



AUSGEO *news*

February 2000 ISSUE No. 56

Ask questions

Chief Scientist's plea

OCEAN GOING RESEARCH
*climate,
oil & gas*

Old ground *new ideas*

Minerals Open Day

Annual General Meeting
awards & directions

Also: Reports on epithermal vein deposits, gold exploration, landslide risk

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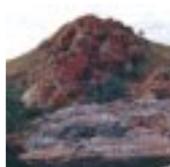
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*Marble Bar, Pilbara country, Western Australia—
visually stunning, geologically fascinating. See
article page 7.*

Photo: David Huston, North Pilbara project
team member

Deliverables important says Australia's Chief Scientist



▲ Australia's Chief Scientist, Dr Robin Batterham has had a distinguished career as a chemical engineer in the private and public sectors. He is currently Managing Director of Research and Technology Support, Comalco, and Chief Technologist, Rio Tinto Ltd.

'Adding wealth is one of the most valuable outcomes from science institutions such as AGSO.'

Australia is a small player in the global economy, but it is nonetheless a player, and AGSO as a government agency must ensure that its science is not about activity but about having an impact on our place in the global economy, says Australia's Chief Scientist Dr Robin Batterham.

Dr Batterham says that although science is about the knowledge base, how to change it and what comfort that gives people, it is also about what scientists deliver in the long run to the economy.

'This is a pretty important deliverable', says Dr Batterham. 'Adding wealth is one of the most valuable outcomes from science institutions such as AGSO.'

Dr Batterham believes that most countries nowadays put money into 'proper' science for two reasons: firstly for development (the here and now), and secondly to generate the future (the long run). He says there is a message here for AGSO: science must be relevant to end-users and it must be integrated into wider arenas because integrative approaches are more likely to attract funding than the 'deterministic and ever-more production' approaches.

He asks, for example, whether information from AGSO projects gives Australia greater competitive advantage, and whether there is leverage from understanding how environments are formed to helping Australia better manage human impacts on present environments.

'Expand your horizons', he says.

He acknowledges that it will not be easy because if Charles Darwin is right and knowledge is doubling every seven years, change is constant. He stresses the need to overcome 'reform weariness' which AGSO scientists like so many others have no doubt felt in recent years. 'Sorry, but you've just got to keep at it' is his response.

'Whether we like it or not, Australia is part of the global economy and if we stop to take a breath the world will go streaming past.'

Dr Batterham says the returns to Australia from traditional resource mapping have been very considerable. But few Australians would know about that or the importance of Australia's ocean territories or the contribution of the minerals industry to the country's wealth. He says AGSO must convince the public that what it is doing is significant and relevant.

'As scientists we carry a terrible impediment', he says. 'We carry the impediment of impeccable scientific framework, namely don't say anything about results until you're sure of them.'

He says this has to change and that geoscientists need to be wary of technical verbiage and jargon that hinders communication with many important recipients of their information.

'Learn how to communicate your enthusiasm and ideas with others so that this relevance to which we are referring is not lost', he says.

Dr Batterham says another thing AGSO must do is nurture its linkages with other research organisations, industry and universities.

'Ride on the shoulders of other groups', he advises. 'Work your linkages as much as you can because they are the mechanisms of swelling your relevance and spreading it further afield.'

Create partnerships, look for more networks and tell the world you are real people with real solutions for the problems that confront Australia was his advice. He also advises AGSO to look internally at the types of people it has generating its science to ensure that bureaucratic types do not outnumber the creative and innovative types who are needed to 'push the frontiers back scientifically'. ■

Getting a much sharper focus on the approaches AGSO employs to achieve its outcomes was the main purpose of its first Science Forum, held December 14-17 last year. Geoscientists from all divisions joined in rigorous debate about what questions they should ask and what methodologies they should adopt. Debate centred on the following themes: Understanding risk, Timing of events, The surface, Geodynamics, Fluid flow through rocks, and Geomatics and geoscience.

In this issue of *AUSGEO News* we look at the opening addresses which set the scene for the flow of ideas. Next issue we provide highlights of topics discussed by some of AGSO's geoscientists. *Science Forum continued page 20*

Open Days opportune for influencing activities

Minerals Open Days, held December 7–8 last year, were a prime opportunity for participants from industry and State Surveys to meet staff and influence the direction and types of projects undertaken by AGSO's Minerals Division in coming years.

Minerals Division chief, Chris Pigram says that with many projects ending this financial year, the division has a range of expertise and capability for new projects.

'We're looking for feedback on where these projects should be, and what form they should take', he says.

'We've had a lot from you already, but we need to talk and bed some things down in the next few months.'

Dr Pigram and AGSO's CEO Dr Neil Williams recently visited State and Territory Surveys and a number of key companies. With feedback from visits, and results of a major review of science agencies almost 12 months ago, the Minerals Division has been reorganised.

'We have a new framework for future directions and the strongest leadership team every assembled for the Minerals Division in the history of BMR-AGSO', he says.

Broad direction

Minerals promotion and technical policy advice is the largest single component of AGSO's budget (38% of budget). AGSO is widening its base, however, to ensure divisional programs encompass environmental, social and economic components. The Minerals Division, therefore, is seeking a greater range of clients than it has had historically.

'We're looking to apply conventional mineral industry techniques to a wider range of problems', Dr Pigram says, 'including some salinity and land-use management issues around Australia'.

Common requests

Dr Pigram says that clients mainly want tools and methodologies for areas of interest or concern. They want to see the regolith in three dimensions and know more about processes, such as those related to the movement of water through the regolith. They seek combinations of geophysical techniques that give an understanding of the volume of rock they are dealing with, how fluids behave, and how deposits are formed. Gravity and seismic are emerging as key tools.

To meet the growing demand for regolith data, two contract staff have been made permanent and another has relocated from Perth to Canberra. In addition, AGSO has arranged with the University of Canberra to appoint a hydrogeochemist to fill a resignation vacancy.

Clients also want province-scale packages and they want AGSO's products free or at a cheaper price than that currently charged.

In relation to prices, Dr Pigram says: 'We hear you and we would like to change our policy about user pays, but we are part of an all-of-government approach to this issue'. An interdepartmental policy committee will convene some time this year to reconsider the pricing issue.

Also requested were national standards and consistency in information management. With State Survey help, AGSO will advance national standards for digital geoscience information. Authority tables and data dictionaries will be included in the standards. In

addition, an AGSO-wide information management system linked to all projects is under development, with a view to establishing an 'integrated national-scale corporate data model'.

AGSO has been asked to expand its geochronology capabilities. This should be possible this year due to: the appointment of an argon-argon specialist; access to Australian National University argon-argon facilities, as well as SHRIMP capabilities in Curtin University, Western Australia; and collaborations with Melbourne University-based geochronologists.

Way forward

With reorganisation and the appointment of research group leaders (what are essentially five senior scientists), Minerals Division projects will be more focused and probably shorter in duration. Each project has a list of annual outputs (refer to Corporate Plan). Projects shut down once outputs are achieved or if a project is deemed 'no longer relevant'.

Projects that have achieved planned outputs and are winding down include: Pilbara, Yilgarn, Lachlan, Gilmore and NABRE (North Australian Basins Resource Evaluation).

With approximately 95 scientific staff in the division, all disciplines will not be covered. More external specialist input and integration with other agencies are expected.

Data acquisition is likely to be multi-disciplinary and focused on solving a particular problem or issue. Because of budget limitations, national surveys will probably only be carried out if there are new initiatives or a specific direction to do so.

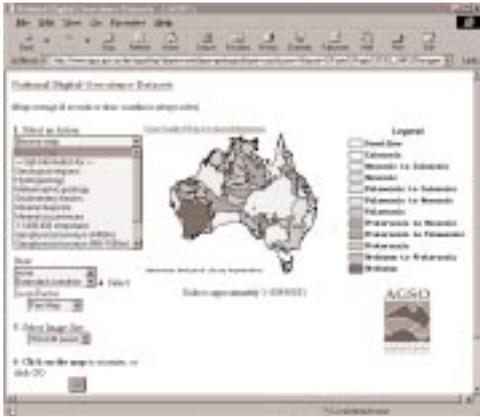
Dr Pigram says: 'We'll look at what's inhibiting successful exploration rather than standing shoulder to shoulder with the States to continue to map areas where we've had a couple generations of mapping'.

Data accessibility will improve over time and it will be delivered in styles and formats preferred by clients. From time to time there will be non-geological reasons, such as a political imperative, to undertake projects that keep a community viable or an environment alive.

Project leaders will regularly consult stakeholders, and project reviews and evaluations will be made public by such means as open days and the web. ■



◀ Chief of Minerals Division, Chris Pigram says the division is looking for a wider range of clients than it has had historically.



On-line seamless national maps soon a reality

What's on the drawing board for national geoscience maps? John Bain, who manages this important area of AGSO business, provided a glimpse during the Minerals Open Days.

From a few lines on paper to digitally compiled datasets accessed on-line at various scales, maps have come a long way.

Within this decade, internet bandwidths will no longer cause problems and we'll download, thanks to survey agency efforts over the next five years, all manner of geoscience data covering all corners of Australia's jurisdiction, to create individualised maps. With advanced visualisation tools, many datasets will be displayable as three-dimensional 'maps'.

Does this sound possible? We believe so.

At AGSO we're moving from analog to digital compilation. We are nominally at the 1:5 million scale, depending on the dataset, and will soon have approximately 30 datasets about the Australian land mass for viewing on the internet. (To see what is available check maps on-line on the AGSO Homepage, then click the 'Australia' link to reach the spatial mapping interface.) Already with our datasets on CD, different map components (e.g. geology, magnetics, mineral deposits) can be combined to build your own maps.

Within the next year or two, lots of new data will be available. All of Australia will be covered, including its marine jurisdiction, and its crystalline provinces and sedimentary basins at a nominal 1:1 million scale. There will be a fourth edition of the magnetic anomaly map of Australia and a new gamma-ray spectrometric map of Australia—the first of its kind. Geophysical datasets will be seamlessly joined with the grid and cell size of your choice. You will be able to view maps at lower resolution on-line and then purchase what you want using e-commerce facilities rather than buying a CD. National digital standards will be developed to facilitate live connections between State and national databases.

What we can achieve in three to five years will depend on data transfer among agencies and among disciplines. A lot of primary data is not held by AGSO, and access needs to be negotiated with the States/Northern Territory and other parties. The complex interpretative nature of geological data and its inconsistency hinder the assembly of seamless national maps. Widely accepted standards will need to be in place within the next couple of years if data are to be readily transferred, merged and analysed.

Nevertheless, within five years we are planning on-line access at various scales to both primary, 'unsmoothed' data (fully attributed digital versions of all published 1:250 000 and 1:100 000 geological maps) and derivative, 'smoothed' seamless national maps at smaller scales. There also will be more geoscience themes—for example: structures (including information re their nature, timing and interconnectivity), alteration (including type, styles, origins, ages), chemistry (including iron ratios, and both superimposed and intrinsic source rock characteristics), environments (depositional and igneous), and regolith (including denudation history, age, and depth of weathering).

Within the decade the range and diversity of Australia's national geoscience maps on-line will be second to none. And we will continue to provide a range of on-demand and litho-printed paper maps. ☐

RISK-BASED ANALYSIS, framework for new projects

Winding down some major projects allows the Minerals Division to think about its priorities and widen its horizons. Lynton Jaques, the division's Senior Scientific Specialist, talks about what the division's management has in mind when determining future projects.

Our current program involves providing technical advice to government on resource issues, and providing pre-competitive geoscientific information to support exploration investment and land resource management decisions. Our future program is being developed in the context of recent changes in the global environment and in AGSO's national role.

AGSO has a national role in developing continent-wide datasets. With the States/Northern Territory, under the National Geoscience Mapping Accord, we undertake multi-disciplinary studies of specific areas to provide new geoscientific information that encourages exploration. We also collaborate with universities, industry and other geoscience agencies in several Cooperative Research Centres and through the Australian Minerals Industry Research Association (AMIRA) projects.

The minerals sector is undergoing radical changes, driven by globalisation, low (now recovering) metal prices, and competitive pressures. Equity markets now demand a greater return on investment and more rigorous assessment of risk. Worldwide, these factors have reduced mineral exploration expenditure, and increased international competition for available risk capital.

Our program must take account of the global issues facing the resources sector and Australia's needs of risk capital for exploration. Exploration companies want geoscientific information that lowers their risk. Their focus is on discovery of world-class deposits that can be mined at low cost.

Risk-based analysis

With this background, the Minerals Division reviewed the major commodities of interest, and the mineral systems that are likely to be important in generating world-class deposits of these commodities, in the Australian context.

We examined the resource base, of Australia and the world, particularly the resource-production ratio in terms of years. From this we identified the commodities that should be of particular interest in framing our program, namely—copper, zinc, lead, gold, silver, nickel, diamonds, high-quality iron ore, chromium, molybdenum, mineral sands, titanium, manganese and phosphate.

In attempting to answer questions about mineral deposit types, we are undertaking a 'rapid risk-based analysis' of Australia's major mineral systems—i.e. trying to establish the generic essential criteria that generate a mineral system. A mineral system is defined as all those elements that contribute to the formation and preservation of a mineral deposit (i.e. source, transport and trap, and preservation). In broad terms, we are trying to build a framework that shows that if one (or more) critical elements of the mineral system are not present in a geological environment, then formation of that type of deposit is unlikely. Real potential exists in those provinces where the elements can be demonstrated to occur.

Knowledge gaps

The petroleum model is well established and robust because the source is known, and the transport mechanism and traps are well understood. This knowledge helps petroleum exploration companies predict locations of potential oil and gas fields. But with minerals, the source frequently can only be broadly inferred, and often the controls on deposition (trap) are not well understood. In many of Australia's provinces, especially the Precambrian provinces, the tectonic framework is poorly understood and we have only rudimentary knowledge of the sequence and timing of events. The basement beneath many of our basins is also poorly known. It is these weaknesses and gaps in knowledge that forms the basis for potential new projects for AGSO (i.e. a focus on 'problem solving' in the context of mineral prospectivity).

By combining what we understand about the mineralising process with what we can determine about the evolution of the province, metallogeny can be put in a modern geological context for exploration companies—thereby improving the confidence attached to assessments of mineral potential.

Program direction

In framing our future program, AGSO's national role will be evident, but we will continue the important partnership with the States and Northern Territory. We will seek projects that address State/Territory priorities and are likely to have impact in the national and international context. We also aim to broaden our collaboration with industry, universities and other science agencies.

Outputs from AGSO's minerals program will include: national maps and databases, thematic maps and databases, and new datasets of strategically important provinces. Under-explored areas will be targeted, especially the under cover extensions of existing mineral provinces, but there will be a balance between projects carried out in 'proven' and 'greenfields' provinces.

For new data acquisition, the integrated multi-disciplinary approach applied in recent years will continue. There will be a major emphasis on information management and delivery using advanced information technologies.

We welcome input in developing a program that continues to underpin the competitive edge currently held by Australia in terms of the quality of its geoscience information as a framework for exploration. ▀

Editor's note

Next issue we look at further presentations from Minerals Open Days, namely major projects that are winding down and some exciting recent developments.

The North Pilbara project is winding down, and it was evident in his Minerals Open Days presentation that project manager Richard Blewett believes much has been gleaned from the geology in this ancient area around Marble Bar in Western Australia.

IMPROVED *magnetic anomaly map* LAUNCHED

Parliamentary Secretary Warren Entsch begins the Minerals Open Days proceedings by launching the third edition of the magnetic anomaly map of Australia.

The map is the culmination of 45 years and nine million line kilometres of TMI (total magnetic intensity) data. With this edition the spurious long-wavelength anomalies are removed and the whole continent is covered at broad reconnaissance scale.

'This map, which almost matches my tie', Mr Entsch says with a laugh, 'shows how AGSO is using cutting-edge technology to explore beneath Australia's surface'.

'The vivid map colours show that instead of a wide brown land, we have a continent rich in resources.'

Mr Entsch says he is fascinated in seeing Australia portrayed this way and added that after every AGSO visit, he has a much better understanding of the continent's diversity and its mineral potential.

The data for the magnetic anomaly map comes from a variety of sources. Most surveys were flown by AGSO. Others were conducted by contractors to AGSO and State and Territory geological survey agencies, or done privately and the data subsequently bought by AGSO.

The map is available at 1:5 million and 1:25 million scales from AGSO's Sales Centre. ▀



▲ Parliamentary Secretary Warren Entsch

PILBARA

Pilbara: covering old ground with new ideas



▲ Folded quartz deposit above an adit at the Barton gold deposit near Nullangine

The Pilbara is a visually stunning part of the country and geologically fascinating. It is an early to mid-Archaean craton, and that makes the Pilbara a lot older than most of that other West Australian Archaean craton, the Yilgarn. With such a long history, there have been many phases in its structural evolution.

It is a granite-greenstone terrain composed of domal composite granitoids. These are typically 50 to 100 kilometres in diameter and resulted from up to 11 magmatic events. In the Pilbara they extend to greater depths (~14 km) than in late Archaean provinces.

Applying exploration models and interpretations from mineral deposits in late Archaean provinces proves unsuitable for the Pilbara. Its geology has differences. More information about the Pilbara's structural uniqueness should reduce exploration risk.

Geoscience mapping

The Pilbara project started in 1995 and is winding down this year. It is a National Geoscience Mapping Accord project being carried out by AGSO and the Geological Survey of Western Australia. The project team also includes researchers from the University of Western Australia. Project activities focus on acquiring and processing geophysical data, with some mineral deposit analysis, structural analysis and geochronology.

Data has been compiled using the HYMAP multi-spectral scanner, gamma-ray spectrometrics, oxygen isotopes, and whole-rock geochemistry. The multi-spectral scanner was engaged for mapping alteration minerals such as pyrophyllite, sericite, and chlorite, and also separating dolomite from calcite in calcrete in the Indee gold district. Gamma-ray data was used to map potassium-depletion anomalies. This was important because potassium depletion corresponds closely to regional chlorite-quartz alteration in the Panorama VHMS (volcanic hosted massive sulphide) district.

In the Panorama district, the project team used oxygen isotopes to map paleotemperatures underneath the discharge zones. These data help predict the localisation of metal deposition. District-scale depletion of zinc and copper also was mapped with whole-rock geochemistry.



▲ AGSO's David Huston discusses geology of the Mons Capri deposit on a field trip for industry through the west Pilbara.

Mineral deposits

There are many mineral deposit types in the Pilbara such as porphyry copper-molybdenum and, interestingly, adularia-sericite epithermal gold deposits. Over the Pilbara's 800 million-year history, multiple mineralising events occurred including several orogenic gold events (unlike the single event in the Eastern Goldfields).

The Pilbara houses the world's oldest mesothermal gold, epithermal gold, nickel-copper, copper-molybdenum, barite, VHMS and tantalum-tin deposits. Many of these deposit types are thought to occur only in much younger rocks, and their presence in the Pilbara could indicate potential in other Archaean and Proterozoic terranes.

One exciting result has been documenting extensive vein systems with epithermal characteristics around the Fortescue unconformity. Although no significant gold mineralisation has been discovered, the geochemistry and textures of these veins hold promise. (See product news: Record 2000/01.)

Structure

The Pilbara's geometry implies some unique tectonic regime. Although only about a quarter of the craton is exposed, exceptional preservation improves the chances of gold and possibly diamonds in the older mid-Archaean, granite-greenstone terrane.

From the gravity, magnetics and seismic refraction data the project team knows that the Pilbara is an ovoid craton some 600 by 550 kilometres with a

mid-crust of 14 kilometres and an overall average crustal depth of approximately 30 kilometres. It thickens to the south underneath the topographically highest part of the Hammersley Ranges.

The contacts between the granites and the greenstone are largely sub-vertical and extend about 14 kilometres. Below the mid-crustal zone is a more dense lower crust. The dominant pattern is the circular granitoid greenstones that are everywhere except in the far north-west. There is a large gravity low in the middle of the craton. The magnetics show there are anomalies around Marble Bar, and that there is a gradient between a generally more magnetic west Pilbara and less magnetic east Pilbara.

No extensive, through-going shear zones are present in the east Pilbara. But they were recorded in the west and central Pilbara (with significant implications for gold potential).

Major achievements

The major achievement has been a wealth of data that shows the Pilbara has new potential. The data proved there are fundamental tectonic and metallogenic differences between the mid-Archaean Pilbara craton and late Archaean cratons. And it suggests that there are extensive epithermal gold systems that need exploring.

New exploration tools allowed remote mapping of the craton and gave the project team a good understanding of its structure. These tools were successfully used over the less-exposed and calcretised Mallina-Indee gold prospects and over the well-exposed Panorama district. Such methods and tools can be employed in other little-known terranes.

Data for the entire Pilbara is stored digitally by AGSO and derivative products are being produced. These include a colour A3-sized atlas and a thematic series of 1:500 000 scale maps and images, as well as a GIS 'teaching' tool. ■

Winners

AGSO achievement medallions



Three staff received AGSO Australia Day Achievement Medallions this year for their contribution to the organisation in the past 12 months.

Heike Apps (left), as the Gilmore project's data manager and GIS specialist, handled a huge amount of data (paper and digital) from many sources. Using a wide range of software applications, some of which were new to her, she developed innovative products that pushed AGSO into three-dimensional GIS territory.

Ken Heighway (centre) is the unassuming project manager behind the Petroleum Promotion group. His contribution to AGSO is his exemplary resource and people management skills in his many years of service in laboratories, field parties and on projects.

Joy Dunn (right) is the exceptional executive assistant whose initiative and efficiency ensures the Minerals Division runs smoothly.

The medallions were awarded at a staff afternoon tea on the Thursday before Australia Day (January 26). ❏

Geoscience popularity raised by unit

If estimates and bookings are anything to go on, AGSO's Geoscience Awareness and Marketing Unit has a big year ahead according to its manager, Gary Lewis.

In the past five years, unit staff have trained more than 1800 teachers in such geoscience topics as plate tectonics, remote sensing and natural hazards. At least another 200 teachers will be involved in similar training sessions this year starting in Brisbane and Melbourne in March and moving to other major centres (Perth, Wollongong, Alice Springs, Townsville, Cairns, Wagga Wagga and Orange) as the year progresses.

Due to popular demand, the highly successful natural hazard workshop for teachers, called Project Lava, will be held again in Hawaii during September school holidays.

'We run training sessions around the countryside', Mr Lewis said, 'and all teachers we train are exposed to our AGSO materials'.

Mr Lewis said that from sales figures and what teachers tell him, he estimates that 500 000 students a year use learning materials developed by AGSO staff.

'Now that reach is extraordinary when you consider that this unit didn't exist six years ago and only recently staff numbers increased to four', he said.

This year at least three more teaching-learning materials will be produced on the topics of tsunamis, caves, and oceans (the third of these being a series of modules on ocean uses, basins, and features under oceans). The tsunami resource will be launched in the first school term, thereby completing the unit's materials on major geological hazards facing Australians.

In addition, a sedimentary rock chart will be released in March, to supplement a rock and mineral identification chart released last year. It is hoped these charts will answer the overwhelming call for 'more', experienced with each training session and two reprints of AGSO's Timescale Bookmark and Australia through Time flyer.

With the opening of the Earth Science Education Centre last October in Canberra, even more teachers and students will access the unit's resources this year.

'In a good year, we will get 6000 students through our centre', Mr Lewis said, 'and that should help make AGSO a household name'.

Not only teachers and students are targeted in unit activities. Field trips are run for decision-makers in government. Three trips with a different focus should be offered this year. The minerals field trip goes underground to gold mines at Browns Creek, visits Cadia Hill and then looks at agriculture-mining issues. The petroleum field trip takes participants to Sale in the Gippsland, on an Esso helicopter to a gas rig, and then on a coastal issues tour. The introduction to geology course comprises a one-day intensive study of geology in Canberra, but Mr Lewis wants it expanded this year to include a field trip to Wee Jasper.

Based on student reactions and the enthusiasm of teachers, Mr Lewis firmly believes that the popularity of geoscience can only increase with today's knowledge-hungry community.

'Promoting geoscience has moved into a new and exciting phase for AGSO', he said, 'and with new staff and fresh resources we plan to enthuse a lot more in the community this year'. ❏

Top secondary students enthused by science



Cindy Trewin from the Geoscience Awareness Unit and Jonathon Root, AGSO's webmaster, give a few pointers about a science exercise posted on the web for National Youth Science Forum students Stephanie Fargher (far left), St Mary's Star of the Sea College, Wollongong, and John Whitlam, Brisbane Boys Grammar.

Ms Trewin and Mr Root are providing Australia's top Year 11 science students with a taste of the work in which geoscientists can be employed. In this particular exercise, students have two street maps of Cairns and web access to geohazard data. They are in the control centre that advises emergency teams on evacuating people from cyclone-torn and flooded areas.

'We're encouraging these bright students to consider careers in geoscience', Ms Trewin says.

'By showing them that geoscience employs the latest tools and that it can have an impact on human

well-being, I believe a few will apply for university geoscience courses in 2001.'

The students spend two weeks of their school holidays in Canberra visiting research agencies such as AGSO, CSIRO, Australian National University and the Department of Defence. In January, 64 students visited AGSO on two separate occasions. AGSO has been involved with the National Youth Science Forum since 1984.

The students attend public and private schools around Australia. A few also come from New Zealand, Canada and South Africa. Rotary clubs and numerous science agencies and companies sponsor the forum. ❏



AGSO testing ground for geophysical helicopter

Before starting its first survey for the year, the geophysical helicopter from Geo Instruments (Sydney) landed in AGSO grounds on January 6 to test its gamma-ray spectrometer.

At 15-minute intervals, four concrete blocks of differing composition were wheeled under the helicopter. One block was used as a 'backgrounder' while the each of the others contained known percentages of thorium, potassium or uranium. The ground under the helicopter was also 'tested' as a cross-reference.

After an instrument check and calibration, no obvious deviation was found.

'The helicopter's survey equipment should be good for another 12 months', says Zoltan Beldi, manager of Airborne Geophysics, who ran the tests.

From AGSO grounds, the pilot headed towards Falls Creek to map the South Victorian Highlands for the Department of Natural Resources and Energy. He was spending much of the next six weeks by himself carrying out a radiometric and aeromagnetic geophysical survey.

The survey is pilot-operated to limit weight in the Bell 206 Jetranger helicopter and thereby improve its performance. To double-check instrumentation, the pilot was flying along a known line, then carrying out the survey, then testing again after the survey.

Mr Beldi says the South Victorian Highlands survey would generate two large maps and enough data in digital form for about another 300 maps.

The helicopter carries 100 kilograms of equipment that, according to Mr Beldi, is up to six years old and worth approximately \$150 000. The detector itself weighs roughly 86 kilograms and contains four salt (sodium-sodium-iodide) crystals. All things going well, the helicopter will return to Canberra next year to test survey instruments against AGSO standards. ❏



Did you know?

In 1999 users of AGSO's web site made more than 33 000 database inquiries and generated approximately 125 000 on-line maps. The server handled 21 366 megabytes of data for more than 85 000 separate client hosts. Many site visitors took advantage of secure on-line product ordering to buy maps, digital datasets and journals.

Users included mining and petroleum companies, all levels of government, academia, and the general public—within Australia and overseas.

The most visited pages were as follows, in descending order: Site search, Homepage, Maps, Cairns risk assessment, Nuclear explosions database, agsoQuiz (education site), Products page, 1999 acreage release notes, and Minerals homepage. The education and library pages also proved popular, which is not surprising considering that Queensland schools are one of the big users of AGSO's web pages.

**For further information phone
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on +61 2 6249 9735 or
e-mail jonathon.root@agso.gov.au ❏**



▲ Bob Henderson (right), current president of the Geological Society of Australia, and Neil Williams, AGSO Chief Executive Officer, sign an agreement to incorporate the AGSO Journal into the *Australian Journal of Earth Sciences*. This agreement is for two years, 2000–2001. The first agreement was drawn up in 1997. As part of the agreement, AGSO will be responsible for one thematic issue each year.

To meet a library exchange arrangement, AGSO will send gratis copies of the journal to its sister libraries in such countries as Great Britain and the United States. These arrangements help AGSO afford and maintain its very high calibre national geoscience library. ❏

Climate change history documented in *Tasmanian* waters

In mid-March, the Ocean Drilling Program's vessel, *Joides Resolution*, sails from Hobart for Leg 189 drilling sites to study changes in sedimentation, oceanography and climate caused by Australia's northward movement from Antarctica in the last 40 million years. AGSO's Dr Neville Exon, co-leader of the two-month expedition, explains.

The Tasmanian Seaway between Australia and Antarctica played a key role in the development of ice age conditions, which are rare in Earth's history. In the Cenozoic Era, which started 65 million years ago with the extinction of dinosaurs and many other organisms, major ice sheets developed in both polar regions, initially on Antarctica and later in the Northern Hemisphere.

In the early 1970s, an hypothesis was proposed (largely on the basis of the coring off Tasmania on Deep Sea Drilling Program Leg 29) that climatic cooling and ice sheet development resulted from plate tectonic changes. These changes progressively isolated the Antarctic continent thermally, as the circum-Antarctic current developed. The current resulted from the opening of the 'gateway' of the Tasmanian Seaway about 30 million years ago, and the Drake Passage south of South America about 20 million years ago. Over time the northward migration of Australia, and the expansion of Drake Passage, strengthened the thermal separation of Antarctica from the warm ocean to the north. The world's ocean changed. What was once warm from equatorial to polar regions, and from the surface to the sea bed, had cooled towards the poles and with depth.

These changes apparently played a fundamental role in climate evolution, sea level fluctuations, and in terrestrial and marine biotic evolution. Thus, the opening of the Tasmanian Seaway was vital to the Cenozoic global evolution of the Earth and to the global climate that humans now enjoy.

Leg 29 provided a basic framework for the paleoenvironmental changes associated with the opening of the seaway. However, coring was of insufficient continuity, quality and resolution to fully test the hypothesis of potential relationships among plate tectonics, circum-Antarctic circulation and global climate, and to time the key events.

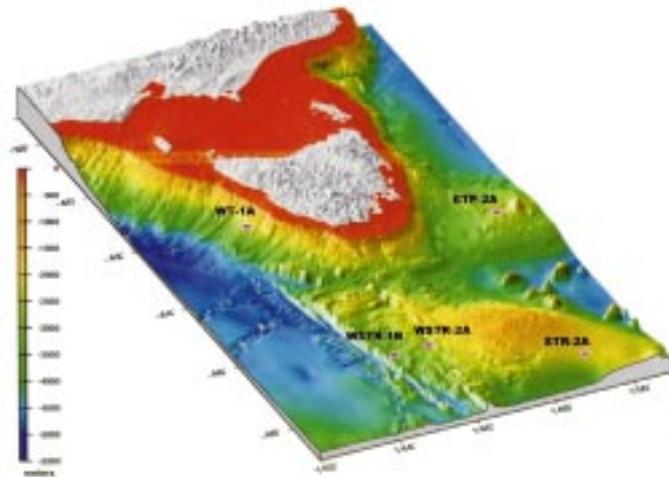
During Leg 189, five sites will be drilled off Tasmania to further test the hypothesis that the evolution of the Antarctic ice cap resulted from the isolation of Antarctica by the circum-Antarctic current. These sites, located in water depths from 2475 to 3580 metres, will be fully cored. Three sites are located at different latitudes in the Indian Ocean, one is in the Pacific Ocean, and one site lies between the two oceans. Four alternate sites have also been selected. The average penetration will be 600 to 900 metres.

Most sites are designed to penetrate to strata 40 million years old, recording all the climatic changes preserved in calcareous sediments since that time. Oxygen isotopes measured in the shells of tiny calcareous plankton record changes through time in sea surface temperature, and the shells of other tiny organisms living on the sea bed record changes in bottom water temperature.

The relatively shallow region off Tasmania (including the sunken continental ridge of the South Tasman Rise) is one of few places on the globe where well-preserved and almost complete marine middle Eocene to Holocene carbonate-rich sequences can be drilled in present-day latitudes of 40–50° S, and past latitudes of up to 70° S.

The sites will document the changes as the area moved steadily northward to its present latitude on 45° S. These will include variations in geochemistry and water mass temperatures, and environmental and biotic changes as the Indian and Pacific Oceans became linked. Sedimentation changes are expected to result from Australia-Antarctica rifting in the Eocene (40 million years ago), the onset of circum-Antarctic surface water circulation (when the area was at 70° S), and the development of deep-water circulation (when it was at 60° S).

Figure 1: Sea-floor topography of the Tasmanian region based on multibeam, conventional and SEASAT bathymetry.



In summary, some major scientific questions to be addressed are:

- How did the circum-Antarctic current develop, and what were the roles of the opening of the Tasmanian Seaway (~30 million years ago) and Drake Passage (~20 million years ago)?
- When did the Tasmanian Seaway open to shallow water across the South Tasman Rise, and how did this affect east-west biogeographic differences, isotopic differences relating to changing climatic regimes, and geochemical differences?
- When did the seaway open to deep waters, and how did this affect surface and deep-water circulation?
- How is circum-Antarctic circulation related to changes in Antarctic climate?
- How did the east Antarctic ice sheet develop in this part of Antarctica, and how does it compare to other sectors?
- What was the nature of the climate on adjacent parts of Antarctica and Australia in the greenhouse period in the middle to late Eocene, and later as the global climate cooled?
- How did sedimentary facies change as the Tasmanian region moved northward, circum-Antarctic circulation became important, and upwelling commenced?
- How did intermediate and surface waters develop in terms of temperature, thermal barriers, and oceanic fronts?
- How were changes in the marine biota tied to changes in the oceanographic system?

From the resources viewpoint, AGSO is keen to learn more of the late Cretaceous to Eocene deltaic sequences that filled the early rifts around Tasmania and on the South Tasman Rise, from 100 to 30 million years ago. These sequences are many kilometres thick, and buried deeply enough to generate oil and gas. By continuously coring the youngest part of the deltaic sequences, important information will be obtained about organic content, and hence the potential to generate oil and gas, and any enclosed traces of hydrocarbons. The record of sedimentary rock types will help researchers assess the potential for petroleum reservoirs and cap rocks.

Dr Neville Exon, and Dr Jim Kennett of the University of California, Santa Barbara, will lead the project. Other Australians aboard the 100-strong expedition, of which 50 are scientific and technical staff, include Dr George Chaponiere, formerly of AGSO and now at the Australian National University, and Peter Hill of AGSO.

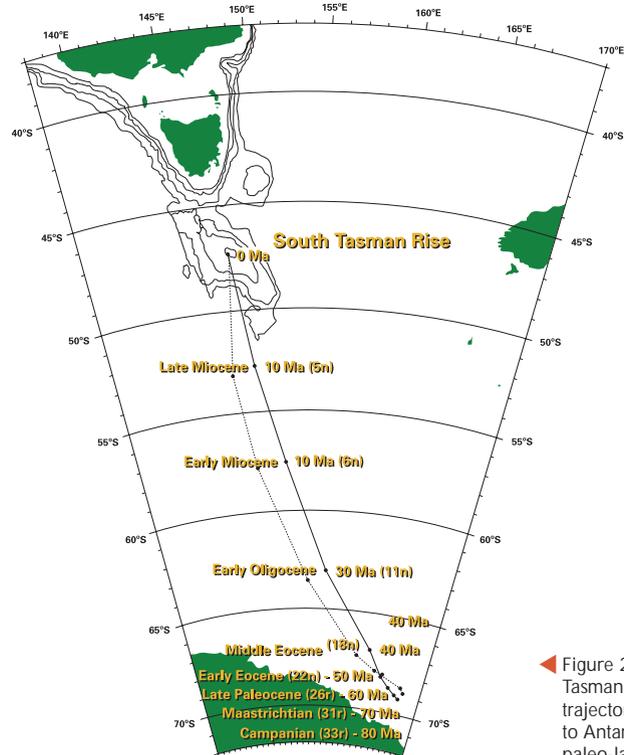


Figure 2: The South Tasman Rise—its trajectory with respect to Antarctica and its paleo-latitudes.

For more information contact Neville Exon on +61 2 6249 9347 or e-mail neville.exon@agso.gov.au or the Australian ODP Office at the University of Sydney on +61 2 9351 3000, or visit the ODP web site http://www.odp.tamu.edu/publications/prosp/189_prs/189toc.html

SIGNS OF OIL & GAS off Lord Howe

Oil and gas may be present in French and Australian territory about 500 kilometres north-north-east of Lord Howe Island. AGSO scientists and other members of a Franco-Australian team found seismic evidence of gas hydrates and about 100 huge sedimentary domes, similar to those in major petroleum fields in the Gulf of Mexico, on their recent mapping expedition between New Caledonia and Lord Howe Island.

AGSO participant Dr Neville Exon says the discovery of the domes was 'completely new, unexpected and very exciting' for the Australian team.

'It shows that the frontier areas off Australia can still deliver major surprises in terms of petroleum potential', he said.

Fairway Basin mapped

The expedition emphasis was on finding out about the very poor known Fairway Basin. It is situated approximately a thousand kilometres east of Brisbane, and is larger than Tasmania. The basin lies between the eastern flank of the shallower Lord Howe Rise, on which there is only thin Cainozoic cover, and the Fairway Ridge, where basement is exposed in places. It is a major, complexly faulted, largely north-south sedimentary basin about 100 kilometres wide and 800 kilometres long, in water depths of 2000 to 3000 metres. East of the ridge is the New Caledonia Basin, about 3600 metres deep.

The Fairway Basin formed during the Cretaceous period of rifting that separated New Caledonia and the Lord Howe Rise and formed the New Caledonia Basin. It is a sedimentary basin containing thick sediments, the oldest of which is perhaps 100 million years old. Because the basin was isolated from the open sea early in its history, it was thought that there might be organic-rich petroleum source rocks deep within.

The northern half of the basin was mapped on the expedition. In all, fifteen north-south lines were run in and near the north-south part of the Fairway Basin, each about 350 kilometres long. In the small, northern-most part of the Fairway Basin, which trends north-west rather than north-south, another nine lines oriented north-west, averaging 150 kilometres in length, were run (figure 1).

Results show that the Fairway Ridge is about 60 kilometres wide, and is cut by canyons running eastward into the New Caledonia Basin. It is a fractured basement ridge with narrow sedimentary basins, and is probably floored with continental basement. The bathymetric maps show that major faults bound scarps and canyons, and that dominant fault directions are north-south (rifting), north-west, and north-east (strike-slip). The same fault directions apply to the Fairway Basin.

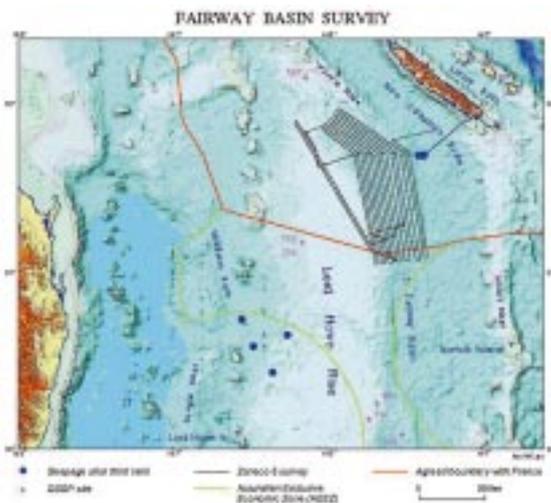
Discoveries

In the Fairway Basin seismic profiles, the roughly flat-lying sedimentary strata are up to five kilometres thick. Surprisingly, in the profiles there is abundant evidence of ongoing small-scale, strike-slip faulting related to compression.

The widespread basinal areas contain an intermittent bottom simulating reflector (BSR) believed to represent gas hydrates. Gas hydrates are a frozen mixture of gas and water that accumulate hundreds of metres below the seabed and form long-term gas resources. Because there is very little organic matter in ODP drill sites nearby, the gas probably is being generated deep in the sedimentary basin, and conventional gas could be present in traps.

One exciting discovery was that the north-south basinal area also contains a seismically transparent sequence lying on basement that is up to 1000 metres thick and from which nearly 100 sedimentary domes (diapirs) rise. The domes are up to 1000 metres high and in places rise to the Oligocene reflector (about 30 Ma), as little as 500 metres below the surface. They vary from domes a few kilometres wide at the base to ridges tens of kilometres long. This may be a sequence of salt, laid down early in the Cretaceous rifting history of this continental margin, or a sequence of rather fluid (over-pressured) mudstone.

The BSR and the domes generally occur together in the thicker part of the basin, although the BSR is more widespread (figure 2). Distinctive hummocky seabed character is uniquely associated with the areas of doming; in places the seabed is cut by vertical faults with displacements of more than 50 metres.



▲ Figure 1. Colour image of the seabed topography east of Australia, showing the area covered by the recent *L'Atalante* expedition involving AGSO scientists. The researchers proved that the New Caledonian north Fairway Basin has real potential for oil and gas, and that the Australian southern part of the basin probably has similar potential.

Salt or shale

Both salt and fluid-rich shale are commonly less dense than overlying sediments and, being mobile, can move upward when deeply buried. But whether the diapirs are salt or shale in this basin, as well as the age of these rocks, are important matters that have not been resolved.

Salt and shale domes are a key part of major petroleum fields, including those in the Gulf of Mexico and off Brazil and Africa's west coast. These deposits were formed largely in the early stages of rifting as America and Europe/Africa started to separate 220 to 150 million years ago. The Fairway Basin deposits may be analogous to these sediments that were laid down in the earliest stage of the formation of the Atlantic Ocean. This analogy suggests that the Fairway Basin may also be highly prospective for petroleum. If the inferred age of the sediment forming the domes in the Fairway Basin is correct—about 100 million years old—the analogy is even closer.

The favoured interpretation is that the deposits are salt, on the basis of their seismic character. Salt deposits need warm, dry conditions to form in large quantities in rifts. The prevailing view is that this area lay at 50 to 60° S in mid-Cretaceous times so, although this was a relatively warm period, this favours the identification of the diapir-forming sequence as shale. However, it is possible that the assumed palaeo-latitude is incorrect and that it was more like 40° S. It is also possible that the dating was incorrect and that salt deposits formed later when the area was further north (e.g. in the warm early Eocene).

If the deposits are over-pressured shales, they may well be organic-rich source beds of Cretaceous or Early Cainozoic age, like those in the Gippsland and Taranaki Basins that were much closer during early rifting of the region. Such black shales are characteristic of the oxygen-poor mid-Cretaceous ocean from 120 to 85 million years ago.

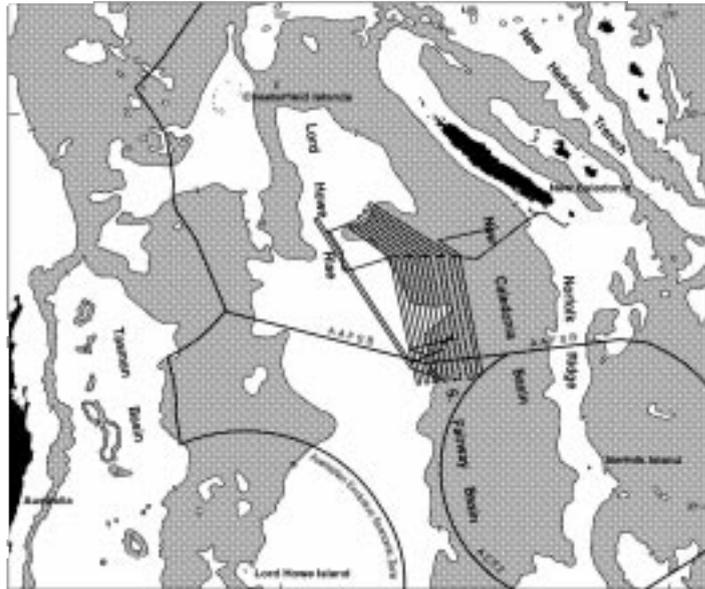
Techniques

The primary technique used on the expedition was multibeam sonar mapping. It rapidly gives very accurate contour maps of the seabed as well as reflectivity information that gives some idea of its nature. In addition, a high-speed seismic profiling system imaged the strata for as much as five kilometres below the seabed. Magnetic and gravity profiles were also recorded. Line spacing averaged 12 kilometres, giving full bathymetric coverage of the region. More than 90 000 square kilometres were mapped: 70 000 in the north-south part of the Fairway Basin and eastern-most Lord Howe Rise, and 20 000 in the north-west trending part of the basin. About 5000 square kilometres of mapping was in Australian waters. Also mapped were two long lines along the crest of the Lord Howe Rise (approximately 15 000 km²), where a number of small volcanoes rise to within 500 metres of the sea surface.

Thirteen cores, averaging 6.5 metres long and totaling about 80 metres, were taken in the southern Fairway Basin. The aim was to investigate whether gas is leaking from the BSR and what its composition might be. The sediments recovered are oxidised reddish, yellowish and white pelagic calcareous ooze dominated by nannofossils with lesser foraminifers, and probably represent sedimentation over the last 300 000 years. Gas samples were taken for analysis at AGSO. James Cook University is examining pore water samples to determine if they are affected by rising gas from the BSR or by rising salt from the domes. Two cores were taken in Australian territory—one over a seismic 'flat spot' suggesting the presence of hydrocarbons, and the other above a large dome.

Continuous measurement of the fluorescence of the surface waters, using AGSO's new fluorimeter, was to determine whether any oil was escaping from the seabed and recognisable at the sea surface. No oil shows were seen, however, despite testing apparent slicks identified by side aperture radar on satellite imagery.

FAIRWAY BASIN SURVEY



▲ Figure 2. Map of a large part of the Fairway Basin, showing the distribution of the largest 'salt' domes and ridges, and of the 'bottom simulating reflector' representing gas hydrates, in relation to water depth.



▲ French vessel *L'Atalante* carried AGSO scientists to the Fairway Basin that possibly houses oil and gas to rival the petroleum-rich belts in the Gulf of Mexico.

Expedition team

The expedition was carried out from 15 October to 7 November 1999 on the French research vessel, *L'Atalante*. It was led by French marine geologist Dr Jean-Marie Auzende of France's premier marine research institute, IFREMER. The expedition, on which Australian scientists were guests, is part of the Zoneco program of assessing the marine resources of New Caledonia. The French scientific contingent aboard included Dr Sabrina van de Beuque, who is currently at AGSO, and Dr Yves Lafoy of the New Caledonian Service des Mines. Australian participants included Dr Jerry Dickens (James Cook University), whose prime responsibility was taking sediment cores in the search for gas, David Holdway (AGSO), who was responsible for fluorimeter measurements, and Dr Neville Exon (AGSO).

Major exploration success needed, AGSO told



▲ Mike Brook, resource analyst with JB Were & Son, and AGM guest speaker, explains why investors have not been excited about resource stocks in recent times.

Good days are ahead for the minerals industry, despite a shrinking resources market and poor performance compared with the industrial sector, according to Mike Brook, AGM guest speaker and resource analyst with JB Were & Son, Melbourne.

A desire for shareholder returns, competition from internet and biotechnology stocks, and few discoveries in recent years have made it hard to excite fund managers into investing in small resources companies Mr Brook says.

'But our outlook for metal prices and therefore larger resource companies is looking positive. Equity investors should keep an eye on a robust annual industrial production growth of about four per cent that is being driven by North America', he says.

'Consolidation, particularly in the copper and nickel industries, could lead to something of high-cost capacity, further underpinning metal prices.'

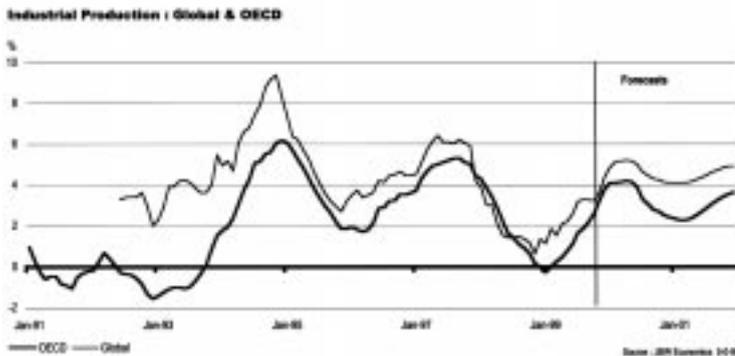
Mr Brook expects that there will be stability in the gold market over the next 12 months, and that gold's long-term price will be about US\$350 per ounce.

'With the signing of the Washington Agreement, a lot of uncertainty has been removed from the gold market. Seventeen of the world's major banks will curtail selling over the next few years, and so no huge amounts of gold should be dumped on the market', he says.

'We have a gold deficit at the moment—in terms of mine production less gold used in fabrication—and that is expected to continue as not a lot of mines are coming into production.'

But the gold sector is shrinking and in November 1999 it was less than 1.3 per cent of all ordinaries compared with 4.5 per cent in February 1997. In fact, the resources sector overall has declined from almost 30 per cent of all ordinaries in February 1997 to 16.4 per cent by November 1999.

'Funding for higher risk exploration or small mining ventures is a major problem', Mr Brook says.



▲ Global growth in 2000: A stronger outlook

'The amount of money raised for resource companies has fallen dramatically. Since January 1998, only two new companies—Murray Basin Minerals and Exco Resources—have been listed on the stock exchange with approximately \$12 million being raised.'

He says small capitalisation is the life blood of the minerals industry and that from 1989–95, junior gold companies had a better success rate than major companies.

But in the past five years junior companies have had limited success and decreasing exploration budgets. The most recent discoveries (e.g. Wallaby, Chariot, Coyote) have been by major companies.

'I monitor about 100 small companies with an average cash position of \$2.5 million. With high administration costs, these companies don't have much left for exploration.'

'So what we are increasingly seeing is exploration partnerships between junior and major companies, larger companies restructuring, and a thrust towards bigger mines to reduce costs.'

Mr Brook believes that the future holds another good period for small companies with a folding up of the 'lame ducks' and more partnerships between junior and major companies, such as the recent initiatives by Billiton and BHP.

He also believes that a deep-drilling phase is essential—initially around known deposits—and that this will be more affordable with improved conceptual modelling backed by sophisticated geophysics and geochemistry.

'What we need is innovative ways of funding and good technical support', he says.

'But the biggest catalyst for investor attention will be another major exploration success in the hands of an Australian junior company.' ■

Equity investors should keep an eye on a robust annual industrial production growth

AGM pitched at AGSO achievements

The Annual General Meeting held at the Hellenic Club on November 25 began with a musical note and ended on a positive tone with staff applauded for some great achievements.

First up was a slide series showing the outcomes, accidents and humour that plotted the working life of AGSO staff in 1999. A staff folk group accompanied the slide show. With guitar and banjo (and the Chief Executive Officer on didgeridoo), they sang about how tough life Down Under can be.

AGSO's CEO, Neil Williams, then took the stage and confirmed that 1999 had been a difficult year for staff with cuts to meet government restrictions and budget pressures. He added that the 'downsize' was smaller than expected thanks to Parliamentary Secretary Warren Entsch.

Despite the difficulties, he says that AGSO staff had responded like true professionals: outputs had rolled on and there were some great achievements.

'AGSO is world class and used internationally', he says.

Among numerous AGSO projects gaining global recognition, he mentioned earthquake and nuclear monitoring, mineral assessments in forest management areas, and marine studies that are giving the world a clearer view of the origins of life on earth.

'Even the United States is referring to AGSO's work in this area', he says.

Dr Williams praised staff for the quality of products produced, evidenced by the winning of a highly prized international award, a Golden Mouse, for a map of Bathurst in New South Wales.

'The challenge for geoscience is that we can't easily display our service and yet our knowledge has a profound effect on Australia.

'Much of Australia's mineral and petroleum wealth is due to our legacy', he says.

Dr Williams says the real challenge for AGSO staff in coming years is to sell these achievements, and that this would be possible by increasing options, improving efficiency and by always striving for scientific excellence.

Proof that this was happening already was then demonstrated through the presentation of the following AGSO awards.

Leadership (individual). Kevin Cassidy and David Champion were recognised for their leadership of the Yilgarn Granites project. They demonstrated the ultimate test in performance and relevance by attracting sponsorship during difficult times for exploration, and by consistently achieving AMIRA's (Australian Mineral Industries Research Association) best-ever assessment ratings from sponsors.

Leadership (team). Neville Exon and Peter Hill's pioneering of modern swath mapping techniques to research seabed problems opened up possibilities for AGSO in marine science research.

Staff development. Lesley Wyborn dominated the field in pursuing training opportunities for staff. And she passed the ultimate test in staff development: leaving her staff well prepared and able to get on with the job when her duties took a change in focus.

Customer service (individual). There were two individual awards for customer service. The first was to Kathy Nelson. In 1999, Kathy had a very large workload that required a lot of effort and commitment. She was the contact person for the AGSO-wide merit promotion round and shouldered much during the restructure and associated downsizing. The second award went to Marcia Wisniewski who ensured library material on loan—much of which had been buried for years—was returned before staff left AGSO. With quiet efficiency, and without ruffling feathers, she achieved a 99 per cent return rate in a very short timeframe.

Customer service (team). The Regional Forest Agreement team (Lloyd David, Danuta Dlugosz, Neal Evans, Subhash Jaireth, Andrew Lucas, Aden McKay, Yanis Miezitis, Suzy Obsivac and Keith Porritt) brought great credit to AGSO through their data on known and potential mineral resources of forest regions. The team's lap-top decision support system promotes informed and transparent decision making in regard to resource access and land use issues. This is the first time that mineral values have been formally integrated into decisions on conservation reserves.



▲ The staff folk group sets the tone for the AGM.

Achieving results. Two awards were given for results achievement. The Petroleum Exploration and Environment Advice Project team (Ian Lavinger, Alan Williams and Russ Temple) provided outstanding support in the form of expert technical advice in short timelines to ISR, Environment Australia, and the Zone of Cooperation Area A Authority. Their work helps sustain a national industry worth \$8 billion annually.

The second award winner, Mark Webster, is representative of staff in the 'new' AGSO. He grasps opportunities, is proactive, and is an outstanding facilitator of the work carried out in his division (Petroleum and Marine). As a technical officer, he straddles a range of areas and has exceeded in all tasks assigned to him.

Corporate contribution (individual). Bruce Kilgore was recognised for his work on AGSO's National Digital Geoscience Datasets, recently released on CD-ROM. This is the first in an ongoing plan to release national thematic maps in digital format.

Corporate contribution (team). Three teams were applauded for their efforts in 1999. The first was the Geoscience Awareness and Marketing Unit



▲ AGSO's CEO Neil Williams plays didgeridoo at the AGM.

(Gary Lewis, Greg McNamara, Julie Gunther, Jeanette Holland and Steve Ross) for raising AGSO's profile in the community through its public education program. The unit's output included the first Earth Science Week, several teaching resource kits (including Gas: Energy and Change and Discovering Remote Sensing), a field excursion to Hawaii, AGSO foyer displays, and the opening of the Earth Science Education Centre in the AGSO building.

The second award went to staff from the Finance section (Dot Auberson, Andrew Baker, Liz Binetti, Kathy Elliott, Deidre Jones, Di Lopaten, Tanya Lumbaca, Toni Murray, Tony Savage, Maria Stirzaker and Joan White) for their fast turnaround in establishing AGSO as a prescribed agency. In just five months they re-established a financial operations unit, implemented accrual accounting, introduced agency banking, updated AGSO's assets register, and prepared two sets of books for the financial year (one for the former set-up as part of a government department and the other for the new, independent organisation).



▲ Management award winner Trish Yates was applauded for her people management skills.

The third team acknowledged for its corporate contribution was the Cities Project team (Don Gordon, Ken Granger, Ingo Hartig, Matt Hayne, Trevor Jones, Marion Leiba, Greg Scott, and David Stewart). The project focuses on urban area vulnerability to natural hazards. Their methodology for mapping and assessing the risk to Cairns in north Queensland has wide application and is likely to be extended to other Australian cities such as Brisbane, Perth and Adelaide.

Management. Trish Yates won the management award for her efficiency, tirelessness, attention to detail, and excellent people management skills.

▼ Trevor Jones accepts, for the Cities Project team, a well-deserved Corporate Contribution award for the team's natural hazards risk assessment work.



CEO award. Doug Finlayson was given this award primarily for his work in the seismic tomography survey of Rabaul volcano as part of a major AusAID contract, but also for meeting the deadline in an Australian bid to establish a new seismic network in the Philippines using Japanese government aid funds. Both the Rabaul tomography work and the Australian bid were successful due, in part, to Mr Finlayson's professional commitment and willingness to change direction at short notice. ▣

PLAN REVEALS AGSO'S ROLE IN NATIONAL WEALTH



Spend 10 minutes reading AGSO's Corporate Plan and you'll be convinced that Australia needs AGSO's scientific input, if it wants to encourage mining exploration, stay wealthy and better manage its natural environment.

Fifty projects with some 250 'outputs' are listed in the Corporate Plan for 1999-2000. Most projects (68%) are ultimately concerned with making Australia's exploration investment opportunities attractive. This is not surprising when Deputy CEO, Trevor Powell, states in the document that minerals and petroleum, worth almost \$41 billion, comprised 36 per cent of Australia's total exports in 1997-1998.

AGSO is to make available geoscientific information (providing the costs are bearable) that reduces commercial risk for mining exploration. It is argued that if exploration companies are better informed, their risks are reduced and the incentive to explore increases. Exploration and substantial new discoveries are required if Australia is to remain wealthy as well as self-sufficient, for example, in liquid hydrocarbons.

Mr Powell says that most mineral deposits remaining to be found in Australia are likely to be buried or concealed by the regolith, and that AGSO needs to shift its emphasis from a traditional surface mapping approach (2D mapping) to unraveling Australia's geology at depth (3D mapping). He stresses the importance of AGSO providing a 'framework' from which the private sector can generate projects and build the country's wealth.

Australia has a large marine jurisdiction that the federal government wants investigated. As a priority, AGSO is to continue surveying the seabed and substrate of Australia's territory. Also ongoing are cooperative efforts with Environment Australia that look at sedimentation, and nutrient and toxicant distribution in estuaries and near-shore shelf areas.

Other projects listed in the Corporate Plan for this year focus on deploying AGSO's knowledge to build safer communities and transportation, and to respond to international disasters. AGSO monitors and provides research on the geomagnetic field in the Australian region, which is about one-eighth of the Earth's surface. The capabilities and tools developed are being used in projects in other countries, such as Papua New Guinea and the Philippines, to minimise community vulnerability and mitigate hazard impact.

Project effectiveness is to be measured against performance benchmarks. These are listed in the Corporate Plan. They cover: global interest and investment in Australian mineral and petroleum exploration; take up of AGSO information for land-use and environmental issues; adoption of AGSO strategies for risk mitigation; acceptance of Australia's marine boundaries claim; up-to-date geomagnetic standards; and international agencies' satisfaction with AGSO's responsiveness to disasters outside Australia.

AGSO released its 40-page Corporate Plan at the AGM last November for all to see what will be achieved and delivered this year. ▣

■ Outlook 2000: New Directions, Future Markets

Australian Bureau of Agricultural and Resource Economics

29 February to 2 March

National Convention Centre, Canberra

Contact: ABARE,
GPO Box 1563,
Canberra ACT 2601.

phone 1800 806 591 or
+61 2 6272 2265,

fax +61 2 6272 2330,

www.abare.gov.au/outlook2000/index.htm

■ Mining Millennium 2000: PDAC International Convention & Trade Show

Prospectors and Developers Association of Canada

5 to 10 March, Toronto, Canada

Contact: Mining Millennium 2000 Convention,
c/- Congress Canada, 49 Bathurst Street,
Suite 100, Toronto, Canada M5V 2P2.

fax +1 416 504 8033,

www.miningmillennium.org

■ ASEG 2000: Exploration beyond 2000

Australian Society of Exploration Geophysicists

14th International Conference & Exhibition

12 to 16 March

Burswood Convention Centre, Perth

Contact: Promaco Conventions, PO Box 890,
Canning Bridge WA 6153.

phone +61 8 9332 2900,

fax +61 8 9332 2911,

e-mail promaco@promaco.com.au

■ AAPG 2000

American Association of Petroleum Geologists Annual Meeting & Exhibition

16 to 19 April, New Orleans, USA

Contact: AAPG, PO Box 979,
Tulsa Oklahoma, 74101-0979 USA.

phone +1 918 560 2679,

fax +1 918 560 2684,

e-mail convene@aapg.org, www.aapg.org

■ Australian Science Festival

29 April to 8 May, Canberra

Contact: Australian Science Festival,
PO Box 193, Civic Square ACT 2608.

phone +61 2 6205 0588,

fax +61 2 6205 0638,

www.sciencefestival.com.au

■ 2000 APPEA Conference and Exhibition: Innovations for the Third Millennium

Australian Petroleum Production and Exploration Association

7 to 10 May

Convention & Exhibition Centre, Brisbane

Contact: APPEA, GPO Box 2201,
Canberra ACT 2601.

phone +61 2 6247 0960,

fax +61 2 6247 0548,

e-mail lgordon@appea.com.au

Bight workshop showcases frontier effort

Timed to support the federal government's release of exploration areas in the Great Australian Bight, the Southern Margin Frontiers project staff held a workshop in December that showed industry an amazing wealth of data on Australia's southern margin that they had compiled in just one year.

The Great Australian Bight 'Regional & Petroleum Geology' Workshop, held at AGSO on 1-2 December 1999, showed potential explorers a new synopsis of the geology and petroleum prospects of the Bight. Earlier in the year the federal government released 11 exploration areas in the Great Australian Bight for competitive bidding. The showcasing of AGSO's pre-competitive data was aimed at reducing exploration risk and encouraging investment in the area. Bids for the Bight Basin acreage close in April this year.

Potential

The hydrocarbon potential of the Great Australian Bight is yet to be truly tested. Encouraging signs for petroleum include minor oil and gas shows and the recent joint AGSO-CSIRO discovery of a paleo-oil column in one of the wells.

No producing fields have been discovered. But the thickest, most prospective sedimentary sections in the Ceduna Sub-basin (figure 1) have never been tested. This sub-basin contains at least twice the sediment volume of all other known hydrocarbon-producing basins along the south-eastern Australian margin, including the Gippsland, Otway and Bass Basins. Also encouraging is a comparison between the Great Australian Bight and the prolific petroleum province of the Gulf of Mexico. In the Gulf of Mexico, approximately 633 600 square kilometres is under exploration and more than 4000 petroleum wells have been drilled. In contrast, the 11 release areas in the Bight occupy 229 016 square kilometres in which only eight petroleum wells have been drilled.

Challenges for explorers include poor regional knowledge of Bight basins (which was addressed directly by the workshop), large water depths in parts of the region, and the area's remoteness in relation to population centres and infrastructure.

Models and concepts

The new sequence stratigraphic framework for the Bight brings together the work of Southern Margin Frontiers project staff over the last 12 months. The work focused on the integration of regional seismic interpretation and well correlations, biostratigraphy, and organic geochemistry. This was combined with regional studies of basement properties and potential field data, structural development and subsidence history, and modern ship-, airborne- and satellite-based hydrocarbon indicator techniques to provide a regional synthesis of basin evolution and hydrocarbon potential.

One important result is the development of petroleum systems models and play concepts (figure 2) specific to parts of the Bight. Such analysis summarises all work of the project in a form suitable for identifying potential targets for future seismic surveys and drilling.

Participants

The workshop attracted a large and diverse audience from international and national petroleum companies, collaborating government and commercial agencies, as well as representatives from several universities. Participants had expertise and interests across the whole range of petroleum geology.

Workshop content

Topics addressed by speakers on the first morning included:

- regional tectonostratigraphic framework of the Bight;
- basement and its influence on basin architecture;
- exploration history in the Bight focusing on early drilling and geological models;
- structural styles;
- the new sequence stratigraphic framework for the Bight; and
- source rock geochemistry.

A large poster display, including interactive displays on burial history, GIS and Oracle databases, was held in the afternoon. This was an opportunity for colleagues from collaborating agencies (CSIRO, PIRSA, Paltech, Desmond Fitzgerald & Associates, Seismic Australia, LaTrobe University, National Centre for Petroleum Geology & Geophysics, University of Sydney) to communicate results from their work on the Great Australian Bight.

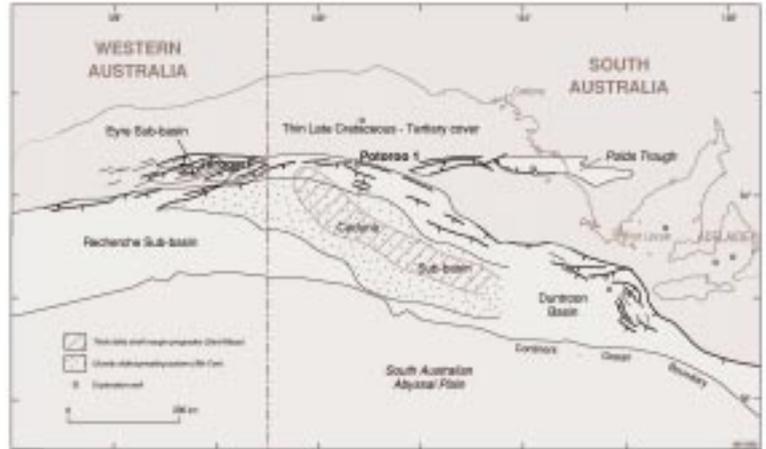
On the second morning oral presentations covered environmental issues relating to exploration, hydrocarbon indicators using the latest remote sensing techniques, petroleum systems and play types, and risk assessment. The morning finished with a formal discussion and closing remarks.

After the workshop, company representatives met with project members to discuss more detailed scientific issues and geological problems. These meetings occurred throughout the afternoon and continued the following morning.

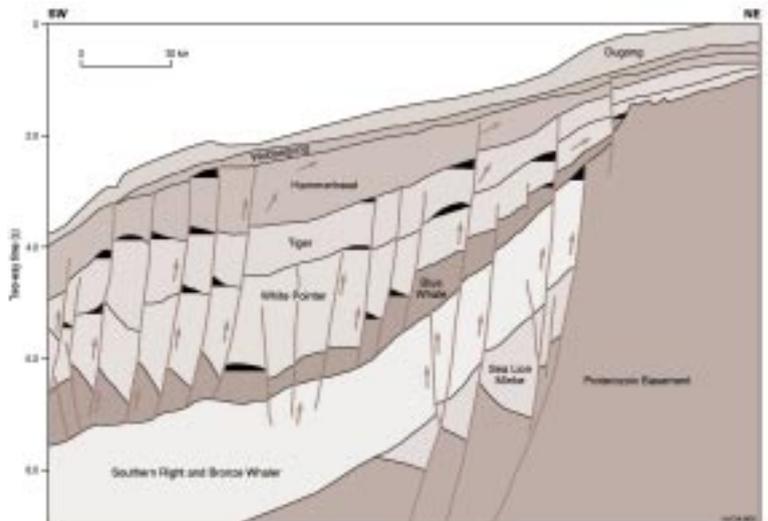
The workshop proved an opportunity for AGSO staff to forge stronger links with industry clients. Participants representing industry gave both immediate and subsequent positive feedback regarding the quality of the work, its regional comprehensiveness, and the quality and style of the

presentations. Anticipated outcomes of the workshop are a better understanding of geological risk for active and potential explorers and a renewed interest in the Bight's prospects.

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▲ Figure 1. Structural elements and location map of the Great Australian Bight



▲ Figure 2. Play element schematic for the Ceduna Sub-basin showing some of the main sequence stratigraphic subdivisions within the Bight, structural elements, and various numbered play types within the basin.

Australia's the place for mineral investment: conference theme

An Aussie contingent involving AGSO staff head to Canada in March to promote Australia as a great place for mineral investment. From March 5 to 10, they will join as many as 12 000 participants in Toronto for the Mining Millennium 2000 international conference and trade exhibition.

The Prospectors and Developers Association of Canada (PDAC) and the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) will jointly host Mining Millennium 2000. The conference comprises six days of technical sessions and there will be two trade exhibitions—PDAC Trade Show and Investors Exchange and the CIM Tradex. These trade shows will cover the complete mining cycle from exploration, financing and development to production, smelting and refining, close down and reclamation.

The Commonwealth Government (represented by AGSO) and the Mines Departments/Geological Surveys of all States and the Northern Territory will join industry groups in mounting a substantial Australian exhibition at the PDAC Trade Show. Industry exhibitors in the Australian pavilion include Mining 2000, Whittle Programming, Clayton Utz, Desmond Fitzgerald & Associates, AMIRA, ENCOM and Queensland Epithermal Minerals.

Web mapping workshop shows real-world application

A cyclone develops east of Cairns and moves westward hitting land just north of Port Douglas. Storms surge, winds roar and eastern Australia has the worst flooding in more than a century. Nearly 2000 people are evacuated from Cairns. Large areas are without power; rail and air corridors shut down. Seven people die and one-third of Australia's sugar cane is flattened.

Okay, so this is just a scenario you say. But this happened in Australia last summer. Cyclone Rona was one example used by AGSO's webmaster, Jonathon Root, in the November workshop of the Australian WWW Mapping Consortium.

The scenario demonstrated the real-world application of web mapping technologies. Multiple map servers from different agencies were accessed simultaneously to build a variety of maps for community information and disaster management. On-line status reporting gave users access to up-to-date information on cyclone location, pressure and storm-surge levels. Emergency workers could more swiftly and with better acumen manage the Cairns disaster.

Distributed web mapping

Jonathon Root also presented a paper on 'Business issues related to distributed web mapping'. He says that although web mapping technologies have been available for some years, growth has been limited by the immaturity of web mapping systems and the 'big three' internet issues of security, privacy and bandwidth. He also says that it has been difficult to develop the 'business case' for adopting distributed, interoperable web mapping techniques.

'The success of distributed web mapping and spatial data management systems relies very heavily on a critical mass of organisations committing to the concept and making their data available', he said.

'The inertia caused by such issues as copyright protection and control over data needs to be overcome by a clearer articulation of the benefits such as improved productivity and reduced costs.'

He says that many large organisations are reacting to the inefficiency of duplicated datasets by creating corporate datastores and improving cataloguing. GIS vendors in turn are improving database connections.

Mr Root believes that a natural extension of these developments is distributed data management systems, such as that being developed by the petroleum industry.

'We look forward to the practice becoming more widespread', he said.

WWW Mapping Consortium

Early in 1999, AGSO joined 23 other Australian industry, government and research and development organisations to form the Australian World Wide Web Mapping Consortium. Since its inauguration, it has become a member of the US-based Open GIS Consortium.

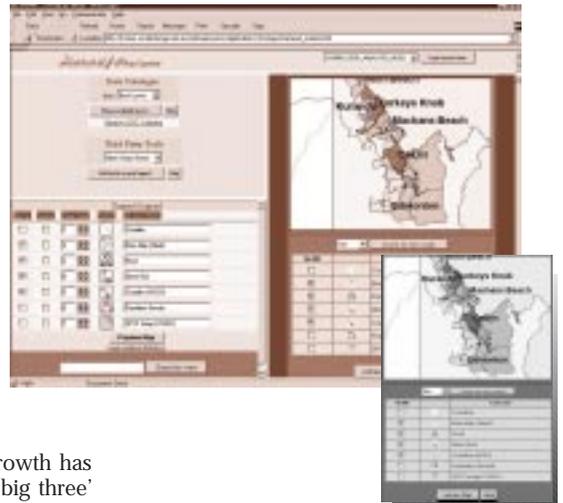
From May, the Australian Consortium has been evaluating and extending

The main reason for the attendance of Australian government agencies is to promote Australia as a favourable site for mineral investment. A major theme of the government display will be the support given to exploration, particularly through major multidisciplinary mapping programs and exploration initiatives.

An additional feature of the conference will be the World Mines Ministries Forum. Mines ministers, senior government officials from around the world, mining company executives, and representatives of non-governmental organisations will discuss the following topics:

- Competitiveness of nations—the search for investment dollars;
- Mining and the community;
- Sustainable mineral development;
- Geological surveys in the information age.

PDAC '99 attracted approximately 6200 delegates, exhibitors and visitors from around the world. With the broader scope of Mining Millennium 2000



commercial and public sector mapping capabilities on the web. The workshop, held in Leura in the Blue Mountains on November 23, was the Consortium's first major workshop to discuss development issues.

Scenarios demonstrated at the Leura workshop were presented at the plenary session of the Open GIS Consortium in December. Concepts developed by the Australian Consortium were well received.

'From all reports, it seems that 2000 will be the year that on-line mapping comes of age', Mr Root said.

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and the inclusion of the Ministries Forum, more than 12 000 delegates are expected.

For more details phone Mike Huleatt on +61 2 6249 9087 or e-mail mike.huleatt@agso.gov.au. For information about the Australian company participation contact Ian Sutherland, Business Development Manager, GeoJAG (Australia), phone +61 3 9258 9313 or e-mail geojag@opc.vic.gov.au.



◀ AGSO's Chief Scientist Phil McFadden stresses the need to ask questions not just count things.

Times and questions changed for AGSO

The Bureau of Mineral Resources (AGSO's predecessor) was created because of a question that the federal government wanted answered: what is Australia's reserve of strategic minerals? The response was to compile uniform systematic geological and geophysical maps of the entire Australian continent. That has been AGSO's job for several decades.

But times have changed. AGSO's data-acquisition ship and aircraft have gone, and technology now enables almost anyone to acquire data. As well, the federal government has put a different slant on what it is asking of AGSO.

'The federal government wants to know what we are going to do that benefits the country in a broader sense—economically, socially and environmentally', says AGSO's Chief Scientist Phil McFadden.

'We're being asked to add value and take on more than our traditional role.'

Dr McFadden says that the fundamental psyche of data acquisition, therefore, has to change and that this could have an effect AGSO's mode of science.

'We must ask questions not just count things', he says.

'We have to move from activities to questions about our science, why we are doing what we do and what impact we expect to have.'

Dr McFadden says that he has seen some very good scientists working on projects for five or six years, putting in a lot of effort and getting good results, but getting little impact. He says that before scientists get 'in too deep' or emotionally involved in their projects, they must define the exit point for the project.

'It is only by stating and regularly examining your exit policy that you really understand the viability and value of your project', he says.

'What we individually want to know does not necessarily meet our client's need. We must make sure that we are answering somebody else's question not our own.'

He adds that there should be no 'x-ology' outcome (i.e. geology, seismology, etc.) because this is not what clients seek.

In terms of a cultural change, Dr McFadden believes AGSO's scientists need to do three things: actively seek criticism, look for maximum impact, and thrive on change. Robust discussion, mentoring and professional respect, even when ideas are 'lousy', are important he says to improve the quality of scientific ideas. More time has to be spent on selling ideas and projects—including during the life of the project—and there should be more publishing (to achieve AGSO goals and not for self-aggrandisement).

Dr McFadden says that change is inevitable and the most comfortable seat when change occurs is the driver's seat.

'Don't wait for opportunities', he says. 'Climb into the driver's seat and make them happen.' ■

Conclusions

The results of the seismic profiling are exciting on three main grounds. Firstly, the average sediment thickness in the Fairway Basin is three to five kilometres—enough to generate oil and gas. Secondly, there are numerous large domes in water depths of 2000 to 2800 metres in much of the basin. Whether they consist of salt or shale, their existence enhances the petroleum prospects of the basin—on both sides of the Franco-Australian border. The domes have formed potential traps. If the domes are organic-rich shale, they could be petroleum source rocks. Thirdly, the BSR (representing gas deposits) covers an area of 50 000 square kilometres in the Fairway Basin. This is twice what was estimated before this expedition, and an area nearly as large as Tasmania. (See article in PESA Journal 26, December 1998.)

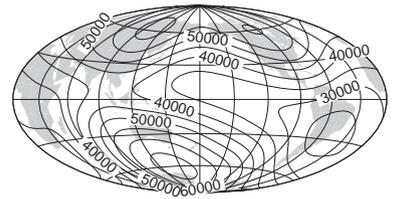
Enough cores were obtained in suitable locations to ensure an adequate test of whether surface gases (at depth as gas hydrates) are present. If they are, they can be used to assess whether thermogenic gas is being generated in the basin. In any case, the nature and age of the basin suggests that there could be organic-rich petroleum source rocks deep within it.

There is every probability that the BSR and the domes extend well south into the equally large Australian part of the Fairway Basin, suggesting considerable petroleum potential.

Discussions are under way on follow-up cooperative 'cruises', on both sides of the seabed border. At this stage negotiations include a considerable seismic program, stratigraphic dredging, geochemical and stratigraphic coring, and possibly a program of measuring heat flow at the seabed. Key participants would come from France, New Caledonia and Australia (AGSO and James Cook University). If results prove encouraging, it is probable that Australian and New Caledonian governments would consider releasing petroleum exploration leases in the region.

For more information phone Chief Scientist, Dr Jean-Marie Auzende, on 1100 687 261 000 or e-mail auzende@noumea.ird.nc, or phone Dr Neville Exon +61 2 6249 9347 or e-mail neville.exon@agso.gov.au ■

International Geomagnetic Reference Field revised



▲ Figure 1. Total intensity of the Earth's magnetic field, as given by IGRF 2000 at epoch 2000.0.

A revision of the International Geomagnetic Reference Field (IGRF) for the year 2000 was recently issued by the International Association of Geomagnetism and Aeronomy. The IGRF can be used to compute the direction and intensity of the geomagnetic field at any location for dates between 1900 and 2005 (figure 1). IGRF has become the world standard numerical representation of the long wavelength features of the Earth's magnetic field, and is used for applications such as processing and updating aeromagnetic survey data, direction-finding, and solar-terrestrial physics studies.

This revision (8th generation) of the IGRF differs from the 1995 revision (7th generation), only by the addition of an IGRF 'main field' model for the year 2000 plus secular variation terms for extrapolation to 2005 (table 1). The remaining spherical harmonic (Gauss) coefficients of the complete IGRF are the same as those for the 7th generation (AusGeo News 1995 Dec; 31:5). Note that the 7th generation main field model remains current and has not been replaced by a definitive model for 1995. (Individual epoch models designated as 'IGRF' are considered to be provisional, ultimately to be replaced by definitive 'DGRF' models when it is agreed that no further improvement in modelling accuracy is likely to be achieved.)

- The complete 8th generation (year 2000 revision) of the IGRF comprises: provisional IGRF main-field models at five-year epochs from 1900 to 1940;
- definitive DGRF main-field models at five-year epochs from 1945 to 1990;
- a provisional IGRF main-field model for 1995 (IGRF 1995); and
- a provisional main-field model for 2000 (IGRF 2000) that includes secular variation terms for forward continuation to 2005.

Between five-year epochs, the spherical harmonic coefficients of the field are obtained by linear interpolation between corresponding coefficients of the two adjacent five-year epoch models.

The new IGRF model indicates that the steady decline in strength of the Earth's main dipole during the past 100 years has started to level out. The decay of the dipole moment has often been used to speculate that a geomagnetic reversal is commencing. The recent levelling out of the decay, together with the paleomagnetic evidence that the Earth's dipole moment is recovering from an abnormally high value reached some 1500 to 2000 years ago, does not support the speculation.

Coefficients for the IGRF can be downloaded from the following sites:

- <http://www.agso.gov.au/geophysics/geomag/>
- <http://www.ngdc.noaa.gov/IAGA/wg8/table1.txt>

Values of the IGRF at any location can be calculated on-line by going to 'reference fields' at the first site.

A software package for computing the IGRF field and annual changes is available from AGSO. It is available in either MS-DOS or Apple Macintosh versions for \$50 plus postage and handling. The package includes:

- IGRFCOF—an ASCII file of the complete set of IGRF coefficients;
- IGRF—a program for computing IGRF values between 1900 and 2000;
- ANYMOD—a program for evaluating any single spherical harmonic model;
- GRIDCON—a program for converting between easting/northing UTM (universal transverse mercator) and latitude/longitude.

gh	n	m	nT	nT/yr	gh	n	m	nT	nT/yr	gh	n	m	nT	nT/yr	gh	n	m	nT	nT/yr
gg	1	0	-29615	14.6	h	5	3	-134	1.7	h	7	6	-25	-0.7	h	9	5	8	0.0
gg	1	1	-1728	10.7	g	5	4	-169	-0.8	g	7	7	-2	-0.9	h	9	6	2	0.0
h	1	1	5186	-22.5	h	5	4	-40	1.9	h	7	7	-6	0.2	h	9	6	9	0.0
gg	2	0	-2267	-12.4	g	5	5	-12	2.5	g	8	0	25	-0.3	g	9	7	9	0.0
gg	2	1	3072	1.1	h	5	5	107	0.1	g	8	1	6	0.2	h	9	7	4	0.0
h	2	1	-2478	-20.6	g	6	0	72	1.0	h	8	1	12	0.1	g	9	8	4	0.0
gg	2	2	1672	-1.1	g	6	1	68	-0.4	g	8	2	-9	-0.3	h	9	8	8	0.0
h	2	2	-458	-9.6	h	6	1	-17	-0.2	h	8	2	-22	0.0	g	9	9	8	0.0
gg	3	0	1341	0.7	g	6	2	74	0.9	g	8	3	-8	0.4	h	9	9	5	0.0
gg	3	1	-2290	-5.4	h	6	2	64	-1.4	h	8	3	8	0.0	g	10	0	2	0.0
h	3	1	-227	6.0	g	6	3	-161	2.0	g	8	4	-17	-1.0	g	10	1	6	0.0
gg	3	2	1253	0.9	h	6	3	65	0.0	h	8	4	21	0.3	h	10	1	1	0.0
h	3	2	296	-0.1	g	6	4	-5	-0.6	g	8	5	9	0.3	g	10	2	2	0.0
gg	3	3	715	-7.7	h	6	4	-61	-0.8	h	8	5	15	0.6	h	10	2	0	0.0
h	3	3	-492	-14.2	g	6	5	17	-0.3	g	8	6	7	0.5	g	10	3	3	0.0
gg	4	0	935	-1.3	h	6	5	1	0.0	h	8	6	9	0.4	h	10	3	4	0.0
gg	4	1	787	1.6	g	6	6	-91	1.2	g	8	7	8	0.7	g	10	4	0	0.0
h	4	1	272	2.1	h	6	6	44	0.9	h	8	7	16	0.3	h	10	4	5	0.0
gg	4	2	251	-7.3	g	7	0	79	-0.4	g	8	8	7	0.4	g	10	5	4	0.0
h	4	2	-232	1.3	g	7	1	-74	-0.4	h	8	8	3	0.7	h	10	5	6	0.0
gg	4	3	-405	2.9	h	7	1	-65	1.1	g	9	0	5	0.0	g	10	6	1	0.0
h	4	3	119	5.0	g	7	2	0	-0.3	g	9	1	9	0.0	h	10	6	1	0.0
gg	4	4	110	-3.2	h	7	2	-24	0.0	h	9	1	20	0.0	g	10	7	2	0.0
h	4	4	-304	0.3	g	7	3	33	1.1	g	9	2	3	0.0	h	10	7	3	0.0
gg	5	0	-217	0.0	h	7	3	6	0.3	h	9	2	13	0.0	g	10	8	4	0.0
gg	5	1	351	-0.7	g	7	4	9	1.1	g	9	3	8	0.0	h	10	8	0	0.0
h	5	1	44	-0.1	h	7	4	24	-0.1	h	9	3	12	0.0	g	10	9	0	0.0
gg	5	2	222	-2.1	g	7	5	7	-0.2	g	9	4	6	0.0	h	10	9	2	0.0
h	5	2	172	0.6	h	7	5	15	-0.6	h	9	4	6	0.0	g	10	10	1	0.0
g	5	3	-131	-2.8	g	7	6	8	0.6	g	9	5	9	0.0	h	10	10	8	0.0

▲ Table 1. Spherical harmonic (Gauss) coefficients for IGRF 2000. Main-field coefficients are in units of nT; secular variation coefficients for extending IGRF 2000 to 2005 are in nT per year.

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National gravity database updated

AGSO has just released the Year 2000 edition of the Australian National Gravity Database. This release contains about 900 000 gravity-point-datavalues, both land and marine, in the area extending from 8° S to 48° S and 108° E to 162° E.

The main gravity stations added since the 1996 edition are in Victoria, Tasmania and the Yilgarn province of Western Australia. Details of the changes in coverage listed by 1:1 million map sheet are available from the e-mail address below.

The price of this dataset is \$5000, which includes an option to purchase updates for five years at an annual price of \$500. Point-data values for individual 1:1 million sheets are available separately for \$200 per sheet. Point-data, grid and image packages are available for selected 1:1 million sheets at \$400. Printed 1:1 million colour pixel-image maps of Bouguer gravity anomalies will progressively become available, starting in 2000, replacing the previous dyeline series.

The digital data are available from AGSO in two forms:

- the complete database on CD-ROM or SUN tar exabyte tape;
- 1:1 million sheet data on CD or MS-DOS format 3.5" diskettes.

Copies can be bought from the AGSO Sales Centre from mid-February. For further information contact Alice Murray, phone +61 2 6249 9264 or e-mail alice.murray@agso.gov.au

North Pilbara: epithermal vein deposits confirmed

After finding epithermal textures in quartz vein deposits in the West Pilbara, AGSO commissioned Alan Marshall of Qestore Pty Ltd to undertake a review of possible epithermal deposits throughout the North Pilbara craton. Record 2000/01, 'Low-temperature, low-pressure (epithermal) vein deposits of the North Pilbara craton, Western Australia' presents the results of this review.

Marshall defined a number of vein deposits with epithermal characteristics, mainly in the Whim Creek district (figure 1). Visits to these deposits by AGSO geologists confirm the epithermal characteristics of many of them, and also indicate the presence of other deposits with epithermal characteristics. It is suspected that these veins may be present through much of the North Pilbara craton.

In the Whim Creek district, epithermal vein deposits are hosted by a number of different geological units, including metasedimentary rocks, mafic volcanic rocks and granite. The deposits commonly trend north or north-north-west transecting the structural grain of the host rock. Geological evidence is most consistent with, but not definitive of, an early Fortescue age for the mineralisation (ca. 2765 Ma). If true, epithermal mineralisation could also be present in the base of the Fortescue Group, which opens up the stratigraphically lower part of the Hamersley basin to gold potential.

Recognition of epithermal vein deposits in the North Pilbara craton indicates epithermal potential in other well-preserved Archaean and Proterozoic cratons in Australia—areas that are traditionally considered unprospective for this type of deposit.

From March a copy of Record 2000/01 can be bought from the AGSO Sales Centre for \$35 plus postage and handling. For more information contact David Huston, phone +61 2 6249 9577, fax +61 2 6249 9983, or e-mail david.huston@agso.gov.au



Figure 1. Possible epithermal deposits of the Whim Creek district. Geological base is courtesy of the Geological Survey of Western Australia.

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- Vol 15(1): Geology of the outer north-west shelf, Australia, 193 pages plus map





Photo: WA Gold Corporation

Australian gold exploration record excellent, report reveals

The recently published AGSO report, *Australia's gold resources 1988 to 1998: A review*, concluded that the Australian gold industry had an excellent record in exploration and resource definition over the 11 years to 1998.

The gold industry made a substantial and sustained contribution to the Australian economy from 1988 to 1998 by producing 2755 tonnes of gold, exporting 2634 tonnes of gold, and generating \$53 596 million in export income while spending \$5195 million exploring for new resources. Exploration not only replaced gold lost to production, but also increased total resources to 8356 tonnes in 1998 from 2950 tonnes in 1988. Over the period, resources were added to the Australian inventory at a cost of just under \$20 per ounce.

Australia's gold industry operates on a very low ratio of resources to production, implying a relatively short resource life at any given time compared with all other mineral commodities. From 1988 to 1998, the maximum gold R/P ratios for measured and indicated resources ranged from 11 to 19. At the 1998-production level of 312 tonnes, at least 10 million ounces must be discovered simply to replace resources lost to production. Ongoing substantial exploration is essential to achieve that level of resource replacement.

Trends

Trends in gold resource levels and types over the 11 years are summarised below. These apply to Australia as a whole as well as to each State and the Northern Territory.

- Successful exploration programs have maintained resources at sound levels since 1988, despite high production.
- Monometallic resources are currently dominant and will be the basis for ongoing production into the long-term future.
- Open-pit mining will continue to dominate, although the share of production from underground resources will most likely increase slowly.
- Current resource stocks appear adequate to support the industry for the near to medium term.
- Low R/P ratio (currently 19) indicates that long-term viability of the industry depends on continuing successful exploration.
- The ongoing success in defining new resources over an extended period is a clear indication of the highly prospective nature of the Australian continent.

Mine costs

Part two of the report, 'Analysis and review of gold mine costs', found that second-hand plant and equipment can be important to the development of small- to medium-size gold mines (i.e. less than 1 Mt pa), particularly for low-grade deposits which are not viable for toll treatment. Generally, the return on small- to medium-size low-grade mines (<3g/t) is not improved by toll treatment.

Increased head grade in the initial years of an open-cut gold mining operation can assist the internal rate of return and pay-back period. Whether a mine is able to operate at elevated head grades in the first years of operation could depend on the mine geology. In relation to ore grade, it was noted that high-grade open-cut mines generally have higher operating costs than similar size low-grade operations because the high-grade mines are able to operate with higher stripping ratios.

A review of cost information found that:

- In 1998, average Australian gold mining cash costs fell to \$US204 per ounce, \$US43 per ounce less than average 1997 costs.

- Even though average world gold mine production costs fell in real terms in 1997, mining company margins were further reduced. In 1997 average cash margins fell below \$US100 per ounce for the first time since 1975. Mining companies constantly have battled declining margins over the past 15 years, and in 1997 average margins fell again from \$US125 per ounce in 1996 to \$US78 per ounce.
- Despite the current low gold price in US dollars, a relatively small production loss is anticipated from closures. This reflects the strenuous efforts miners are making to keep operating in the short term. Those mines which are able to increase the head grade of their reserves are doing so; pits are being redesigned; cut backs are being delayed; stripping ratios are falling and non-essential capital expenditure is being avoided. In the longer term, these endeavours will reduce mine life.
- A highly competitive contract mining sector has been a significant factor in the competitiveness of many new underground mines. Use of contractors has also insulated most underground gold producers from high capital development costs and some project risk. JB Were resource analysts estimate that by early next decade, 38 per cent of Australia's gold production (about 100 t) will come from deep mines. This compares with a recent figure of 29 per cent, and as little as 17 per cent in 1990.

What's ahead

Considerable challenges lie ahead as a result of the current and forecast low, world gold price. Exploration expenditure will come under severe downward pressure, so the returns from it must be maximised.

Exploration can be assisted by:

- stable long-term access to land in regions prospective for gold mineralisation;
- quality pre-competitive geoscientific data; and
- ongoing encouragement and support for research programs aimed specifically at improving exploration technology.

Purchase details

Copies of Record 1999/44, *Australia's gold resources 1988 to 1998: A review*, can be bought from the AGSO Sales Centre for \$30 each plus postage and handling, phone +61 2 6249 9519.

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