10.1071/PVv2010n148p31

Geophysics at Geoscience Australia: now and in the future

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The following is based on the Plenary Address delivered by Geoscience Australia CEO, Dr Chris Pigram, to the ASEG–PESA 2010 Conference in Sydney on 23 August 2010.

Introduction

Following the global financial crisis, our region is driving strongly towards another major cycle in the development of and demand for resources. While all booms have cycles, there is no doubt that as very large populations of our region develop we will see a sustained demand for energy and resources. Accompanying this is a strong message coming out of China that the future has to be green and sustainable.

In this context, geophysics will be at the forefront of Australia's exploration and mining industry as they tackle the challenge to extract more and better quality geological information and knowledge from new and existing data sources to enable Australia to meet the demand for energy and mineral resources.

As one of the largest employers of geophysicists in the country, Geoscience Australia will seek to utilise its skills to improve our knowledge of the Australian continent, at a range of scales, to sustain a resources pipeline and to understand the intra-plate processes which drive the occurrence of natural hazards. The challenge we face is great but it is clear that any real breakthrough in characterising and understanding the Australian continent will only come from an understanding of the depth dimensions. That is, we have to be able to begin understanding the continent, and all the processes which have shaped it, in 3D and 4D.

Geophysics is a fundamental component in 3D earth models and mathematically rigorous methods will underpin the work Geoscience Australia does to achieve this understanding. Ultimately, when applied in a holistic way, this approach will help to advance Australia's resource discovery rate.

The success of pre-competitive datasets in Australia is well documented, but the future for organisations such as Geoscience Australia rests in combining traditional geoscientific data collection with rigorous mathematical modelling and inversion techniques and ever increasing computer power. This will allow us to map the Australian crust in the depth-dimension and thereby obtain a far better understanding of the geological evolution of the continent and, consequently, the processes which have influenced our massive natural resource endowment. It will provide opportunities also to exploit new energy sources such as geothermal power.

National datasets

During the past 60 years, enormous quantities of high quality geophysical and geological data have been acquired over the Australian continent and offshore jurisdictions by Geoscience Australia and its partners in the States and Northern Territory as part of a systematic mapping of the Australian continent. This has resulted in the production of a series of fundamental national datasets which provide the highest quality national coverage in the world.

Through its Onshore Energy Security program, Geoscience Australia commissioned the Australia Wide Geophysical Survey (AWGS) which was the largest single airborne geophysical survey ever flown. It covered the Australian land mass with north–south flight lines spaced 75 kilometres apart, and east–west lines spaced 400 kilometres apart. The survey baseline results allowed 640 separate airborne radiometric surveys to be levelled and merged together to produce a new Radiometric Map of Australia.

Because the new Radiometric Map has been calibrated to the International Atomic Energy Association datum, researchers and explorers can now make quantitative assessments and comparisons of radiometric anomalies. Results from the AWGS have been used also to improve the quality and detail of the Magnetic Anomaly Map of Australia, with Geoscience Australia recently releasing the 5th edition (see Figure 1).

This new map and associated grid database has increased the accuracy of the continental-scale of the Magnetic Anomaly Map by matching and merging 795 individual survey grids, and includes an additional 155 individual grids acquired since publication of the previous edition.

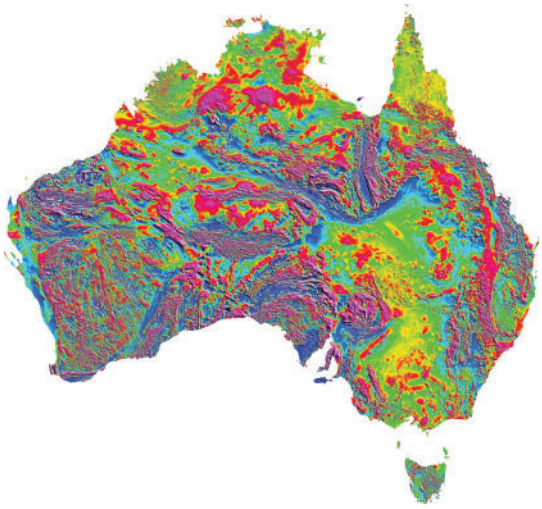

Fig. 1. *Magnetic Anomaly Map of Australia (5th edition).*

As well as the new composite digital grid of the total magnetic intensity of Australia at a resolution of 80 metres, a range of new digital derivative magnetic products at the same resolution will be released shortly. These will include variable reduction-to-the-pole of the TMI, the first vertical derivative of the TMI and various others.

Seismic surveys

Seismic reflection surveys are a primary tool to image Australia at depth and Geoscience Australia has obtained more than 5000 kilometres of deep crustal reflection seismic and magnetotelluric traverses to date. These data target uranium/thorium and geothermal potential in the Mt Isa province and the Gawler craton as well as hydrocarbon potential in the Officer, Amadeus, Georgina, and Darling Basins.

In North Queensland, the work resulted in the discovery of the previously unknown Millungera Basin beneath the more recent Carpentaria Basin to the east of the Mt Isa province. The work also revealed a fundamental crustal suture at the eastern edge of the province, a thinning of the crust towards the Georgetown province and a world class faulting of the Moho. These discoveries together have changed the understanding of the geological evolution of the region and its crustal processes.

AEM for regional depth imaging

Geoscience Australia also has begun pioneering the use of airborne electromagnetic (AEM) surveys as a regional depth imaging technique. Regional-scale AEM surveys have been flown in the Paterson province of Western Australia, the Pine Creek province of the Northern Territory and a third survey is underway in the Frome Embayment region of South Australia (see Figure 2). This is the first time that entire geological provinces have been covered by a single regional AEM survey using line spacing of up to 5 kilometres.

Geoscience Australia is flying AEM to reduce risk in uranium exploration by imaging large scale geological structures such as unconformities, faults and paleochannel systems, as well as providing baseline information about the penetration and resolution of AEM surveys, particularly geological terrains, which will assist industry when designing more detailed surveys.

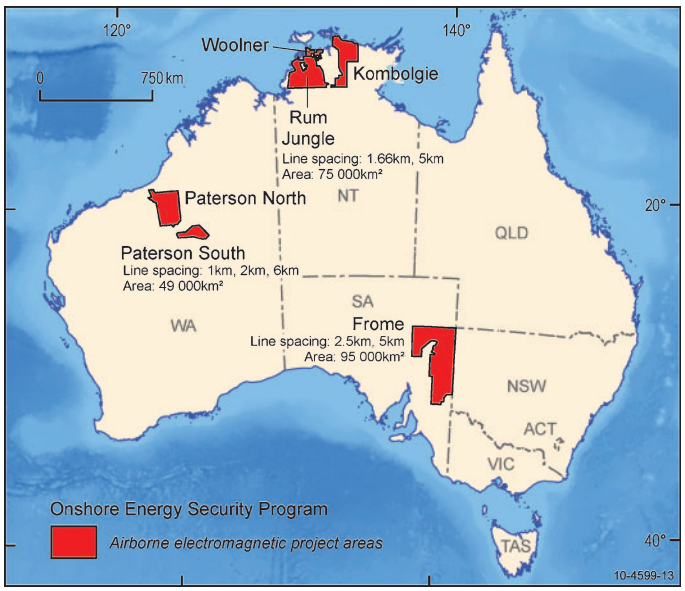

Fig. 2. *Location map showing major regional airborne electromagnetic surveys.*

Geodesy programs

It is timely to remember that these great datasets are possible only because of precise, high quality navigation, a benefit in which Geoscience Australia plays a vital role through its Geodesy programs. The agency operates the National Geospatial Reference System which can be used during acquisition of geophysical data to ensure precise spatial location information.

Geoscience Australia is moving to improve the Geodetic Reference Frame to millimetre accuracy, which will provide a

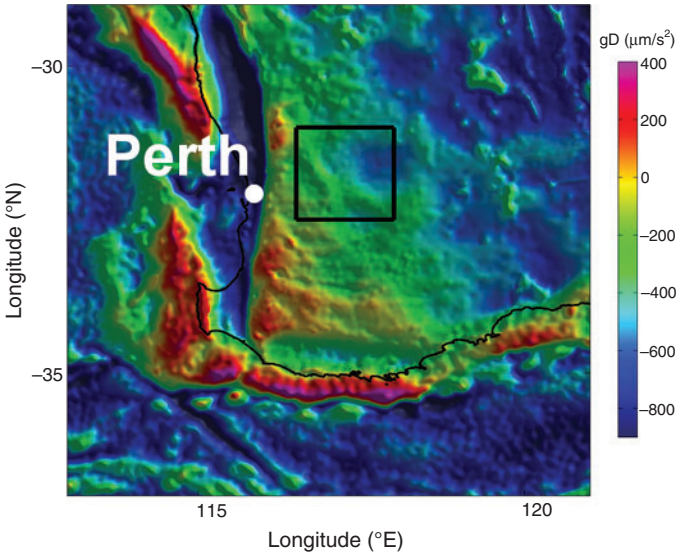

Fig. 3. *Kauring geophysical test site northeast of Perth, Western Australia.*

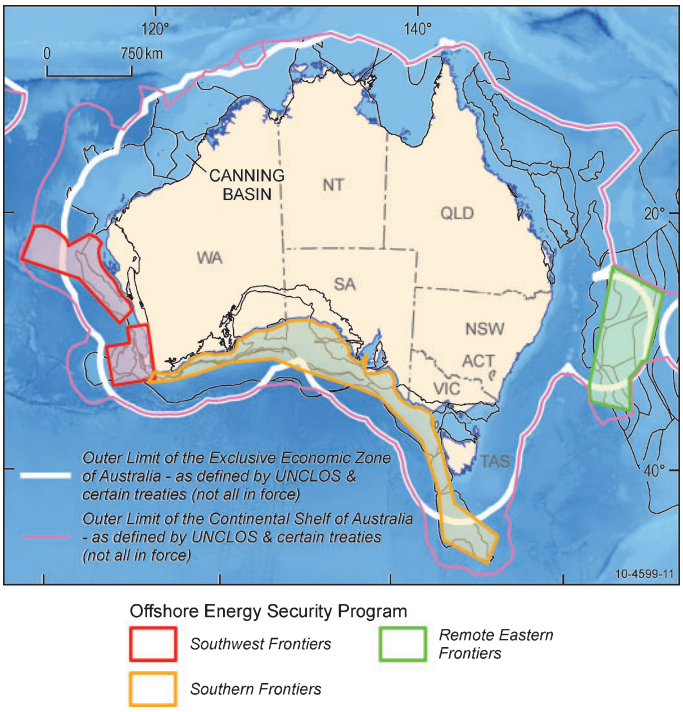

Fig. 4. *Areas of activity under the Offshore Energy Security program.*

positioning capability of less than two centimetres across the whole of the continent.

When complete this high precision reference frame will allow the measurement of deformation in the Australian continent and begin to understand for example the intra-plate deformation which is occurring in Australia and, subsequently, better understand the drivers and causes of the earthquake hazard in Australia.

Kauring geophysical test site

As a further step to improve data acquisition and interpretation, the Kauring geophysical test site (see Figure 3) has been set up 100 kilometres from Perth to fully test and evaluate available and future exploration technology.

Established as a collaboration involving Geoscience Australia, the Geological Survey of Western Australia, Rio Tinto and the aerial survey company, Fugro, the test site has been covered by detailed ground gravity surveys which will provide an excellent level of accuracy for researchers, industry and service companies to ground-truth and compare airborne systems.

Researchers and companies can acquire data along standard test profiles and compare outputs to the high quality ground observations, and the results of trials carried out by other organisations. The geoscientific research community will be able to download data for analysis and comparison to determine their suitability for different applications.

Offshore Energy Security program

Geoscience Australia's Offshore Energy Security program also obtained 2D seismic reflection, swath bathymetry and gravity and magnetic seismic data offshore from Western Australia in support of the Australian Government's acreage release program (see Figure 4 for locations). That work involved the acquisition of more than 7300 line kilometres of 2D seismic reflection, 230 000 square kilometres of swath bathymetry and some 25 000 kilometres of gravity and magnetic data. The agency also acquired high quality reflection seismic, gravity and magnetic data along with refraction data using sonobuoys, over the Capel and Faust Basins off the east coast.

Data integration

Combining gravity anomaly data, magnetic and radiometric datasets with earth imaging data such as seismic reflection and refraction, magnetotelluric and AEM data is the first step in preparation for computer simulation and modelling applications to help us better understand the 3D potential in greenfields and underexplored areas.

All of these advances will enhance the attractiveness of Australian geological terrains to the global exploration industry and ensure future investment in Australia's resource industries to sustain prosperity for future generations.

These outcomes can be achieved only through the use of geophysical techniques and the employment of geophysicists to interpret and integrate these potentially vast datasets. The challenge that sector now faces is to provide high quality pre-competitive geological information to expedite exploration successes.