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Editor
Mary Walsh

Graphic Design
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Geographics

Geoscience Australia
GPO Box 378
Canberra ACT 2601 Australia
Cnr Jerrabomberra Avenue &
Hindmarsh Drive
Symonston ACT 2609 Australia

www.ga.gov.au

Chief Executive Officer
Dr Chris Pigram

Subscriptions
Online subscriptions
www.ga.gov.au/about-us/news-media/subscribe/index.jsp

Editorial enquiries & Feedback
Mary Walsh
p: +61 2 6249 9171
f: +61 2 6249 9926
e: ausgeomail@ga.gov.au

Sales Centre
p: +61 2 6249 9966
f: +61 2 6249 9960
e: sales@ga.gov.au
GPO Box 378
Canberra ACT 2601 Australia

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CEO comment

Geoscience Australia can now claim to have two state-of-the art robots which will improve the accuracy of satellite positioning in Australia.

This issue of *AusGeo News* provides details of the new antenna calibration facility, consisting of two outdoor robots, that is one of only three of its kind in the world and the only one in the Southern Hemisphere. The facility will enhance Geoscience Australia's role in enabling Australia's national position capability to operate and analyse the data from a national network of permanent Global Navigational Satellite Systems stations.

What's happened to geothermal? In the period 2005–2010 geothermal energy showed rapid growth in Australia with many tenements being taken up, significant exploration activities and a number of very deep wells drilled. Since that time, despite world-leading technical success, investment in geothermal development has been inadequate to sustain the pace of development forecast. This article examines why this decline has occurred and looks at the place of geothermal energy in Australia's clean energy future, including the development and deployment needs of the geothermal industry and research sector, and how this might be coordinated.

The Minister for Resources and Energy Gary Gray released new offshore petroleum exploration areas at the Australian Petroleum Production and Exploration Association (APPEA) conference in Brisbane. Details of the 2013 Offshore Petroleum Exploration Acreage Release, comprising 31 areas located across six basins in Commonwealth waters in the offshore areas of Northern Territory, Western Australia, Victoria and the Territory of Ashmore and Cartier Islands, are included in this issue.

Congratulations to Marita Bradshaw, Geoscience Australia's Senior Science Advisor, for winning the award for Best Oral Presentation at the APPEA 2013 conference. Marita won this prestigious award for her presentation entitled *Unconventional hydrocarbons—Australia's old rocks prove their worth.*

This issue provides an article Marita has written on the role government geoscience has played, and continues to play, in revealing the resource endowment of Australia. The article discusses how new Government funding will enable Geoscience Australia to undertake a strategic analysis of the petroleum potential of both onshore and offshore Australia, leading to new exploration opportunities and discoveries.

The Australian Agency for International Development (AusAID) is diversifying its approach to economic development and poverty reduction in developing countries through the Mining for Development Initiative. Details of the role Geoscience Australia is playing in conducting a scoping program for the Initiative is summarised in this issue.

Geoscience Australia has a new set of Science Principles, developed to guide the agency's geoscientific research that helps inform decision making by governments, industry and the wider community on a range of economic, social and environmental issues.

Dr Chris Pigram
CEO Geoscience Australia

Australian Government
Geoscience Australia

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What's happened to geothermal?

Simple in concept—complex in application

Anthony Budd

Introduction

In the brief period 2005–2010, geothermal energy showed rapid growth in Australia with many tenements being taken up, significant exploration activities and a number of very deep wells drilled. Since that time, despite world-leading technical success, expenditure, activity, tenement holdings and personnel numbers have decreased markedly. Success has been achieved with the generation of electricity by Geodynamics Ltd at Innamincka, and the creation of a geothermal reservoir by Petratherm Ltd at Paralana. This article examines why this decline has occurred, and looks at the place of geothermal energy in Australia's Clean Energy Future.

"Geothermal is a flexible source of heat energy which is very environmentally benign, and it also has excellent financial benefits for Australia."

What is geothermal?

Geothermal energy is heat (thermal) from the Earth (geo). Heat is constantly generated within the Earth by the process of radioactive decay, and heat is still residual from planetary accretion (KamLAND collaboration, 2011). This heat passes from the inside of the Earth into outer space. We see evidence of this heat loss at volcanos and mid-ocean ridges, and in features such as geysers, hot springs, fumaroles and mud pots, however, heat flows everywhere across the globe at varying rates (Dickson and Fanelli, 2004).

Human kind has utilised geothermal energy for millennia, mostly using water from hot springs for cooking, bathing, heating and washing (Cataldi 1993). Electricity was first successfully generated from geothermal steam at Lardarello in Italy in 1904 and this field continues to produce 10 per cent of the world's geothermal power.

Most of the world's current utilisation of geothermal energy is in areas of active volcanism because that is where the heat flux is highest and most accessible. In Australia, a continent without active volcanism, high temperatures are generated by high heat producing rocks (particularly granites) within the upper part of the crust and from the underlying mantle. These are lower grade heat sources than the magmas at volcanos so a thermally-insulating blanket is needed to trap the heat and achieve sufficiently high temperatures. This blanket is provided by thick layers of fine-grained sediments and coals. Temperature measurement in parts of Australia shows that we do have many areas with temperatures high enough for power generation, and it is not widely appreciated that a small power plant has been operating at Birdsville for approximately two decades.

Australia's geothermal resources are said to be 'unconventional', because they are different to the volcanic-associated systems utilised elsewhere in the world for power generation. Some of our resources will be shallow and hot enough to be used in a manner similar to conventional systems - these are often called 'Hot Sedimentary Aquifer' systems (HSA), and the Birdsville power plant in the

Great Artesian Basin is an example. The systems in Australia that are hot enough to generate large amounts of power will mostly be deeply buried and therefore difficult to flow water through. Flow paths will need to be enhanced, so this type of utilisation is called an 'Enhanced (or Engineered) Geothermal System' (EGS) (Figure 1). To explain, cool water is pumped from surface down an injection well, flows through the hot rocks to be heated, then is recovered to surface for use via a production well—this works as a "closed loop". There are many other countries also interested in EGS and Australia will benefit from international collaboration.

Figure 1: Hydraulic stimulation at the Paralana-2 wellhead. Courtesy of Brooke Whatnall (The Advertiser Newspaper) via Petratherm Ltd.

Why geothermal?

Energy security is of vital importance to Australia as we are an energy intensive society. Our mining and manufacturing industries in particular are dependent on cheap power and heat.

Geothermal is a flexible source of heat energy which is very environmentally benign, and it also has excellent financial benefits for Australia. Geothermal is renewable and sustainable. Geothermal resources in Australia have no emissions nor produce other pollutants. If emissions throughout the full life cycle of power production are considered, geothermal is one of (if not the) cleanest form of power we have available to us. Geothermal plants have a small footprint for their energy production.

Geothermal energy has a high availability - energy is provided constantly (regardless of time of day or weather) and therefore a high capacity factor (for example, power plants produce at close to their maximum capacity, all the time). Load following is also possible. Heat energy is produced from the hot water, and can be used for electricity production or directly in a wide variety of industrial processes. Geothermal power stations can be modular or scalar, so can produce power at less than 1 megawatt (MW), through to gigawatts (in theory). This is a similar range to other baseload or peaking power stations. For example, in NSW the Liddell gas turbine station has a capacity of 50 MW, the Vales Point coal station is 1320 MW, and the Tumut 3 pumped hydro station is 1500 MW.

Geothermal power has been estimated to be one of Australia's cheapest future power options (Energy White Paper, 2012). Australia has a very large potential resource base. Geothermal energy cannot be traded internationally, providing price security, and it demands a high Australian workforce content at all stages of development and production.

Mythbusting geothermal

Geothermal energy is new to Australia, and the general populace as well as decision makers and investors are right to question whether this technology should be deployed in Australia. This section outlines some of the concerns that the author has come across in speaking to people about geothermal, and attempts to provide information for readers to have an informed view.

It will cool the Earth

The concerns expressed here range from catastrophic (freezing the Earth), to questions as to whether this is actually a renewable energy resource. Even if geothermal was very widely

utilised, heat would still only be extracted from a very minor volume of the outermost part of the Earth's crust—it will have a negligible effect on the Earth's temperature.

It will heat the atmosphere

Here the concern expressed is that heat would be extracted and removed from the Earth at a rate faster than would happen naturally, and that this heat is then dumped into the atmosphere as a by-product of energy production. However, burning fossils fuels, as done now, releases both heat and emissions. Geothermal can displace the use of fossil fuel, lowering the amount of heat released into the atmosphere.

It is not renewable

As explained above, heat within the Earth comes from the core and from heat generated during radioactive decay. The extraction of geothermal heat does not affect the production of heat in the Earth, which is a natural and recurring process; that is, the heat budget of the Earth is self-renewing. Therefore geothermal energy is renewable—our activities will not impact future generations' ability to access geothermal resources.

The closed loop is to contain radioactive elements

This concern arises from the belief that because the heat driver for geothermal systems in Australia is from radioactive decay, the systems must be highly radioactive. Further, the suspicion is that water is returned to the geothermal reservoir because it is highly radioactive. Neither of these fears are correct. The abundances of uranium, thorium, and potassium in the granite heat source rocks is absolutely natural, is much lower than ores that are mined for nuclear fuels, and orders of magnitude lower than that of nuclear weapons. Indeed, there are some beach sands that are more radioactive than granites. The return of reservoir fluid to the reservoir once it has been passed through the power plant is for the purposes of water conservation, as well as for maintaining reservoir pressure and temperature. The use of a closed loop is fundamental to water management and heat extraction and is not an attempt to engineer a 'natural' nuclear reactor.

It can be used anywhere

Some prospective geothermal developers have used the term 'EGS Anywhere' to try to explain that the use of geothermal energy is not restricted to the areas immediately around volcanos. However, in Australia geothermal power has not yet been demonstrated to be economic from any EGS reservoir, let alone from low-grade reservoirs. It will be some time before it is economic to drill to depths of more than six kilometres and we need more robust reservoir enhancement methods before we can deploy the technology to very low grade resources and have a suitable return on investment.

It causes earthquakes

Seismic activity is well-known to be associated with many of humankind's activities, such as mining and water damming. Hydro-shearing, the most common method used for improving permeability of geothermal reservoirs, uses high-pressure water to force existing fractures further open (by fractions of a millimetre only) and this does cause earthquakes. No earthquakes larger than magnitude 4 are known to have been caused by any EGS geothermal development in 35 years of operations worldwide, and none have been shown to have caused damage to buildings or other infrastructure. Extensive research is being undertaken for the dual purpose of enabling suitable regulation and effective reservoir development.

It is too remote

This is one of the most common reasons given as to why geothermal will never work in Australia, with the assumption being that building power lines is too expensive and line losses will be high. High-voltage direct-current power lines have very low line losses and are already used as long interconnectors in Australia. The need to build long power

lines during the construction phase of power plant development would certainly be an additional financial burden, but there are four mitigating factors that need to be considered. Firstly, small local markets may exist close to some geothermal resources, enabling income during scale-up. Secondly, further exploration work may reveal resources close to off-grid markets, which are likely to provide better power prices than connecting to the over-supplied National Electricity Market. Thirdly, geothermal projects are potentially very large so that the expense could be financially justifiable. Lastly, being remote generally means less complicated approvals processes, including objections to induced seismicity.

Virtually every resource used in Australia requires transport, and this issue needs to be addressed by geothermal projects, but is not per se an issue that will prevent geothermal development.

It doesn't work

The Enhanced Geothermal Systems concept was developed at Fenton Hill in the United States of America in the early 1970s, and several other experimental deep projects have been undertaken since then. In Australia, Geodynamics Ltd has successfully produced power from its Innamincka pilot plant in mid-2013. There are no technological barriers to producing power at commercial scales, rather technology developments and improvement in our knowledge of particular reservoirs are required to bring costs down in order to attract the investment necessary to scale the projects up.

If it was easy, it would have been done by now

Geothermal energy is simple in concept, however in Australia it has been proven to be more complex in application—something that should come as no surprise with hindsight. Most technologies go through a difficult development phase including where their costs are higher than competing technologies which they eventually displace. Still, it is no more complicated than oil and gas extraction methods carried out routinely. The difference is that EGS is deep so drilling costs are high (including in the resource discovery phase), and fossil fuels have always been cheap in comparison, making the leap from a proven energy source to an unproven one—no matter how much cheaper and cleaner it may be in the longer term—has proven too risky for the current investment market.

It is too expensive

With expected improvements in flow rates achieved from wells, and better drilling procedures, EGS energy in Australia could be our cheapest zero-emission base-load power source. The problem is that until a 10s of megawatts demonstration plant has been successfully operated in Australia and shown to be profitable, no investors are presently willing to make the risk on investment. Deep geothermal cannot be demonstrated in a cheap fashion in the way that other energy technologies can be—from laboratory bench-scale to pilot to demonstration.

What's gone wrong?

Several development projects have been undertaken in Australia and overseas, but with little progress in evidence, it is commonly assumed that unconventional geothermal systems do not work. Here I examine the events that have contributed to this view, and comment on the significant learnings that have come from each of them. Unfortunately these events are seen as failures, and the very valuable learnings and advances from each are not broadly recognised.

The geodynamics experience—Habanero EGS project

In October 2003, Geodynamics Ltd completed the Habanero-1 well to a depth of 4421 metres, and found unexpectedly high fluid pressures as well as the high temperatures expected. The high fluid pressures required changes to the drilling configuration to use a heavy mud rather than water in order to control the overpressures. This led to a doubling of the original budget—to approximately $11 million—to complete the well

(Geodynamics, 2003). Two fractures were able to be stimulated in this well, creating a reservoir considerably larger than previously managed at any other EGS project in the world.

Habanero-2 was drilled in July 2004 and successfully intersected the fractured reservoir created from Habanero-1, with flow demonstrated between the two wells at higher rates than had previously been achieved elsewhere. However a stuck drill pipe during a well clean up and intervention event caused the well to be abandoned in June 2006. The final cost of drilling was significantly above the original budget of $10.5 million (Geodynamics ASX Announcement 12 July 2004).

In response to the host of drilling problems of Habanero-2, Geodynamics bought their own rig. This was used to drill Habanero-3 (August 2007 – February 2008, 4221 metres, 250 °C), Jolokia-1 (March–September 2008, 4911 metres, 278 °C) Savina-1 (October 2008–February 2009, ~3700 metres), and Habanero-4 (March–September 2012, 4024 metres,). Drilling progressed without significant incident in Habanero-3 and Jolokia-1 but stuck pipes caused the abandonment of Savina-1, although a good overpressured fracture was intersected within granite prior to the abandonment.

"On 6 December 2006 a magnitude 3.4 earthquake occurred at Basel, Switzerland where an EGS operation was conducting hydraulic stimulation in a well sited within the city itself."

During mid-2009 Geodynamics successfully achieved closed-circuit flow between Habanero-1 and Habanero-3, a very significant technical feat. Within a week prior to connecting the flow circuit to a 1 MW generator, the steel casing in the upper part of Habanero-3 cracked. A detailed investigation determined that an incomplete cement job left an air pocket between the steel casing and the rock formation. As hot water was cycled through the well, expansion and contraction of the casing eventually caused work hardening and then failure of the steel. Geodynamics received a major proportion of the cost of the well back from well insurance.

The joint venture partners spent $9 million on the design of Habanero-4 to mitigate all of the issues encountered in the previous wells. In the later part of 2012 Geodynamics conducted further hydraulic stimulation and flow testing from Habanero-4 and achieved the highest ever open-well flow rates from an EGS well. Geodynamics successfully commissioned the 1 MW pilot power plant in Quarter 2 2013 using Habanero-1 as injector and Habanero-4 as producer.

The successful drilling of Habanero-4 reflects the vast experience that has been gained at this project by Geodynamics. These learnings have come at a high cost—in excess of $0.5 billion—but will provide the basis for making EGS technology more available.

Fears of induced seismicity, and changed market conditions

Two events overseas raised awareness of geothermal induced seismicity, and concerns raised at a potential Australian project caused far reaching effects.

On 6 December 2006 a magnitude 3.4 earthquake occurred at Basel, Switzerland where an EGS operation was conducting hydraulic stimulation in a well sited within the city itself. Public outcry caused the immediate suspension of the project and legal action against the project proponents, although no charges were upheld. No damage was caused to buildings, although the geothermal company did pay out insurance claims because it was cheaper to do so than to go through a legal process with many claimants.

A company undertaking drilling for an EGS trial at The Geysers geothermal field, California, stopped its work partly due to public opposition. This project had US Department of Energy (DoE) funding

for the work, which caused embarrassment to the department and Government. As a consequence the DoE commissioned the development of a protocol for addressing induced seismicity associated with enhanced geothermal systems (Majer et al. 2012).

An Australian company (Greenearth Energy Pty Ltd - GRE) operating in the Otway Basin near Geelong made an application for Round 2 of the Geothermal Drilling Program (GDP) during late 2009. Based on news reports from the two overseas incidents above, a local resident, seeing plans for an EGS trial on the GRE website, raised concerns about induced seismicity. This happened at the same time as the Home Insulation Program was caught up in controversy and Government enforced a higher level of risk mitigation in its programs. This required adjustment to the GDP that delayed it by six months. By then the full effects of the Global Financial Crisis (GFC) were being felt and risk capital had become unavailable meaning that the five geothermal companies awarded Round 2 GDP grants ultimately relinquished the grants because they were unable to meet the matching funding obligations. Also, during this time, the price of oil went up resulting in higher drilling costs, and power demand in the National Electricity Market declined.

Petratherm received a Round 1 grant from the GDP, drilled Paralana-2, successfully hydraulically stimulated the metasedimentary reservoir (July 2011, Figure 1), and achieved good flows from the well in October 2011 (Figure 2). However, despite these good results, Petratherm was unable to raise sufficient matching funds from the investment market to match the remainder of its GDP grant.

Figure 2: Water flowing from the Paralana-2 open well flow test. Courtesy Petratherm Ltd.

Other setbacks

In December 2009 the proposed Carbon Pollution Reduction Scheme failed to pass through the Senate, and the Government subsequently announced a decision to delay implementation of any such scheme. This, combined with the GFC, acted to further reduce investment in the renewable energy sector, including geothermal companies.

Significant flooding occurred in central South Australia during 2009 and 2010, leading to delays in drilling at the Paralana and Habanero projects.

Panax Geothermal Ltd drilled the Salamander-1 well in the western Otway Basin. Flow testing in early 2010 failed to produce the high flow rates predicted by the company. In 2011 Geodynamics announced that the Celsius-1 well in the Cooper Basin did not have the permeability required to achieve economic flow rates. Both of these wells were targeting 'Hot Sedimentary Aquifer' resources, and the low flow rates achieved were received by the media and other observers as a failure of geothermal technology in Australia.

Government policy

Successive Australian Governments have had programs and other measures in place to assist the uptake of renewable energy in Australia. The largest of these has been the Renewable Energy Target. Geothermal projects have not advanced at a sufficient rate to benefit from this scheme.

Uncertainty around carbon pricing schemes has also not helped to encourage investment in geothermal companies.

The Australian Centre for Renewable Energy (ACRE) was established in October 2009 to promote the development, commercialisation and deployment of renewable energy and enabling technologies and improve their competitiveness in Australia. ACRE managed over $690 million of funding committed to support renewable energy and enabling technology development, and the Emerging Renewables Program was designed to include support for technologies such as geothermal energy. ACRE was incorporated into the Australian Renewable Energy Agency (ARENA) on 1 July 2012. ARENA is an independent statutory authority established under the Commonwealth Authorities and Companies Act 1997, tasked with the objectives of improving the competitiveness of renewable energy technologies and increasing the supply of renewable energy in Australia. ARENA is part of the Clean Energy Future package and has $3.2 billion of funding.

Geothermal exploration and drilling projects have received funding from the Australian Government through the Renewable Energy Demonstration Initiative, the Renewable Energy Demonstration Program, and the Geothermal Drilling Program. Several State Government grant funds have also been made available to geothermal companies.

Geothermal exploration and research and development activities have also been made eligible for tax rebates.

Each State and the Northern Territory have legislation and regulations in place that allow for geothermal exploration and extraction.

In 2008 the Department of Resources, Energy and Tourism produced the Geothermal Industry Development Framework, and Geothermal Industry Technology Roadmap. ARENA is conducting a geothermal review in the latter half of 2013 with an international panel of experts.

The future of geothermal in Australia

Despite the many advantages offered by geothermal, investment in geothermal development has been inadequate to sustain the pace of development forecast by companies in the mid-2000s. Further demonstration projects are needed to increase investor confidence in the technology, together with improvements across the resource discovery, characterisation and extraction processes to lower the costs of energy delivery. The challenge for geothermal in Australia is to rapidly build a level of understanding that will allow robust and reliable resource utilisation, in a timeframe shorter than the century or so over which technologies in the minerals and petroleum sectors have developed. This will require coordination, collaboration and increased funding. The geothermal sector is now working with ARENA in each of these areas.

References

Cataldi R. 1993. Review of historiographic aspects of geothermal energy in the Mediterranean and Mesoamerican areas prior to the Modern Age. Geo-Heat Centre Quarterly Bulletin (Klamath Falls, Oregon: Oregon Institute of Technology) 18 (1): 13–16.

Dickson MH & Fanelli M. 2004. What is Geothermal Energy? Istituto di Geoscienze e Georisorse, CNR, Pisa, Italy, Prepared on February 2004. Available at www.geothermal-energy.org/geothermal_energy/what_is_geothermal_energy.html.

Energy White Paper. 2012. Department of Resources, Energy and Tourism, Commonwealth of Australia, Canberra.

KamLAND Collaboration. 2011. Partial Radiogenic Heat Model for Earth Revealed by Geoneutrino Measurements. Nature Geoscience, 4:647—651, doi: 10.1038/ngeo1205.

Majer E, Nelson J, Robertson-Tait A, Savy J. & Wong, I. 2012. Protocol for Addressing Induced Seismicity Associated with Enhanced Geothermal Systems, DOE/EE-0662 www1.eere.energy.gov/geothermal/pdfs/geothermal_seismicity_protocol_012012.pdf

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Robots to improve satellite positioning accuracy in Australia

Sub-millimetre accuracy for global positioning

Nicholas Brown, John Dawson, Michael Moore, Shane Nancarrow and Guorong Hu

Robots are used in many ways to improve our lives by doing things more precisely, efficiently and quickly. As of May 21st 2013, Geoscience Australia can now claim to have two AuScope Australian Geophysical Observing System (AGOS) funded robots which will improve the accuracy of satellite positioning in Australia.

"Australia is in the fortunate position to be one of the few regions in the world to see all the new and emerging Global Navigation Satellite Systems."

Introduction

Satellite positioning is increasingly ubiquitous. Global Positioning System (GPS) users can currently achieve 5 metre accuracy with a hand held device (for example, smartphone), but within the decade the accuracy is anticipated to increase to a few centimetres due to improvements in computational and modelling techniques, and exploiting Australia's geographic location. Australia is in the fortunate position to be one of the few regions in the world to see all the new and emerging Global Navigation Satellite Systems (GNSS), including Galileo (Europe), GPS III (USA), GLONASS (Russia), COMPASS (China) and other regional systems being developed by Japan and India. This will enable new geospatial applications in geoscience, intelligent transport, precision agriculture and industrial automation to emerge as well as opening a world of new possibilities for smartphone applications. Nevertheless, for this ambition to become reality, a number of advancements and developments are required to geodetic infrastructure, analysis and modelling.

Geoscience Australia's role

Geoscience Australia has a key role in enabling Australia's National Positioning capability by operating and analysing the data from a national network of permanent GNSS stations that both realise the national coordinate system (that is, the set of reference locations that define Australia's latitude and longitude) and support the determination of the precise orbits of the GNSS satellites, a key requirement of precise user positioning.

Centimetre accurate positioning with GNSS

The underlying signals transmitted by the GNSS satellites can be considered as repeating sine waves. Measurements of these waves are referred to as carrier phase observations and they differ from the range-to-satellite measurements that the current generation of smartphones use. Carrier phase observations enable the distance between the orbiting satellites and a user's receiver to be determined with centimetre accuracy and are subsequently used to compute the user's 3D position. The more accurate the range measurements are, the more accurately the user can compute their position.

Carrier phase observations have been used for two decades by surveyors to undertake relative centimetre-accurate positioning but limitations

in communications, ground infrastructure and the expense of the receivers have meant that this capability has not transferred to the mass-consumer market. But this is set to change as the national GNSS network is supplemented with more sites with better communication links, high quality user receivers become cheaper and analysis techniques become more sophisticated.

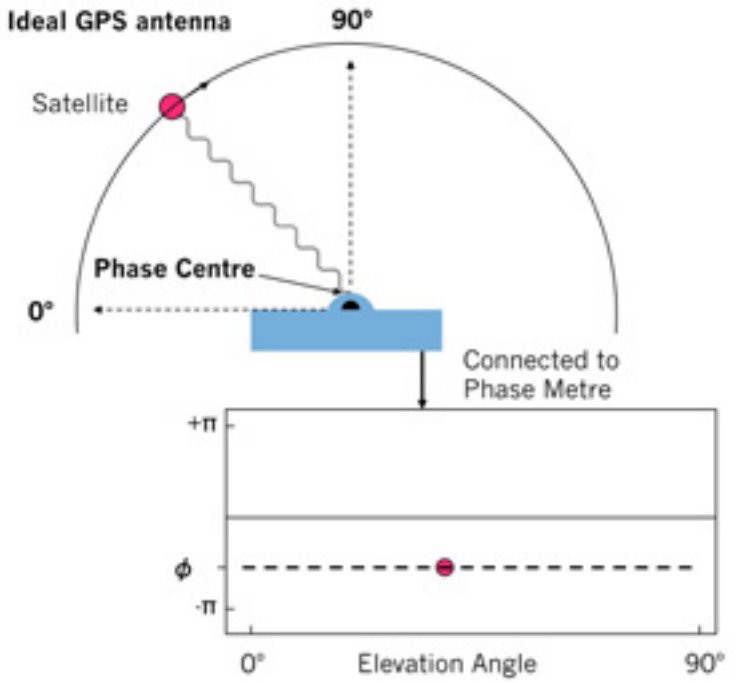

Figure 1: An ideal antenna, no bias (modifed from Gerry Mader).

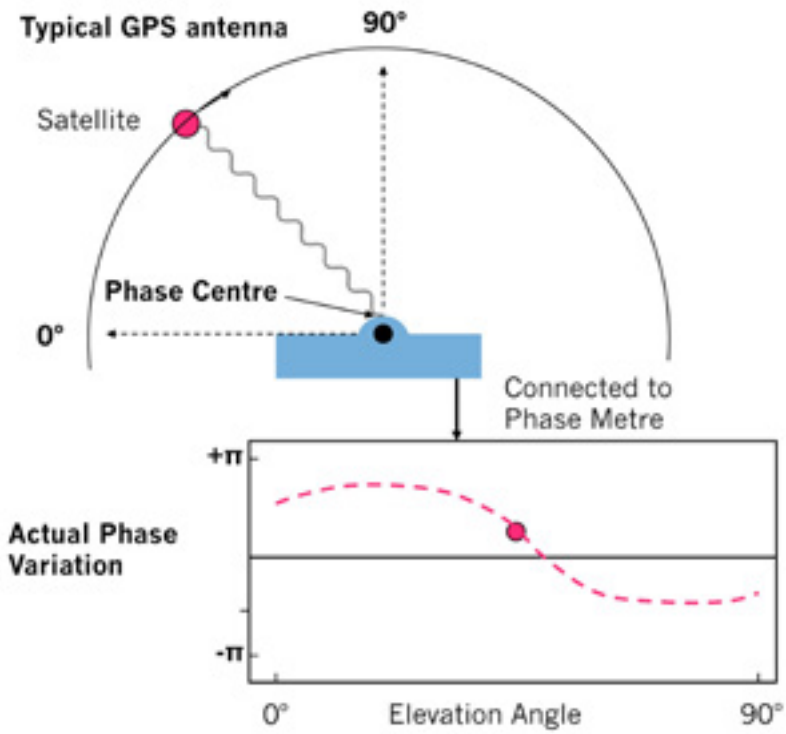

Figure 2: A typical antenna, with bias (modifed from Gerry Mader).

Modelling antenna biases

In the attempt to further improve positioning accuracy, the geodetic community have looked to each and every error source and have attempted to either eliminate or better model that error. GNSS antenna biases are one such error source. All GNSS antennas have small inconsistencies in their electronic components caused by the manufacturing process that currently limit their accuracy (compare Figure 1 and Figure 2). This is where the robots come in: they provide a means to investigate and develop models of the antenna biases. Essentially, antenna biases vary depending on the position of each satellite as they move across the skyline (that is, the satellite's azimuth and elevation). By rotating and tilting the GNSS antenna with a robot as it tracks the GNSS satellites, a highly accurate model of the antenna bias can be determined (Figure 3). By applying the models derived from the robotic system, these biases can be removed and the positional accuracy improved.

The GNSS research community have up until recently used generic antenna models for antenna types. However, with the ever growing accuracy requirements of GNSS users, individual antenna-specific modelling is necessary to further improve positioning accuracy. Antenna-specific models can only be derived using robotic calibration systems or prohibitively expensive anechoic chambers, neither of which was available to researchers in Australia, until now.

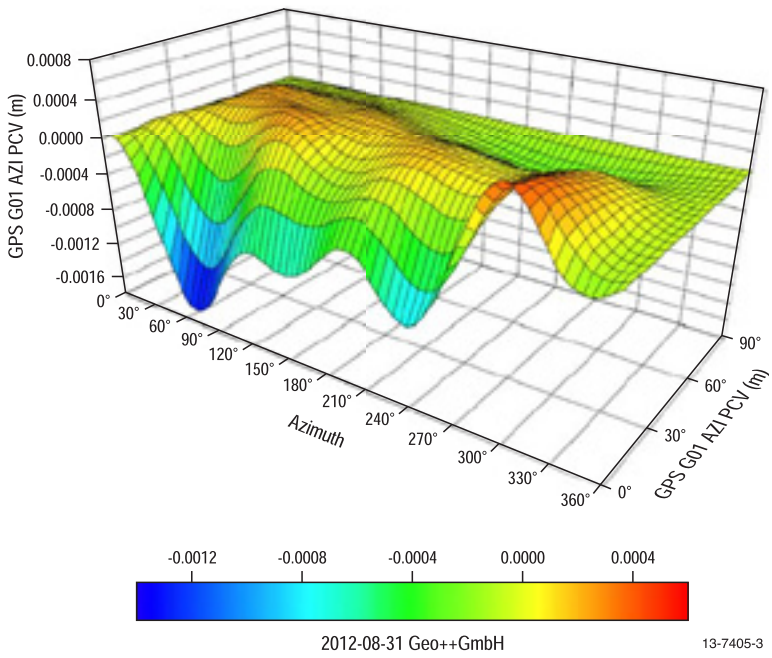

Figure 3: Antenna calibration solution plot.

Our robots

GNSS antenna calibration is a niche and highly specialised activity. Geoscience Australia is the home to one of five GNSS antenna calibration capabilities in the world and the only one in the southern hemisphere. The other four are at the National Geodetic Survey (Virginia, USA), University of Bonn (Bonn, Germany), SenB (Berlin, Germany), Geo++ (Hannover, Germany) and the Institute of Geodesy (IfE) (Hannover, Germany). The smaller of the two Geoscience Australia robots was purchased from Germany and its primary role will be to calibrate antennas prior to them being used in the field so the positions they record are free from antenna modelling bias. The larger of the two robots is unique to GNSS calibrations globally and will enable experiments to assess the impact of station and antenna design on positioning accuracy. Furthermore, it has a lifting capability large enough to support the calibration of GNSS satellite transmitters prior to launch and the speed and agility to replicate the movement a GNSS station would experience in an earthquake.

Improvements for science, industry and the public

Scientific and industrial GNSS users require high accuracy and integrity for applications to fields such as environmental monitoring, crustal motion, mining and construction. The improvements provided by absolute antenna modelling will allow these users to acquire positions an order of magnitude more accurately than they could of in the past.

A new national coordinate system

The current Australian geodetic datum, the Geocentric Datum of Australia 1994 (GDA94) was established in the 1990s, has relatively poor internal accuracy, weak linkages to the latest global coordinate system, and is 'frozen' at an epoch date of 1994. It will be unable to support the next generation of GNSS services and the many scientific endeavours that require accurate positioning, including sea level rise studies. The robotic calibration facility will enable an upgrade of Geoscience Australia's national GNSS network which will underpin an update of the Australian geodetic datum.

An improved understanding of earthquake hazard

Earthquakes in Australia occur after the long-term accumulation of strain on faults that is subsequently released. Over the last decade scientists have suggested that precise GNSS observations of crustal motion might provide insights into this seismic cycle. Towards this objective, Geoscience Australia, together with our State Government counterpart agencies, have established monitoring networks in the seismically active areas of Australia including the south-west seismic zone near Perth in Western Australia, the Flinders Ranges near Adelaide in South

Australia, and south-east Australia (Gippsland and Otway Basins). Geological evidence suggests that the deformation is likely to be small, perhaps as little as 0.1 mm/yr, and difficult to measure except over very long time spans. However, with improved GNSS antenna models the possibility of measuring deformation before an earthquake occurs may become a reality in time spans of several years. With this, an improved understanding of earthquake hazard in Australia will be achieved.

Figure 4: Robots are used to calibrate GNSS antennas and improve how accurately we can measure the dynamic Earth.

Sensing the atmosphere to improve weather forecasting

The Earth is surrounded by layers of gases held in place by the Earth's gravity field. Signals, such as those transmitted by GNSS, propagated from space, are delayed as they pass through the atmosphere. In the troposphere, the layer of atmosphere from the Earth's surface to approximately 20 kilometres altitude, the delay is proportional to temperature, pressure and humidity. The ionosphere, the layer of atmosphere from 50–1000 kilometres altitude, causes signal delays as a function of the frequency of the signal. The composition of both the troposphere and ionosphere vary both in space and time, and this variability currently limits the accuracy, speed and reliability of GNSS positioning. But it's not all bad news, and like a computer axial tomography (CAT) scan in medical science, the new GNSS signals and satellites can potentially be combined to provide a more complete 3D picture of the atmospheric delay as a function of time. Models that more completely remove the atmospheric delays will lead to improved accuracy, speed and reliability of positioning, and this ability to sense the atmosphere should ultimately lead to improved weather forecasting in Australia.

Construction process

Site selection and design for the antenna calibration facility began in the second half of 2011 with a number of site selection surveys to identify the best location for the facility on the grounds of Geoscience Australia. Ultimately, the location on the western side of the Geoscience Australia's support building was chosen as the preferred site because of its close connection to a power supply, good ground conditions and an unobstructed view to the north. This is important for GNSS users in the southern hemisphere because of GNSS satellite constellations; the majority of satellites are to the north of our location.

The construction of the facility was underway in January 2013 with Geoscience Australia managing the contractors. The

facility includes the smaller Geo++ robot and larger industrial robot, an air-conditioned hut for the robot controller to operate the robots, a rubidium external frequency (high accuracy) clock, a continuously operating GNSS station, multiple GNSS receivers and web camera to monitor the calibrations.

The state-of-the-art Global Navigation Satellite System robotic antenna calibration facility was officially opened by the Minister for Science and Research, Senator Don Farrell, at Geoscience Australia on 20 May, 2013.

For more information

email: ausgeomail.com.au

Related articles and websites

Video footage of the robots and the launch by Senator Don Farrell

www.ga.gov.au/about-us/news-media/media/accuracy-for-global-positioning.html

in brief

Mathematics embraces the Planet in 2013

This year is the International Year of Mathematics of Planet Earth (MPE). The year is aimed at developing a broader understanding of mathematics and statistics while encouraging discussion and more research on how the discipline can help to address global challenges.

The Australian Mathematical Sciences Institute is teaming up with Geoscience Australia and others to spread the word about how mathematics can help understand and address global challenges. Geoscience Australia's Chief Scientist Dr Clinton Foster is a proud ambassador for this initiative to promote the essential role of mathematical sciences in society.

Not simply disciplines of their own, mathematics and statistics are essential components to many. The year aims to emphasise just how big a role the mathematical sciences play in our world.

The central event of the MPE program will be a conference in Melbourne from 8–12 July to bring together the entire scientific community to cultivate discussions and collaboration and draw on the mathematical sciences to solve challenges faced by our planet.

Sessions will support the MPE themes:

- A planet to discover
- A planet supporting life
- A planet organized by humans
- A planet at risk

Geoscience Australia is organising sessions on 'Mitigating Natural Disaster Risk' and 'Realising our Subsurface Potential'. Plenary speakers invited for these sessions are Dr Robert Muir-Wood from Risk Management Solutions (London) and Professor Brian Kennett from the Australian National University (ANU). Professor Malcolm Sambridge from ANU will give the public lecture that will touch on the contributions of mathematics to the MPE themes and also point to new horizons.

Related articles and websites

Register for the event
http://mathsofplanetearth.org.au/events/2013/

Dr Clinton Foster talks about Maths and Planet Earth
http://mathsofplanetearth.org.au/clinton_foster

For more information

email: ausgeomail.com.au

in brief

2013 Acreage Release provides opportunities in underexplored regions

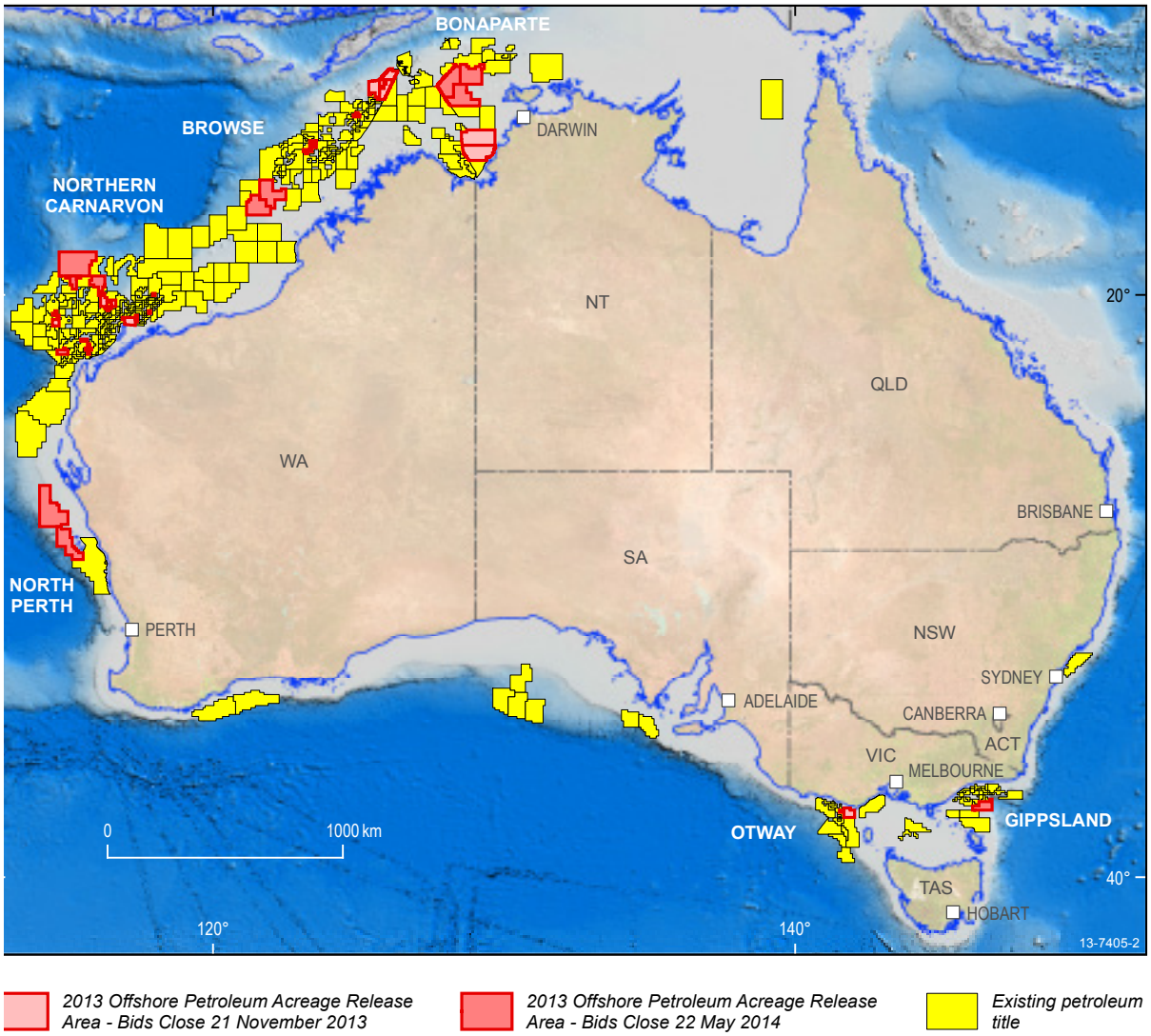

Figure 1: Offshore areas released for petroleum exploration as part of the 2013 acreage release

The Minister for Resources and Energy Gary Gray has released new offshore petroleum exploration areas at the annual Australian Petroleum Production and Exploration Association (APPEA) conference in Brisbane.

Minister Gray announced that 31 areas in 6 offshore basins would be available for petroleum exploration in Commonwealth waters off the Northern Territory, Western Australia and Victoria. Areas on the North West Shelf off Western Australia again feature prominently and also include the northern Bonaparte Basin.

Area sizes vary from 80 square kilometres to 134 668 square kilometres. The largest release areas are offshore from the Northern Territory and Western Australia in underexplored regions of the Browse Basin, the northern Exmouth Plateau and the offshore northern Perth Basin. Two areas in the Otway and Gippsland basins offshore from Victoria complete the 2013 Acreage Release.

The Australian Government's annual release of offshore petroleum exploration acreage encourages investment and provides open access to comprehensive pre-competitive geological and geophysical data gathered and collated by Geoscience Australia. This data helps industry to make informed investment decisions in relation to its exploration programs.

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Geoscience Australia's Dr Tom Bernecker, Senior Geoscientist and leader of the Acreage Release Project, said at the APPEA conference that this year's acreage release was again well supported by multiple industry nominations, signalling a sustained interest in exploring both mature and frontier regions.

"The 2013 Acreage Release also provides opportunities for exploration companies of all sizes in a range of shallow and deep water locations. Many areas are in already producing regions and close to existing infrastructure, while areas in underexplored regions present opportunities for applying innovative exploration concepts," Dr Bernecker said.

New data acquired in the northern Perth Basin as part of Geoscience Australia's recently completed Offshore Energy Security Program supports two key areas in this year's release. This data has been interpreted and integrated with existing datasets to provide a comprehensive assessment of the potential hydrocarbon prospectivity of this offshore frontier. Highlights of this work were presented by Dr Nadège Rollet and Dr Emma Grosjean at the APPEA conference.

Details of the 2013 release can be found on the Department of Resources, Energy and Tourism's Acreage Release website.

Related articles and websites

Offshore Petroleum Exploration Acreage Release

www.petroleum-acreage.gov.au/index.html

Minister Gray's media release

http://minister.ret.gov.au/MediaCentre/MediaReleases/Pages/acreage-release-announced.aspx

APPEA conference

www.appea.com.au

Offshore Energy Security Program

www.ga.gov.au/energy/energy-security-program/offshore-energy-security.html

For further information

email: ausgeomail.com.au

Promoting Australian mineral exploration investment opportunities in Canada

Figure 1: The *Australia Minerals* booth at PDAC2013

In March 2013 Geoscience Australia, together with senior representatives from the State and Northern Territory government geoscience agencies (the *Australia Minerals* team), attended the Prospectors and Developers Association of Canada's (PDAC) annual convention. The PDAC convention is the world's leading forum for investors, service providers and government agencies active in or associated with the global mineral exploration and mining industries. The convention was held in Toronto from 3–6 March and attracted over 30 000 Canadian and international delegates.

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The profile of *Australia Minerals* was lifted at PDAC 2013 with a new, professionally designed, custom booth and new branding (Figure 1), plus a mineral exploration investment seminar. One of over 600 booths in the Trade Show, the updated booth is more in line with Australia's leadership position in world mining and exploration. Feedback on the new booth was very positive.

In conjunction with Austrade, *Australia Minerals* also organised a mineral exploration investment seminar focussed on Australia's recent nickel, uranium and rare earth element discoveries in new mineral provinces, with presentations by Andy Barnicoat of Geoscience Australia and Australian exploration companies. The seminar also included a presentation by Ernst and Young on Australia as a low-risk mineral investment destination. The PDAC Technical Session on 'Australia's Au-Cu Deposits: Current Scene and Hidden Future', co-chaired by Rick Rogerson (Geological Survey of Western Australia), highlighted recent discoveries and involved Roger Skirrow from Geoscience Australia who presented on 'Australia's iron oxide Cu-Au provinces: world-class opportunities'.

Related articles and websites

Mineral Exploration Promotion Section
www.ga.gov.au/exploration-promotion

For further information

email: ausgeomail.com.au

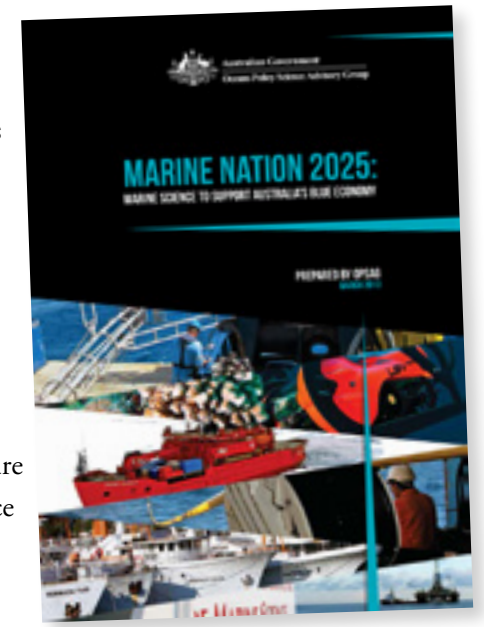
Working together for a marine nation

The importance of marine research to Australia's economy and to furthering our knowledge of Australia's vast marine jurisdiction was recently recognised with the release of the Australian Government's revised marine science framework, *Marine Nation 2025: Marine Science to Support Australia's Blue Economy.*

The Marine Nation 2025 framework report, prepared by the Oceans Policy Science Advisory Group, identifies the national challenges facing Australia and its marine estate, and outlines the opportunities for marine science to provide innovative solutions. It recognises strengths and weaknesses in marine research infrastructure and capability, recommends development of a 10-year marine science strategy and proposes the formation of a National Marine Science Advisory Committee.

Marine Nation 2025 outlines six interconnected grand challenges facing Australia's marine jurisdiction:

- Sovereignty, security, natural hazards
- Energy security
- Food security
- Biodiversity conservation and ecosystem health
- Dealing with changing climate
- Optimal resource allocation



Each of these grand challenges has a significant marine dimension with gaps in understanding or tools that can be addressed by marine science. To meet these challenges, *Marine Nation 2025* outlines a case for future investment in the three traditional pillars of

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science: observation, experimentation and modelling. The report also recognises that investment in science communication is needed to improve application and acceptance of science in policy, legislation and regulation.

Marine science cuts across many disciplines, and involves a range of government, university and research institutions. The Oceans Policy Science Advisory Group is as an advisory body comprising the leaders of Australian marine science organisations involved in marine research and providing information to support the management of Australia's marine domain. It is currently chaired by the CEO of the Australian Institute of Marine Science, Mr John Gunn.

Geoscience Australia contributed to development of *Marine Nation 2025*, in particular in relation to advice on territorial boundaries, marine planning, biodiversity conservation, natural hazards management, energy security and climate change adaptation measures. Our agency will continue to participate in the Oceans Policy Science Advisory Group and assist in the implementation of the revised framework.

Related articles and websites

Oceans Science Policy Science Advisory Group
www.aims.gov.au/opsag

For more information

email ausgeomail@ga.gov.au

Best practice science is open and transparent

Dr Clinton Foster, Chief Scientist, Geoscience Australia.
This article was first published as a Conscience piece in the June 2013 edition of Australasian Science.

We take for granted science outcomes like the GPS navigation functions in our smart phones, although few of us understand the science behind it. Science underpins everything we do in our modern society and yet the numbers studying science in schools, and in some disciplines at universities, are continuing to fall in Australia.

Science information is literally available on tap via the internet—but provides answers that are often many and sometimes contradictory. These may be without supporting evidence and untested, and are what I call 'assertive science'.

The past century has been an age of assertive science in which the title 'scientist', a white lab coat and the use of jargon allowed assertions to be made, sometimes with dire consequences. In public, an assertive statement or the phrase 'trust me I am a scientist' was commonly offered in support of a conclusion. Often they were made by an individual scientist presenting answers produced by a single research agency. That type of assertive science should, quite rightly, be unacceptable. But, paradoxically, it has persevered in our age of easy and rapid access to information.

There are two key issues: firstly, recognition that science actually underpins everything we do, and, secondly, what is the evidence base supporting a particular conclusion. Both are often overlooked. Current assertive science is often without evidence, yet its outcomes or answers may be widely accepted in public.

There is a temporal symmetry to this type of science, both based on data access: too little data (20th century) and too much untested data (21st century). In both cases there is a lack of understanding or explanation of processes undertaken to gather the available data.

The scientific method is based on the principle of testing ideas or hypotheses, through rigorous observing, recording, and repeated testing of data, understanding its limitations, and by allowing the processes, findings and data to be independently reviewed. The

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caveat is that it is to the best of our current knowledge, and that research is ever ongoing to discover and understand the unknown.

In the tsunami of information available on any topic, researchers and the public need to be confident that conclusions used to inform community decisions are based on the best available data, and that concepts and results are tested and accessible to interested persons or groups. There is an Australian Code for the Responsible Conduct of Research, and it is within that context that Geoscience Australia has reaffirmed its principles for research activities.

The six principles are embedded in Geoscience Australia's long term strategic planning and day-to- day operations. They reflect the fact that our reputation for providing timely, relevant, accurate and trusted technical advice on geoscience and spatial matters that affect the nation is highly valued.

As science is the fundamental tool of the agency, we recognise that our science outputs must be evidence-based, testable and transparent. It is essential that these outputs are peer reviewed, communicated effectively, and our science programs are benchmarked and monitored to ensure sustainable capability. This also requires a collaborative and cooperative approach within the agency, with external stakeholders, and with other science agencies. Collaborative science is essential because of the complexity and interrelationship of parameters that must be considered to assess issues such as the impact of natural hazards on communities.

Data custodianship and access is also a key priority to ensure that the best geological and spatial data sets are acquired, maintained and made available to all interested stakeholders, and particularly collaborative science agencies.

We are confident that these principles provide a solid foundation for our continued contribution to Australia's future well-being through the delivery of quality geoscience and spatial data and information.

The Science Principles document is available as a free download from the Geoscience Australia website.

Related articles and websites

Geoscience Australia Science Principles
www.ga.gov.au/about-us/corporate-documents/science-principles.html

Australasian Science
www.australasianscience.com.au

For more information

email: ausgeomail.com.au

Government geoscience enters new phase in the search for oil and gas

Marita Bradshaw, Senior Science Advisor, Geoscience Australia.
Article first appeared in PESA News Resources, June-July edition, Issue No. 124.

From colonial times, government geoscience has played a key role in revealing the resource endowment of Australia, even when geology itself was a young science. Today that work continues and one of the roles of Geoscience Australia is to build the national geological framework to assist petroleum and mineral exploration. As an agency within the Australian Government's Resources, Energy and Tourism portfolio, Geoscience Australia works closely with the State and Territory government geoscience agencies and with industry to achieve a national understanding of Australia's resources.

The announcement in November 2012 of additional on-going funding to Geoscience Australia will augment the provision of pre-competitive data that industry uses to discover and develop Australia's energy and mineral resources. Over the past few months the proposed components of Geoscience Australia's new and expanded petroleum program

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have been discussed with exploration companies, continuing the long partnership between government geoscience and industry. The new funding will enable Geoscience Australia to undertake a strategic analysis of the petroleum potential of both onshore and offshore Australia leading to new exploration opportunities and discoveries.

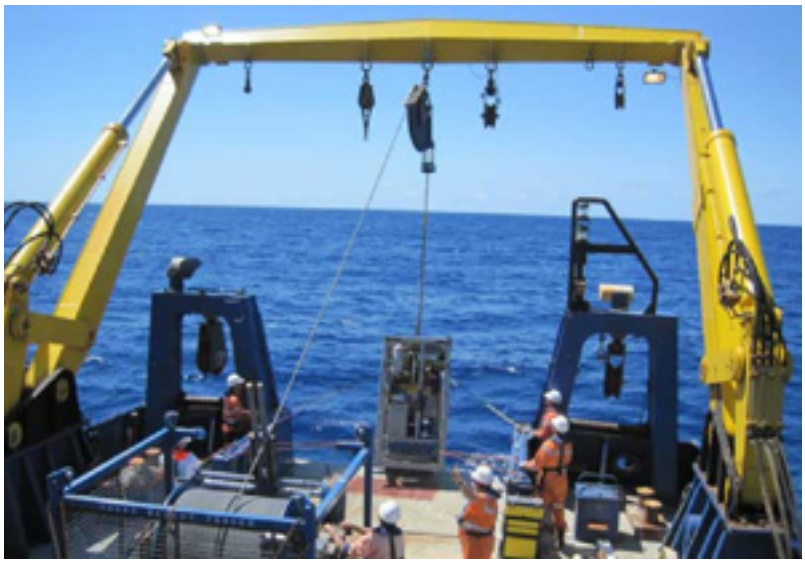

Figure 1: Crew aboard the RV *Southern Surveyor* deploy equipment during a hydrocarbon seepage survey of the northern Perth basin.

Geoscience Australia and its predecessors, the Bureau of Mineral Resources (BMR) and the Australian Geological Survey Organisation (AGSO), have been in the business of providing fundamental geoscience to underpin the search for hydrocarbons in Australia for over 60 years. The BMR was established in 1946 to acquire the fundamental data sets to reveal the resource endowment of the continent. Both geological mapping and geophysical surveys were part of the mix from the beginning. Australia's first seismic survey was undertaken by BMR around Roma, Queensland, in 1949–50 and early mapping in the Carnarvon Basin directed Ampol to the Exmouth Gulf region and the first oil discovery at Rough Range in 1953. An effective partnership between government geoscience and industry continued with the introduction of the *Petroleum Search Subsidy Act* in 1957 and deepened further once the Australian Petroleum Production and Exploration Association (APPEA) (or APEA as it was then) came on to the scene in 1959.

The onshore basins were the initial focus of the search for oil and gas by both industry and BMR. There was a shift offshore with the discovery of the giant oil fields in the Gippsland Basin, underlying Bass Strait, in the 1960s and BMR's continental margins surveys during 1972–73. This program systematically surveyed Australia's offshore areas using several different seismic vessels and so mapped the basin framework revealing areas of thick sedimentary section on the western, southern and eastern margins. From 1985 to 1998 the BMR's *Continental Margins Program* contracted the research vessel the *Rig Seismic* to map and sample the offshore to assess petroleum prospectivity and to start to build the database to define Australia's marine jurisdiction.

Government geoscience subsequently underpinned Australia's submission for areas of extended continental shelf to the United Nation's Commission on the Limits of the Continental Shelf (CLCS). In 2008 the Commission adopted recommendations that confirmed Australia's jurisdiction over an additional 2.5 million square kilometres, including some areas with petroleum potential.

Major pre-competitive programs of seismic data acquisition and dredging in offshore frontier basins were undertaken by Geoscience Australia during the 2000s. New data changed perceptions and exploration was encouraged into the Bremer, Ceduna and Duntroon sub-basins of the Bight Basin on the southern margin, and into the offshore northern Perth Basin on the southwest margin. Today more than 90 per cent of Australia's identified conventional oil and gas resources have been discovered in offshore Mesozoic marginal basins.

Results of pre-competitive program undertaken as part of the Offshore Security Program (2006–2011) will also be presented at the 2013 APPEA conference, including studies of the offshore northern Perth Basin in support of the annual offshore petroleum acreage release. Some of Australia's oldest petroleum systems will also be discussed, as the petroleum

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potential of the onshore basins is reconsidered.

However a new balance is now being struck with a pivot back to the onshore as the importance of coal seam gas (CSG), shale gas and tight oil and gas grows. The coming of age of the CSG industry in Australia and the 'shale gale' in North America has prompted a reconsideration of the petroleum potential of Australia's onshore basins. From 2010 to 2012 there has been a near doubling of the onshore basin area under exploration license and several major international companies have joined local explorers in their endeavours to unlock the potential of Australian Paleozoic and Proterozoic petroleum systems. The data holdings and previous studies of government geoscience agencies, including detailed geochemical analyses undertaken by Geoscience Australia, provide a knowledge store to support this new phase of onshore exploration.

The major increase in Geoscience Australia's funding enables the continuing story of government geoscience for hydrocarbon discoveries. Geoscience Australia has recently received additional on-going funding of $40 million per year ($34 million in 2013–14) to enable provision of pre-competitive data to help secure Australia's future energy and mineral resource needs. This funding will also deliver enhanced data stewardship and the continuation of vital services for geoscience monitoring and advice. This significant reinvestment will mean Geoscience Australia can, in effect, deliver a new prospectus for the nation's hydrocarbon resources, which will support the continued growth of onshore exploration and drive offshore petroleum acreage release.

Components of the new program will include whole-of-margin and national studies to address fundamental issues affecting prospectivity, plus the acquisition of new data and geological studies in areas adjacent to proven basins, and in poorly understood and remote frontiers. Petroleum systems, palaeogeography, and onshore source rock studies will be a particular focus; and there are plans to undertake a major tectonic and structural study of the western and north-western margins. Data custodianship is a key priority of the new program to ensure that geological and geospatial information is captured and made freely available to industry, government, academia and the public.

Details of the new future program are currently being developed. Geoscience Australia's CEO Dr Chris Pigram provided an update on the future program as a keynote presentation at APPEA's annual conference in Brisbane.

For more information

ausgeomail.com.au

The new funding enables Geoscience Australia to continue to build the fundamental datasets and undertake the geological framework studies that will help to reveal Australia's petroleum endowment. The new program has a long-term focus, with pre-competitive data acquisition campaigns both onshore and offshore, as well as new scientific studies.

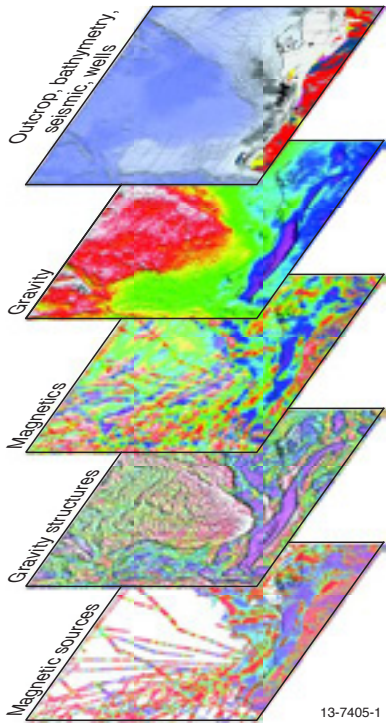

Figure 2: Series of datasets obtained during the South-west Margin Project completed under the Australian Government's Offshore Energy Security Program (2006–2011).

Related articles and websites

PESA News

www.pnronline.com.au/article.php/200/2350

in brief

Geoscience Australia support for AusAID's mining for development initiative

Humanitarian aid programs supporting basic health, education, and disaster response initiatives are often the public face of efforts by the Australian Agency for International Development (AusAID). However, initiatives to support economic development in partner countries are also an important objective and AusAID is diversifying its approach to economic development and poverty reduction through the Mining for Development (M4D) Initiative. The details of this assistance initiative were announced by the former Prime Minister, the Hon. Julia Gillard MP, in October 2011. The AusAID M4D Initiative encompasses development assistance in the areas of economic policy and legislative development, governance and regulatory frameworks, revenue transparency, community engagement, and improving geoscientific information to enhance sustainable management of the mining sector. Geoscience Australia has been contracted to scope a three-year program designed to assist developing countries to sustainably develop their mining sectors through improved geoscientific information delivery.

The importance of geoscience information in an aid context

Geoscience information underpins the sustainable development of mineral resources. Stimulating sustainable resource development and wealth for both communities and governments can contribute to economic growth and poverty reduction within developing countries. One way to achieve this is through the acquisition, management, interpretation, and dissemination of pre-competitive geoscience data. The presence of skilled geoscience professionals, knowledge and data about national mining potential and strong geoscience management arrangements improves the ability of countries to attract and regulate mining exploration and investment in a sustainable manner and allows for long-term economic, physical, and social planning. Governments with good geological information are also better placed to negotiate with mining companies—this can result in higher royalty payments, improve local participation and increase investments in shared infrastructure.

Geoscience Australia's role in M4D

The role of Geoscience Australia, in conjunction with the State-Territory geological surveys in the successful development of the Australian minerals industry is a key reason why Geoscience Australia has been contracted by AusAID to conduct the current scoping program. The Geoscience Australia-led M4D Geoscience Information Strengthening project has scoped the feasibility and demand for engagement by partner countries in a longer term three-year capacity building project.

Major outputs to assist developing countries

To date Geoscience Australia has completed the 'Assessment of Mineral Potential, Geoscience Survey Capacity, Risk, and Geological Aid in Africa, Asia, Latin America, and the Pacific' report which was formally released by Minister Gary Gray on 23 May 2013. The report provides a baseline assessment of the mining sector in assessed countries, and provides the regional context within which M4D will ultimately operate. In this report, the mineral sector potential of 138 developing countries was assessed using four broad categories: geological potential and existing resource sector, geoscience survey capacity, socio-political risk, and the degree of geological assistance the countries have, or are currently receiving. The report breaks down the assessments into four broad geographical regions, with each region's data being displayed graphically (Figure 1).

Data displayed in the report are from a mixture of commercially provided, published and unpublished sources. Where data have been generated specifically for this report, full methodologies, and the limitations of those methods, are described.

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Figure 1. Overview of the status of known mineral resources and the minerals industries of the Latin American region. The figure shows two of the assessments in the Mineral Potential and Mineral Resources chapter. The known mineral resource assessment informs readers about how many well-known deposits of minerals ('resources') there are in any given country, while the existing mining industry assessment uses world production rankings to indicate how much existing mines are currently producing . See the full report for a detailed methodology. The categorised assessment approach used in all of the assessments facilitates easy observations: in this figure the maturity of the mining sector in Brazil is evident, with both very large known mineral resources and a very large existing mining industry (e.g., primarily iron ore).

In addition to this report, a series of in-depth information briefings has also been completed for countries and territories identified as potential assistance recipients. Detailed briefings have been prepared for: Afghanistan, Bougainville, Ghana, Indonesia, Liberia, Myanmar, Papua New Guinea, the Solomon Islands, South Sudan, Sri Lanka, and Zambia. These reports provide an assessment of the geology, mineral resources, exploration opportunities, mineral production, mining sector institutional capacity (legislation, economics, sectoral constraints, etc), and the general geoscientific capacity of the current government geological survey and Ministry of Mines.

An important milestone in the M4D scoping process was to conduct in-country scoping missions to:

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- test if demand for an activity to improve the quality of available geological information is present
- explore possible areas of collaboration between the Survey's and other agencies
- understand the policy environment, and inform Geoscience Australia's program design.

Scoping missions to Indonesia and Papua New Guinea were undertaken in December 2012 and April 2013, respectively. These missions allowed Geoscience Australia staff to meet potential partner agencies and others in the mining sector to obtain a better understanding on whether assistance under the M4D Initiative would be beneficial, and where that assistance would be best targeted to have the most sustainable and far-reaching impact. Particular care was taken during scoping missions to engage with a range of government agencies, industry representatives, and possible assistance delivery partners to assure an informed view of assistance that might be considered.

The findings from these scoping missions and the earlier desk-based research are currently being used to produce a full program design which was submitted to AusAID for consideration in May 2013.

For more information

email: ausgeomail@ga.gov.au

Related articles and websites

Assessment of Mineral Potential, Geoscience Survey Capacity, Risk, and Geological Aid in Africa, Asia, Latin America, and the Pacific

www.ga.gov.au/metadata-gateway/metadata/record/gcat_74580/

product news

New geophysical datasets released

Datasets from four new geophysical surveys have been released since March 2013.

Airborne Magnetic – Radiometric - Elevation Surveys

Survey	Date	1:250 000 Map Sheets	Line Spacing (m), terrain clearance (m), orientation	Line km	Contractor
Mount Barker/ Lake Muir	April 2011 – January 2013	Pemberton (pt), Mount Barker (pt), Irwin Inlet (pt), Albany (pt)	200 m 50 m north – south	120 000	GPX Surveys Pty Ltd
South Pilbara	May 2012 – January 2013	Yarraloola (pt), Pyramid (pt), Mount Bruce (pt), Roy Hill (pt), Newman (pt), Balfour Downs (pt), Robertson (pt)	400 m 60 m north – south	133 818	GPX Surveys Pty Ltd
Widgiemooltha South	November 2012 – April 2013	Widgiemooltha (pt), Norseman (pt)	100 m 50 m east – west	131 396	Thomson Aviation

Gravity Surveys

Survey	Date	1:250 000 Map Sheets	Station Spacing (m), orientation	Stations	Contractor
West Murchison	September – November 2012	Belele (pt), Murgoo (pt), Cue (pt), Yalgoo (pt), Kirkalocka (pt), Perenjori (pt), Ninghan (pt), Barlee (pt), Jackson (pt), Bencubbin (pt)	2500 m NS-EW grid	11 897	Atlas Geophysics Pty Ltd
East Amadeus	May – July 2012	Ayers Rock, Kulgera (pt), Lake Amadeus (pt), Henbury (pt), Finke (pt), Rodinga (pt), Hale River (pt), Mount Liebig (pt), Hermannsburg (pt), Alice Springs (pt)	4000, 2000 and 1000 m NS-EW grid	7560	Atlas Geophysics Pty Ltd

For more information

email: ausgeomail.com.au

events

Exposing earth science at Geoscience Australia

Geoscience Australia continues to offer education and outreach programs to promote awareness and knowledge of the Earth sciences, and the contribution geoscience makes to the Australian economy, resource management and environmental protection. Outreach programs, such as Open Day, and participation in activities to celebrate National Science Week and Earth Science Week, aim to raise awareness and promote the programs that Geoscience Australia undertakes.

Geoscience Australia's Open Day will be held on Sunday 18 August 2013. Open Day, which coincides with the conclusion of National Science Week, is an opportunity for interested members of the public to visit the agency's headquarters at Symonston, ACT. A range of displays, tours and activities will showcase how the agency's research is being applied to some of the major challenges facing Australia today. Tours of the Australian Tsunami Warning Centre, the Sensitive High Resolution Ion Microprobe (SHRIMP) and fossil laboratories, an Antarctic experience, a walk back in time, rock identification, gold panning and map making are some of the activities planned for the day. The roving dinosaur will also be back for another year, encouraging children to experience what it may have been like in the Jurassic.

Figure 1: Crowds at Geoscience Australia Open Day 2012.

Earth Science Week (ESW) is an international initiative to promote the Earth sciences and raise awareness of the contribution geoscience makes to the community. This year's ESW will be held from 13 to 19 October with the theme of 'Mapping Our World'. Geoscience Australia will once again host the Earth Science Week 2013 webpage to promote activities that will happen around the nation.

In the lead up to Earth Science Week, Geoscience Australia will again be running the Top GeoShot photographic competition. This competition is open to members of the public and aims to produce a collection of images that capture the essence of Earth science in Australia. This year's theme is 'Exposed to the Elements' and entries are due by 23 September 2013. Winning entries will be announced during Earth Science Week and will be on display in the foyer of the Geoscience Australia building.

Further information and updates on Open Day and Earth Science Week activities will be included on the Geoscience Australia's Public Programs website.

Related articles and websites

Geoscience Australia's Public Programs

www.ga.gov.au/education/public-events.html

For more information

email: ausgeomail.com.au

events

Australian Museum night talk: Geology of Australia—how a continent shaped a nation

Following a series of highly successful public lectures in Perth and Canberra, Dr Richard Blewett from Geoscience Australia will again be presenting the popular *Shaping a Nation* public lecture at the Australian Museum in Sydney on Thursday 18 July.

Australia's geography and geology have shaped the nation in many ways, through the climate, soils and landscapes, seascapes, water, minerals and energy, as well as the unique flora and fauna of this continent and what the fossil record tells us about the evolution of life and the planet in general. Join Richard Blewett in exploring the challenges and opportunities presented by Australia's rich geological heritage.

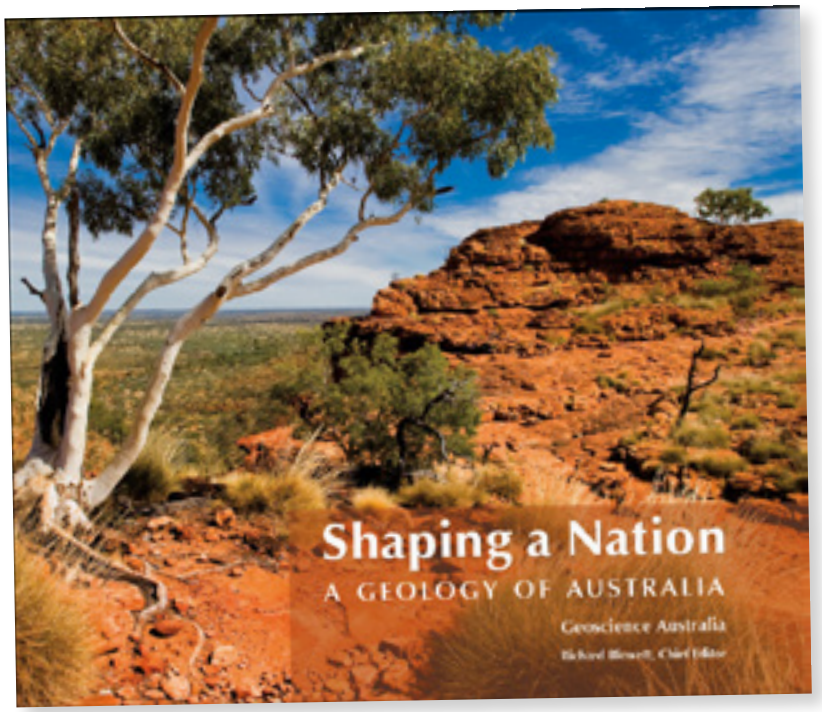

Figure 1: Cover image of Shaping a Nation: A Geology of Australia.

Bookings are essential via the Australian Museum website, or please call 02 9320 6255.

Dr Richard Blewett, an Aussie by birth, left for Africa and UK in the 1970s to study and work. He returned to Australia in 1990 to join Geoscience Australia, where he is presently the Group Leader of Regional Geology and Mineral Systems in the Minerals and Natural Hazards Division. Richard was Chief Editor of *Shaping a Nation: A Geology of Australia* which was published to celebrate Australia as the host nation of the 34th International Geological Congress held in Brisbane in 2012.

Related articles and websites

Australian Museum Geology of Australia Night Talk
http://australianmuseum.net.au/event/Night-Talk-Geology

For more information

email: ausgeomail.com.au

events

Conference of the Australia Science Teachers Association (CONASTA 62)
7–10 July 2013

La Trobe University
Contact: Australian Science Teachers Association (ASTA)

conasta@asta.edu.au
www.asta.edu.au/

Mathematics of Planet Earth 2013
8–12 July 2013

RMIT Melbourne
Contact: Joanna Wilson

phone: +61 3 9035 9536
fax: +61 3 8344 6324
mpe@amsi.org.au
www.mathsofplanetearth.org.au/mpe2013/

Australian Museum night talk: Geology of Australia—How a continent shaped a nation
18 July 2013 (7.00pm)

Australian Museum
Australian Museum Geology of Australia Night Talk

phone: +61 3 9320 6225
http://australianmuseum.net.au/event/Night-Talk-Geology

International Geoscience and Remote Sensing Symposium
21–26 July 2013

Melbourne Convention and Exhibition Centre
Contact: Institute of Electrical and Electronics Engineers (IEEE) Geoscience and Remote Sensing Society

info@igarss2013.org
www.igarss2013.org/

National Science Week 2013—A Century of Australian Science
10–18 August 2013

Contact: National Science Week Office

scienceweek@innovation.gov.au
www.scienceweek.net.au

ASEG-PESA 2013—23rd International Geophysical Conference and Exhibition
11–14 August 2013

Melbourne Convention and Exhibition Centre
Contact: The Australian Society of Exploration Geophysics and the Petroleum Exploration Society of Australia

aseg-pesa2013@arinex.com.au
www.aseg-pesa2013.com.au

Geoscience Australia—Open Day
Sunday 18 August

Geoscience Australia
Contact: Vicki Pow

vicki.pow@ga.gov.au
www.ga.gov.au/education/public-events/open-day.html

IAH 2013 Congress—International Association of Hydrogeologists
15–20 September 2013

Perth Convention and Exhibition Centre
Contact: 2013 IAH Congress website

www.iahcongress2013.org/

events

Top GeoShot photographic competition—'Exposed to the Elements'
Closing date 23 September 2013

Geoscience Australia	www.ga.gov.au/about-us/news-media/news-2013/do-you-have-australias-next-top-geoshot.html

Earth Science Week 2013—Mapping Our World
13–19 October 2013

Contact: info@earthsciweek.org	www.earthsciweek.org www.ga.gov.au/education/public-events/earth-science-week.html

For more information

email: ausgeomail.com.au