chapter 2 covers four porphyry Cu-Au deposits, including Grasburg, the world's largest Cu-Au porphyry deposit, located in Irian Jaya. Diagrams of sections through the Batu Hijau deposit in Indonesia showing gold and copper grade and magnetic susceptibility demonstrate the clear relationship of mineralisation to magnetite. Chapters 3 and 4 cover high-sulphidation and low-sulphidation epithermal deposits. At Yanacocha in northern Peru, the silica altered rock is highly resistive within conductive clay alteration. Resistivity methods have been used successfully in exploration for the massive silica bodies which host the gold. Examples of radiometric mapping are also given, with epithermal deposits commonly showing a low radiometric response due to the intense acid alteration.

There are two pages of references and two appendices consisting of laboratory magnetic property measurements and electrical property measurements of samples from Alumbrera, Batu Hijau and Grasberg. The magnetic properties were measured at CSIRO under supervision of David Clark; the electrical properties were measured by Don Emerson of Systems Exploration Pty Ltd.

A table on page 38 provides a summary of the application of different geophysical methods to the exploration of porphyry and epithermal systems. High resolution magnetics and resistivity appear to be the most useful methods in the exploration of these mineralised deposits.

This book is recommended reading for anyone involved in porphyry or epithermal exploration. It provides a good overall summary of how these mineralised systems can be characterised by their geophysical responses. It should find a wider audience amongst people generally interested in practical applications of geophysical methods.

This book can be ordered through CODES publications, http://fcms.its.utas.edu.au/scieng/codes/, or email publications@codes.utas.edu.au.

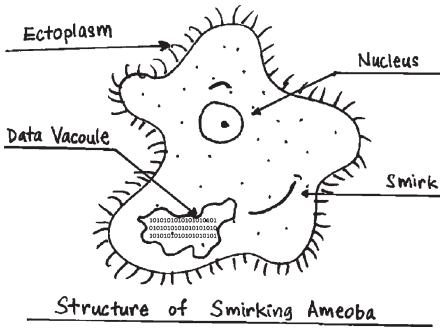
Reviewed by John Brett
Email: john.brett@dmp.wa.gov.au

The future of data storage

Guy Holmes
Guy.Holmes@spectrumdata.com.au

Has anyone ever seen a 'futurist' presentation, or an advertisement to go and see one? Futurists talk about what things will be like in the future and how cool it will be to be alive when you can fly your car to work.

I attended a Futurist presentation about three years ago and they told me that soon data measured in terabytes would be stored on the back of an amoeba in some kind of holographic storage medium and that we could use our amoeba USB thumb drive to carry our life around in a compact form.



I was like – 'yeah – whatever' … but then yesterday I was walking through Perth and saw an amoeba walking down the street with a smirk on his face and a tiny backpack filled with data. My first thought, 'smug little amoeba', second thought – 'how did that futurist know', and lastly, 'I need to stop drinking'.

Today I got up and thought, I can predict the future with almost 100% certainty, I am going to be a futurist (and at that very moment, I had made my first accurate prediction; I was chuffed). After all, I am a little old to do Planking and my wife tells me it's dangerous – being a futurist still makes me sound cool to my kids.

What follows are my predictions for data storage and data formats for the oil and gas sector and the mining industry. Predictions make you a futurist – even if they are incorrect.

Seismic surveys

Current issue – Seismic data will continue to be gathered in massive quantities and it will need something to store it that is easy to access, has longevity and is cheap.
Prediction – Magnetic tape has a long life ahead of it. You will see magnetic tape being developed for at least another 20 years. And it will have three letters emblazoned on the side of it – IBM.

Current issue – Magnetic tape is a real pain in the butt to use.
Prediction – Magnetic tape will continue to be the storage medium of choice for long-term archive. Go get one of those doughnut ring thingies to sit on.

Well logging

Current issue – The formats used to record well logs are far too complex and completely unnecessary.
Prediction – Geophysicists and geologists will continue to 'enhance' the data formats used by industry for logging, and will skip this part of my article. Flip the doughnut ring over and use the other side.

Potential field data – magnetics

Current issue – I don't have a very solid background in magnetics, other than that if I wear my Harley Davidson belt buckle through airport security something beeps. But I have been told that magnetics are very useful and colourful to look at – especially in 3D.
Prediction – I will continue to not have a very solid background in magnetics, AND, airport security is going to want me to put my amoeba thumb drive into a tray with my belt when I pass though. Oh, AND someone will realise that my prediction above was not a prediction at all, just a statement of fact.

Seismic navigation data

Current issue – Navigation and positional data – not just for seismic, but other data types – is considered a separate type of data even though it is useless without the seismic, and the seismic is useless without the navigation.
Prediction (actually more of a dream really) – Seismic acquisition and processing contractors will start to populate the seismic recording formats they create correctly, and include navigation in the data so that no one ever has to merge navigation with seismic ever again.

Conclusion

I think the truth of the matter is that as we try and create faster and better machines and formats, we also create a past that has no place in the present. This then creates disdain for the past, and as unachievable as it may be, a hunger for that future state that can never be achieved.

Being a futurist is easy. You look at the problems of today, decide whether a commercial solution is viable and bammm … you can pretty much be guaranteed of predicting the future with 100% accuracy. You don't even need to come up with THE solution – just the fact that someone, somewhere, sometime will. After all, the 'future' is a very long piece of string.

November			**2011**
8–11 Nov	Sustainable Earth Sciences 2011: Technologies for Sustainable Use of the Deep Sub-surface http://www.eage.org	Valencia	Spain
15–17 Nov	2011 International Petroleum Technology Conference http://iptcnet.org/2011	Bangkok	Thailand
20–22 Nov	10th SEGJ International Symposium http://www.segj.org/is/10th/	Kyoto	Japan
21–23 Nov	33rd New Zealand Geothermal Workshop http://www.nzgeothermal2011.org.nz	Auckland	New Zealand
December			**2011**
1–3 Dec	GEOINDO 2011: International Conference on Geology, Geotechnology, and Mineral Resources of INDOCHINA http://home.kku.ac.th/geoindo2011/	Khon Kaen	Thailand
4–8 Dec	20th World Petroleum Congress http://www.20wpc.com/	Doha	Qatar
5–9 Dec	AGU 2011 Fall Meeting http://www.agu.org/meetings	San Francisco	USA
11–14 Dec	First International Conference on Engineering Geophysics http://www.eage.org	Al Ain	United Arab Emirates
January			**2012**
22–24 Jan	4th International Professional Geology Conference: Earth Science – Global Practice http://www.4ipgc.ca	Vancouver	Canada
February			**2012**
8–10 Feb	Workshop on EM in Hydrocarbon Exploration http://www.eage.org/	Singapore	Singapore
16–18 Feb	SPG India, 9th International Conference & Exposition on Petroleum Exploration http://www.spgindia.org/	Hyderabad	India
26–29 Feb	**22nd ASEG Conference and Exhibition 2012: Unearthing New Layers** **http://www/aseg2012.com.au**	**Brisbane**	**Australia**
April			**2012**
2–5 Apr	Saint Petersburg International Conference & Exhibition 2012 http://www.eage.org	Saint Petersburg	Russia
June			**2012**
4–7 June	Copenhagen 2012: 74th EAGE Conference & Exhibition incorporating SPE EUROPEC 2012 http://www.eage.org	Copenhagen	Denmark
August			**2012**
5–10 Aug	34th International Geological Congress http://www.34igc.org	Brisbane	Australia
November			**2012**
4–9 Nov	SEG International Exposition and 82nd Annual Meeting http://www.seg.org	Las Vegas	USA

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ASEG 2011 WINE OFFER

The ASEG SA/NT Branch is pleased to be able to present the following wines to ASEG members. These wines were found by the tasting panel to be enjoyable drinking and excellent value. The price of each wine includes GST and bulk delivery to a distribution point in each capital city in late November/early December. Stocks of these wines are limited and orders will be filled on a first-come, first-served basis.

Please note that this is a non-profit activity carried out by the ASEG SA/NT Branch committee only for ASEG members. The prices have been specially negotiated with the wineries and are not available through commercial outlets. Compare prices if you wish but you must not disclose them to commercial outlets.

Angove 2009 Vineyard Select Shiraz - McLaren Vale

"Bright hue; a lively and juicy wine with abundant plum and black cherry fruit supported by good acidity and tannins, oak a minor support role." – James Halliday Aus. Wine Companion 2012 edition – 90 points – 4.5 stars

"Good-value table wines are Angove's forte. This McLaren Vale shiraz is typically generous, offering ripe, sweetly spicy berry fruit seasoned with a well-measured dose of coconut-tinged oak. It tastes smooth and velvety with soft tannins to keep together nicely." – Australian Gourmet Traveller Wine July 2011

"Here is a full in-your-face ripe shiraz from McLaren Vale. Masses of liquorice and plum with a decent whack of vanillin oak. It's balanced and delivers all you want" – Newcastle Herald – 4 stars

ASEG Price $150/case (usually retails at around $228/case)

Pikes 2010 Clare Hills Riesling – Clare Valley

"The 2010 vintage was one of the earliest on record for the Clare Valley beginning in early February. While most of South Eastern Australia was affected by the continuance of a severe drought, rainfall in the Clare Valley was almost average. An early budburst followed by a warm spring and summer hastened the ripening of all varieties which meant timing of harvest was critical. The resultant wines have excellent up front flavour concentration and balanced acidity.

Pale green appearance with typical Clare Valley Riesling characters on full display, including citrus blossom, lemon, quince and a little honeysuckle. The palate is crisp, dry and fresh; the balanced acidity ensuring a soft, clean finish." – Neil Pike, winemaker

ASEG Price $110/case (not normally available for purchase in Australia - suggested retail price approx. $180/case)

2011 ASEG WINE OFFER: orders close FRIDAY NOVEMBER 11th 2011

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Telephone: (08) 8463 3087, Fax: (08) 8226 3200, email: philip.heath@sa.gov.au

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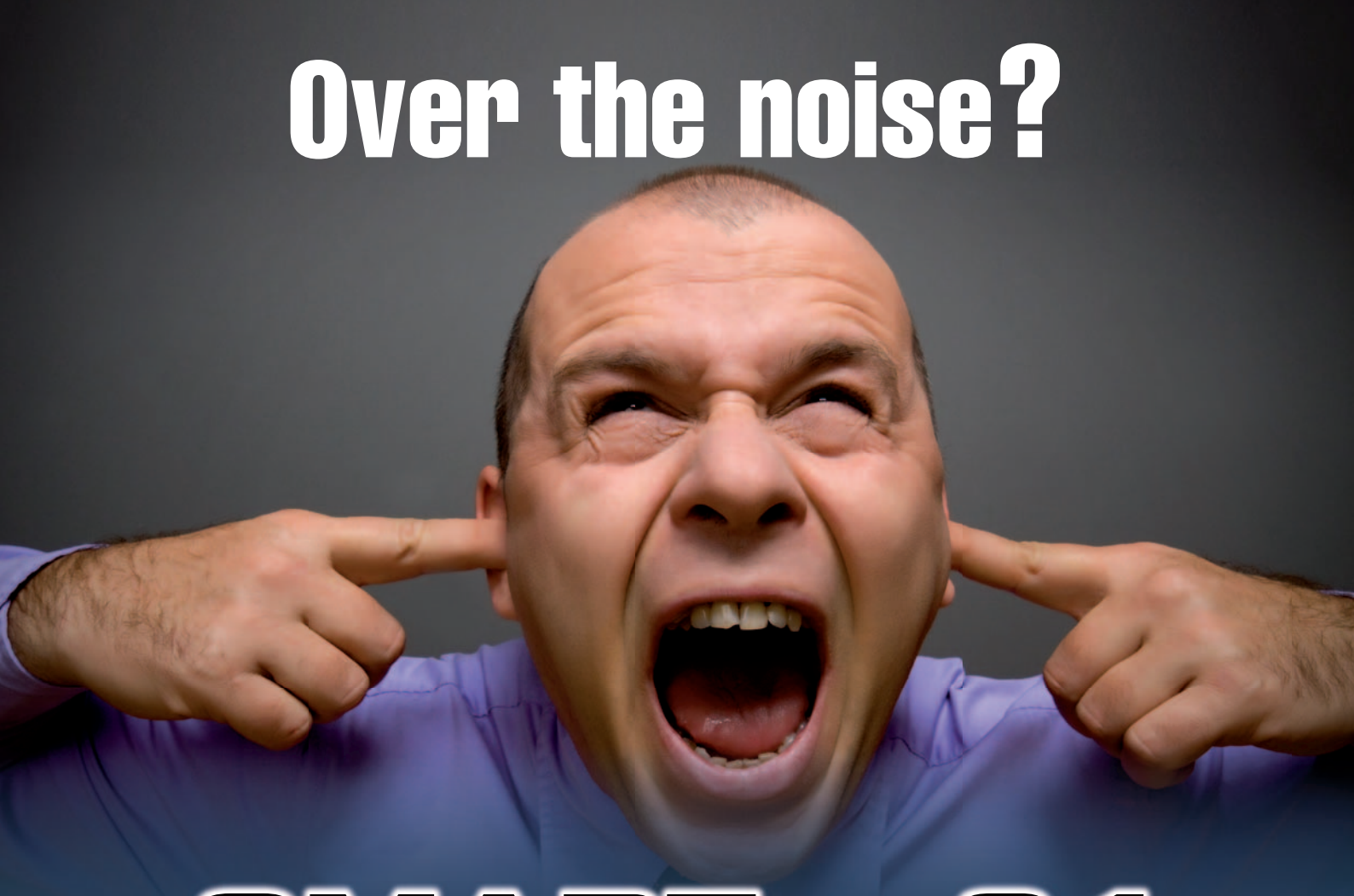

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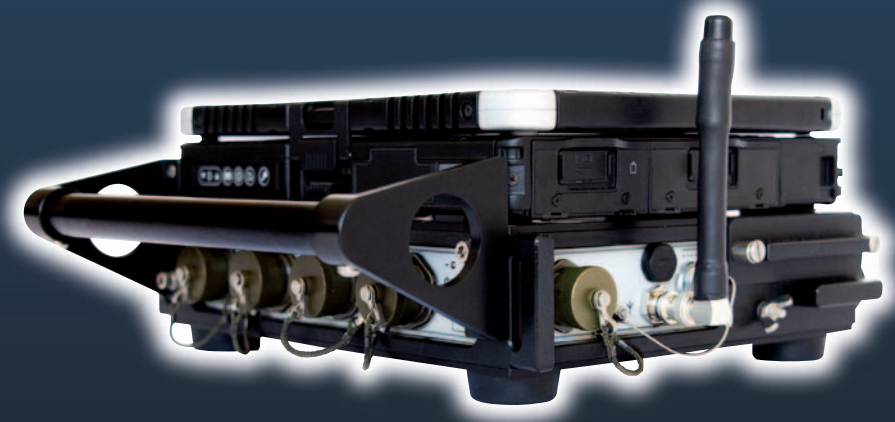

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