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UNCOVER initiative
Ushering in a new era of exploration in Australia

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On behalf of the UNCOVER Executive Committee, Australian Academy of Science, Canberra.

The UNCOVER initiative is now moving into an implementation phase. The upcoming open Summit in Adelaide will begin to chart the necessary journey for exploration geoscience in Australia. This is an initiative owned by industry, geological surveys and researchers alike.

Introduction to UNCOVER

It is well-recognised that Australia has benefited enormously from its rich endowment of mineral resources. It is also widely believed that most of Australia's easily-found economically viable mineral deposits have already been discovered and, to a large extent, exploited.

Most of our future mineral discoveries will have to occur in the approximately 80% of Australia that is covered by regolith.

While there is every reason to believe that the prospectivity of these covered areas is similar to that of those areas where Australia has already proven to be richly endowed, exploring undercover presents a new set of difficult challenges and so the success rate of mineral exploration has dropped dramatically. Simply put – our traditional approaches are falling way short of being as effective as they were in the outcrop. This is a global problem, but affects Australia more than most due to the amount of and in parts, the depth of cover.

What we need in reality is a technical and economically attractive value proposition for mining companies so that they are compelled to invest a greater proportion of their exploration and mining development budgets in Australia compared to the alternatives.

Real investment levels, especially in the non-ferrous metals arena, have failed to significantly improve despite efforts by industry, state and federal surveys and researchers to provide the technical solutions. There is little doubt that Australia possesses the intellectual capability to meet these challenges and to develop the knowledge necessary to usher in a new era of successful exploration in covered areas. UNCOVER was developed from the recognition of the real issue being the development of an effective national collaboration to bring together players from industry, government and academia to define the important questions and then work together to answer those questions in an effective manner.

The goal of the UNCOVER initiative is to develop that collaboration and, through consultation across the sector, identify and define the important questions and datasets. This will then inform a strategic approach that will identify, develop, and deliver the science to create the knowledge and technologies that will improve the success rate of mineral exploration in the covered areas of Australia.

A strategic focus on the questions that are important to industry will facilitate the development by geoscience researchers, leveraging off the work done by geological surveys and industry, of knowledge that will have a much greater direct impact than is currently the case. Between the industry ($500 M), the geological surveys ($150 M) and R&D ($200 M) there is close to $1 billion a year in funding on an infrastructure base of around $3 billion. The issue for UNCOVER is to make more effective use of that investment in order to unlock the future mineral potential before the current mining industry exhausts the known reserves base.

It should be noted here that the initiative is not, in and of itself, about science and scientific research. It is, instead, fundamentally about resources for the nation; science is the tool.

It should also be noted that there is no suggestion here of a quick-fix solution. This is a strategic approach intended to position Australia well for the future when it becomes apparent to international mining companies that most of the world's easily-found economically viable mineral deposits have already been discovered and that Australia is providing the technical and economically attractive solutions to attract exploration investment.

UNCOVER history, success so far and immediate future

The Australian Academy of Science (the Academy) dedicated its 2010 Theo Murphy High Flyers Think Tank to the important national issue of the decline in exploration success. Participants proposed an ambitious and integrated research programme to enable Australia to uncover more of its mineral wealth.

A group of science leaders convened under the aegis of the Academy to address, through implementation of the think tank's recommendations, this decline in the success of Australian mineral exploration. This has now become the UNCOVER Initiative.

After broad consultation, UNCOVER released the document *Searching The Deep Earth: A vision for exploration geoscience in Australia*.

That vision has now been broadly accepted and forms the core of the National Mineral Exploration Strategy recently released by the Government's Standing Council on Energy and Resources.

For the first time, each of the state geological surveys, Geoscience Australia, CSIRO geoscience programmes and State and Commonwealth governments are working to the same vision and strategic plan.

UNCOVER was used to frame the arguments leading to Geoscience Australia receiving $11 million per annum (from 2013–14 onwards) for onshore pre-competitive data acquisition. This funding was announced on 11 November 2012. The work, which will be undertaken in collaboration with state and territory geological surveys and the research community, will involve a systematic drilling programme to test geological models and to identify key indicators that point to mineral resource potential in the subsurface.

Each of the state geological surveys now has regional drilling initiatives firmly in their sights and, as noted above, Geoscience Australia has been funded for a systematic drilling programme. These drilling initiatives will feed into many of the UNCOVER programmes. Companies

are well-aware of these initiatives and may participate via co-funding. The Deep Exploration Technologies CRC is undertaking research and development to deliver the technology to enable these programmes (drilling through the cover and real-time sampling analysis).

Important ARC geoscience Centres of Excellence (such as the Core to Crust Fluid Systems centre) have aligned their goals to the UNCOVER vision.

UNCOVER members, the CSIRO, the Centre for Exploration Targeting (the University of Western Australia and Curtin University) and the Geological Survey of Western Australia, have recently been awarded a 4-year $4 million grant '*The Distal Footprints of Giant Ore Systems: UNCOVER Australia*' as a specific UNCOVER research programme.

Critical to the success of UNCOVER is that it is, and has been seen to be, neutral and independent; it is not controlled by any of the big players such as the geological surveys, the CSIRO, a university consortium, or an industry consortium. Likewise, it is important that the UNCOVER initiative is not a funding provider.

UNCOVER has a clear and simple agenda: to identify, develop, and deliver the science necessary to improve the success rate of mineral exploration in Australia under covered areas and influence the effectiveness of that science investment to industry.

As an initial step in the implementation phase, UNCOVER has recently undertaken a comprehensive face-to-face and web-based survey of industry, the geological surveys and academia. One of the strong messages from this survey is that there is a strong appetite for greater collaboration in order to strengthen the outcomes as envisaged by UNCOVER.

The UNCOVER summit

As a vital step in this implementation we will be holding an UNCOVER Summit in Adelaide from 31 March through to 2 April 2014. This Summit will bring together key members of the exploration industry, academia, and government agencies such as Geoscience Australia, the state geological surveys and the CSIRO.

It is the intent of the UNCOVER Executive that this Summit will inform a significant report identifying the important scientific questions that need to be answered and the critical datasets that need to be gathered in order to improve the success rate of mineral exploration in the covered areas of Australia. Reflecting the views of the Summit, the report will also identify an appropriate strategy to achieve a national focus on addressing these important questions and acquiring the critical data.

The report will be provided to the relevant Federal, State and Territory Ministers, the Chief Scientist's office, the Australian Research Council, the state geological surveys, Geoscience Australia, universities, relevant scientific agencies such as the CSIRO, and geoscience societies.

This is not a conference – the UNCOVER summit is a facilitated cross sector collaboration meeting, driven by industry's need to do things differently. Come prepared to work and participate in discussions about the future of exploration geoscience in Australia.

Each of the four UNCOVER themes will be discussed around the table:

- The Cover: Characterising Australia's cover - new knowledge to confidently explore beneath it. Depth, definition, and how we see through it and sample it for maximum benefit.
- The Lithosphere: Investigating Australia's lithospheric architecture – a whole lithosphere architectural framework for mineral systems exploration. Expanding knowledge to understand continental assembly and evolution of the deep crust and its influence on the cover.
- 4-D metallogenesis: Resolving the 4-D geodynamic and metallogenic evolution of Australia – understanding ore deposit origins for better prediction.
- Footprints (and fingerprints): Characterising and detecting distal footprints of ore deposits – towards a toolkit for minerals exploration. Determining camp to regional to continental scale background and signatures of deposits to improve vectoring to ore bodies.

At the summit we will also be identifying appropriate individuals to populate the UNCOVER action committees: science and network/communications.

Immediately following the 2½ day Summit, Richard Blewitt of Geoscience Australia will be hosting an UNCOVER technical workshop to examine possible improvements to the many geophysical tools for use in determining depth of cover in Australian terrains.

As many have done already during the vision roadshows and the engagement surveys, members are encouraged to have their say on the UNCOVER vision and influence it's future direction at the Summit. If members are not able to attend the summit, you should bring up the topic of UNCOVER as opportunity arises in conversation with surveys and researchers about what you see as vitally important science to exploration in Australia.

Further information

Further information on UNCOVER and a link to the Summit registration can be found at http://science.org.au/policy/uncover.html.

2013: not the best year for Australian resource industries

Mineral exploration levels continue to decline

After three years of growth from 2009 until the beginning of 2012 the level of investment in mineral exploration has continued to decline. The trend data compiled from the Australian Bureau of Statistics shows that after the peak expenditure of A$1.067 billion in the March 2012 quarter there has been a continuous fall in exploration activity (Figure 1).

At the time of writing the most recent data available are from the September quarter of 2013 when only A$612 million was invested. The good news is that the rate of decline appears to be flattening off and an investment of more than A$2 billion a year will probably be sustainable for several years. It is unfortunate that the major resource companies don't seem able to smooth out the sharp peaks in exploration activity. After all, they are nothing new; look at the peaks at June 2008 and June 1997 in Figure 1. There will surely be many more similar variations in the future unless the companies take a longer term look at the value of exploration.

Mineral resource shares lose value on ASX in 2013

One might expect that mineral exploration levels and the performance of the main resource industries on the stock market would be strongly linked. But this has not been the situation on the ASX. In Figure 2, I have plotted the total market capital of the resource industries in the top 150 companies listed on the ASX. Since the peak in April 2011, the total market capital of the larger resource industries has declined to 65% of what it was at its peak at the end of 2013. Not good for investors in resource shares, particularly those who invested in gold. For example, Newcrest's market capital fell from A$17.5 billion in January 2013 to A$6.0 billion at the end of December 2013.

Meanwhile the All Ordinaries Index has climbed steadily from September 2011 to the end of 2013 from 4070 to 5324 respectively. This represents a rise of approximately 30%, much better than a fixed interest deposit in any of the banks.

During the last quarter of 2013 the downward trend in the value of resource industries appeared to be levelling off, but it is worrying that the major companies are likely to cut back further on exploration and innovation and focus more on their known resources.

Iron ore was good but gold and coal did not fare so well in 2013

A major factor in the decrease in value has been the falling prices for some of the main mineral commodities over the past two years. Table 1 shows some of the numbers for gold, iron ore and coal.

Basically, the gold price fell by approximately 28% in the past two years while production levels remained fairly constant. Coal followed a similar pattern with prices declining by approximately 35% while the production values have remained at about 135 Mt per quarter. The iron ore price has declined by less than 10% while production has risen from 130 Mt per quarter to 156 Mt. So for 2013, iron ore was a marque commodity. Figure 3 shows more details about gold.

The price of gold declined significantly from the peak in March 1980 and it appears that there may be a similar decline from the second peak in March 2012. Production rates appear to have peaked in December 1997 with a quarterly value of 82 tonnes.

Quarterly production was fairly constant at between 60 and 70 tonnes from March 2011 until the end of 2013 and it appears unlikely to reach the peak of 80 tonnes anytime soon.

In the past five years the investment in gold exploration correlates closely with the gold price rather than the production output. Whether these relationships will continue is not clear. Obviously if

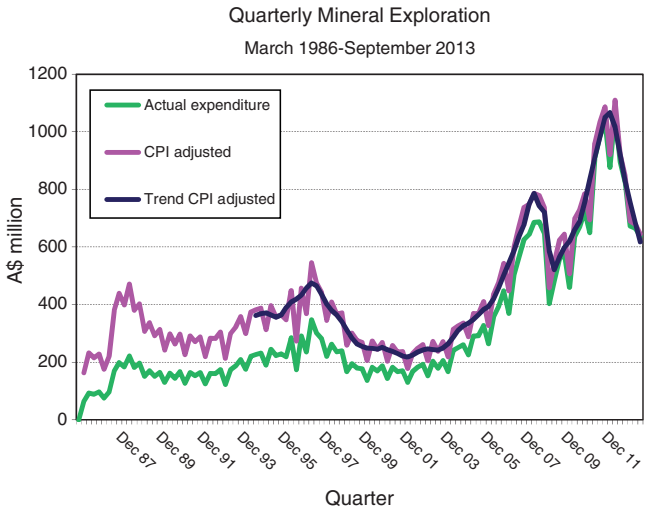

Fig. 1. *Australian quarterly mineral exploration from March 1986 to September 2013. The green curve represents actual dollars spent, the purple curve shows the consumer price index (CPI); corrected numbers adjusted to December 2013 A$. The black line is the trend line. All data were provided courtesy of the Australian Bureau of Statistics.*

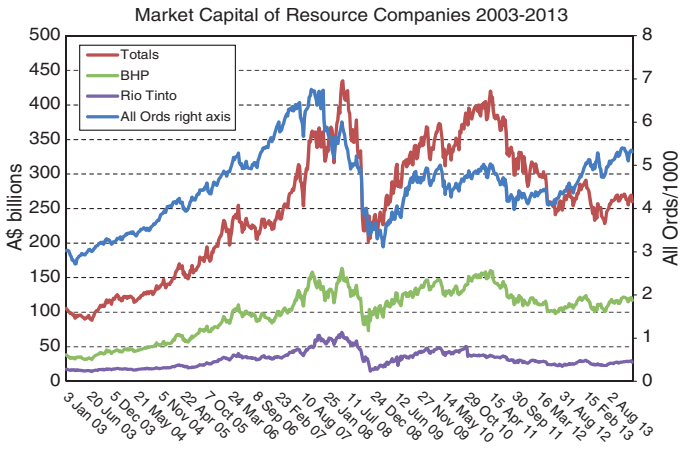

Fig. 2. *Total market capital (in A$ billions, left axis) of resource companies in the top 150 companies listed on the ASX (red), together with plots for BHP and Rio Tinto. The All Ords Index is plotted in blue (right axis). The graphs cover the period January 2003 to December 2013. No corrections have been applied for increases in the CPI. Since the peak in April 2011, the total market capital of the larger resource industries has declined to 65% of what it was at its peak at the end of 2013.*

Table 1. Quarterly production and prices for gold, iron ore and coal during the past two years

Commodity	Dec 11	Mar 12	Jun 12	Sep 12	Dec 12	Mar 13	Jun 13	Sep 13	Quarter
Gold	64	62	63	62	66	62	65	68	t
	1753	1814	1676	1735	1753	1658	1381	1358	Price A$/Oz
Iron	130	119	130	133	138	133	150	156	Mt
	133.4	133.4	126	103	96	118	116	122	A$/t
Coal (high quality)	123	109	123	133	136	123	135	133	Mt
	237	237	203	188	146	150	152	146	A$/t

there is no exploration, gold production will eventually decline to zero, so there should be an optimum level that produces maximum returns. At present 60 t/quarter should realise about A$2.3 billion, so the exploration component of A$150 M/quarter should be a good investment.

Petroleum exploration very healthy in 2013

Meanwhile, petroleum exploration has been going from strength to strength (Figure 4). Since 2008 the quarterly spending on petroleum exploration has been of the order of A$1 billion. As can be seen from the figure the incentive to find more petroleum and gas is still very strong. This is in spite of Australia's oil production peaking in March 2000.

One of the driving factors is the gradual increase in oil price since the end of 1998. There has been considerable volatility, but the long-term trend is upwards. The other driving factor is the high cost of offshore exploration. Many of the exploration areas are beneath sea water that is 1000 m or more deep. In fact, of the current 15 areas open for offshore bidding, 12 contain water depths greater than 1000 m. As soon as explorers go offshore the cost to develop a prospect increases dramatically; not so much from the geophysical surveys, but from the exploration wells that have to be drilled to test targets and develop fields.

Another factor is the development of coal seam and shale gas in eastern Australia. I don't want to get into a debate on the environmental issues involved in hydro-fracturing coal seams and shale deposits, but there can be no doubt that these sequences hold huge hydrocarbon resources. As long as the price of oil continues to increase there are going to be incentives to explore in these basins. As a result, the onshore component of oil exploration is steadily rising as a percentage of the total investment. During 2010–11 it made up 23% of the total, in the September quarter it had risen steadily to 27% – quite significant when the total is over A$1 billion.

Summary

During 2013 petroleum exploration activity in Australia maintained a level of investment of over A$1 billion; there is likely to be more of the same in 2014, particularly if the oil price continues to rise.

The mineral industry has big challenges. In the past year mineral exploration fell from A$895 M in the September quarter of 2012 to A$638 M in the September quarter of 2013 – that's a massive 29% in one year.

Fortunately, geophysicists are always going to be in demand to find new deposits, but the situation is not that simple. Companies, like politicians, are also tending to look in shorter time frames. Unfortunately the time from exploration to development can cover at least three election cycles, and it seems to

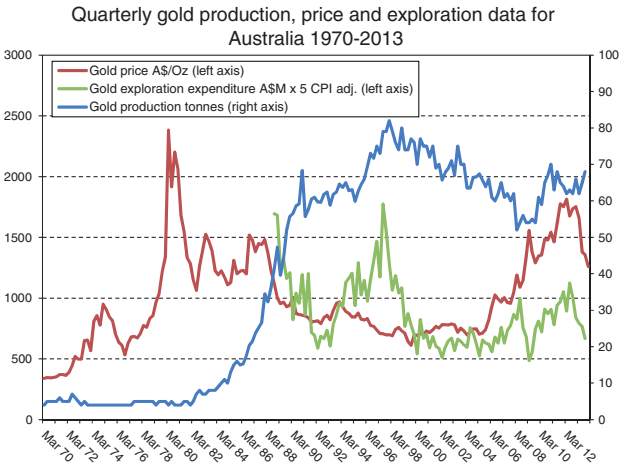

Fig. 3. *Australian quarterly gold production (blue curve), investment in gold exploration (green curve) and gold price (red curve) for the period 1970 to September 2013. All prices are plotted in A$ CPI adjusted to December 2013.*

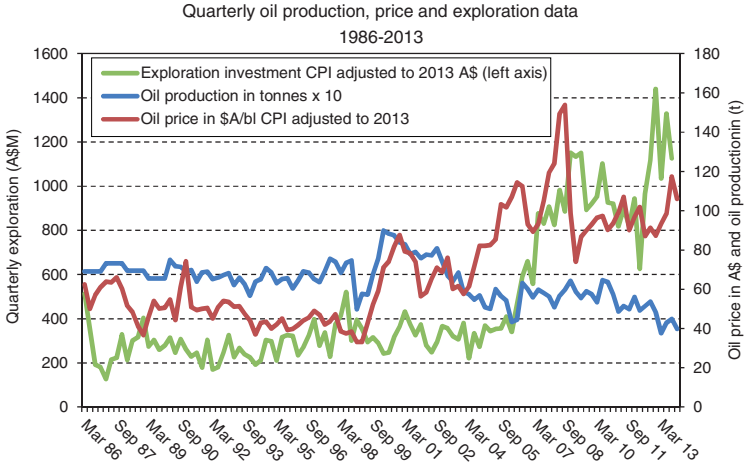

Fig. 4. *Quarterly oil production (including condensate) in Australia from 1986 to September 2013. All dollar values are in A$ adjusted to the CPI number in December 2013. A conversion factor of 0.8581 has been used to convert kl to tonnes.*

me that this short-term vision is not going to go away.

Acknowledgements

I thank the Australian Bureau of Statistics and the Bureau of Resource Energy Economics for the use of their data. I hope that the government's razor gangs leave these wonderful organisations, which provide invaluable sources of data, intact – we need them for our national wellbeing.

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Opportunities for offshore petroleum exploration in 2014: but explorers will need deep pockets

The Minister for Industry, the Hon. Ian Macfarlane MP, is scheduled to announce the 2014 Offshore Petroleum Exploration Acreage Release (Acreage Release) at the Australian Petroleum Production and Exploration Association (APPEA) Conference in Perth in April 2014.[1]

In the meantime 15 areas are already available for bidding. These comprise the 2013 round 2 areas and re-releases of some 2012 areas. Twelve of these areas are situated where water depths are greater than 1000 m. This indicates the extent to which exploration is being encouraged in unexplored high-risk areas. Exploration in water depths greater than 1000 m is expensive enough, but if new gas or petroleum fields are found, the number of dollars needed to market the product will be in the billions of dollars.

Bidding for all these areas (see table) closes on 22 May 2014.

Summaries of the prospects of these areas are given below. The legend for all figures is the same as that shown in Figure 1.

Area	Basin	Sub-basin
NT 13-1, 13-2 and 13-3	Bonaparte	Northern Petrel
W13-4 and W13-5	Browse	Barcoo
W13-6, W13-7, W13-8 and W12-11	Northern Carnarvon	Exmouth Plateau
W13-19 and W13-20	North Perth	Houtman and Abrolhos
V13-2 and V12-3	Gippsland	
T12-2	Sorrell	Sandy Cape and Strahan
W12-7	Browse	Scott Plateau

[1]*This article is based on the Offshore Petroleum Exploration Acreage Releases for 2012 (http://www.petroleum-acreage.gov.au/2012/release.html) and 2013(http://www.petroleum-acreage.gov.au/2013/release.html). The text does not necessarily represent the views of the Department of Industry. Readers should refer to the website for any clarification or more information.*

Northern Petrel Sub-basin: NT13-1, NT13-2 and NT13-3

These areas are located in shallow water (40–200 m) in the north east Bonaparte Basin in the Timor Sea. Areas NT13-1 and NT13-2 are in the Malita Graben, with NT13-1 also partly overlapping the Darwin Shelf. Area NT13-3 is mostly situated in the northern Petrel Sub-basin (Figure 1). These areas are situated in an underexplored gas province.

The active petroleum system in the region has been defined as the Jurassic Plover-Plover Petroleum System. The main structural plays are broad faulted anticlinal structures over tilted fault blocks at the base of the regional seal.

For more information, go to: http://www.petroleum-acreage.gov.au/2013/release-areas/northern-petrel-sub-basin.html.

Barcoo Sub-basin: W13-4 and W13-5

Areas W13-4 and W13-5 are located in the Barcoo Sub-basin (Figure 2). W13-5 also overlies the Oobagooma Sub-basin of the offshore Canning Basin in the south and the Rowley Sub-basin of the Roebuck Basin in the southwest. These underexplored areas span the continental shelf, with water depths ranging from 60 m to over 1000 m.

The Barcoo Sub-basin is approximately 200 km long by 130 km wide and contains up to 12 km of Paleozoic to Cenozoic sediments. Miocene fault-reactivation inversion anticlines

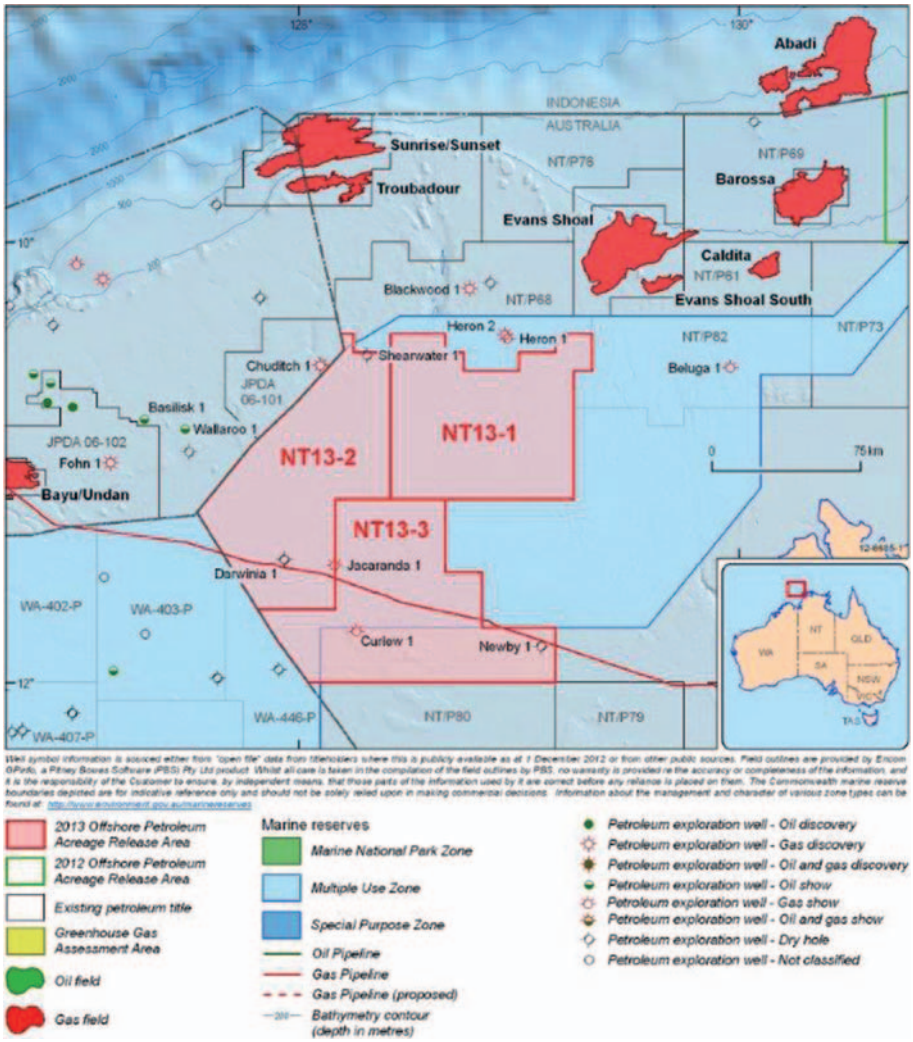

Fig. 1. *Location of the NT13-1, NT13-2 and NT13-3 areas. Note the paucity of wells in these areas (image source: http://www.petroleum-acreage.gov.au/2013/documents/release-area-maps/Release_Area_Map-Northern_Petrel.jpg).*

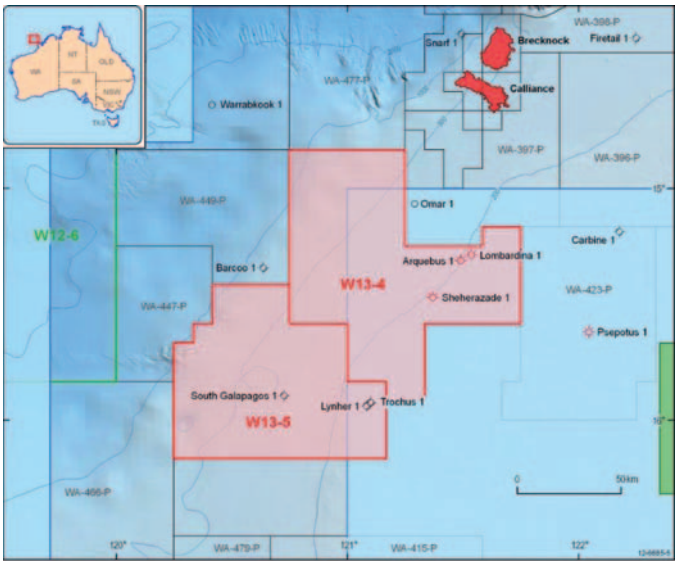

Fig. 2. *Location of the W13-4 and W13-5 areas (image source: http://www.petroleum-acreage.gov.au/2013/documents/release-area-maps/Release_Area_Map-Barcoo.jpg).*

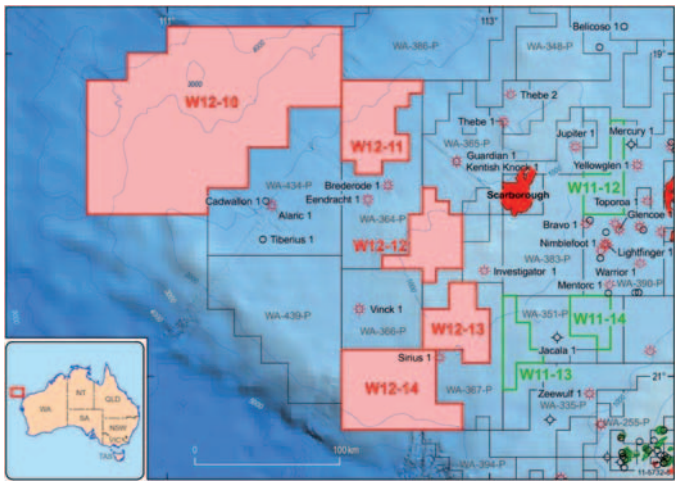

Fig. 4. *Location of area W12-11; this is a re-released 2012 area (image source: http://www.petroleum-acreage.gov.au/2012/release-areas/documents/carnarvon/Quicklookexmouthplateau_11-5732-5.jpg).*

along the margin of the Barcoo Sub-basin and Leveque Shelf provide structural traps. An inferred hydrocarbon column was found at Arquebus 1 ST1 and a gas accumulation was intersected in the lower Cretaceous drape on the Leveque Shelf at Psepotus 1.

For more information, go to: http://www.petroleum-acreage.gov.au/2013/release-areas/barcoo-sub-basin.html.

Exmouth Plateau: W13-6, W13-7, W13-8 and W12-11

Areas W13-6, W13-7 and W13-8 are underexplored regions of the northern Exmouth Plateau of the Northern Carnarvon Basin (Figure 3), with water depths ranging 850–4500 m.

The plateau is underlain by 10–15 km of flat-lying and tilted, block-faulted Paleozoic to Mesozoic sedimentary rocks, deposited during periods of extension before continental breakup in the Middle Jurassic and Early Cretaceous. The Triassic fluvio-deltaic Mungaroo Formation has been the target for many explorers in the Exmouth Plateau, acting as both source and reservoir in places. Other reservoirs include the Jansz Sandstone and sandstone units in the Barrow Group and the Brigadier Formation. Proven play types include Triassic fault blocks and drapes, and stratigraphic traps of Late Jurassic Early Cretaceous age.

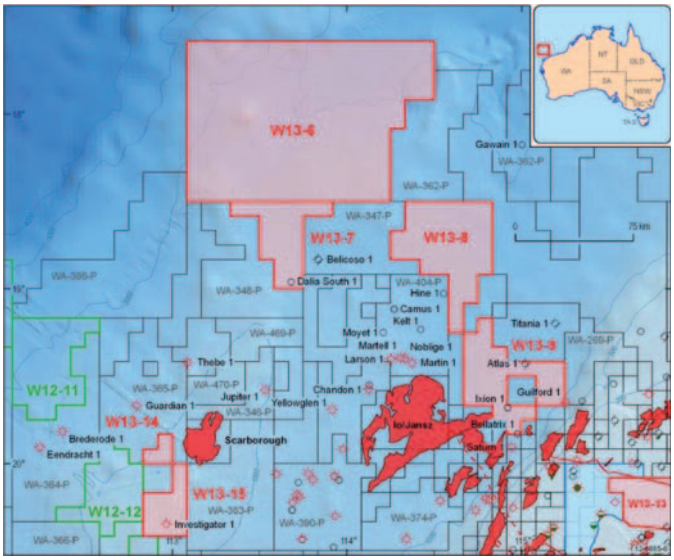

Fig. 3. *Location of the W13-6, W13-7 and W13-8 areas. These are real frontier tenements (image source: http://www.petroleum-acreage.gov.au/2013/documents/release-area-maps/Release_Area_Map-Exmouth_Plateau.jpg).*

For more information, go to: http://www.petroleum-acreage.gov.au/2013/release-areas/exmouth-plateau.html.

W12-11 is located on the Exmouth Plateau, a deep-water marginal plateau of the Northern Carnarvon Basin, with water depths ranging 1400–2500 m (Figure 4).

The plateau hosts numerous giant to supergiant gas fields and has recently become Australia's premier deep-water gas exploration province. The plateau comprises a thick pre-rift section of block-faulted Permo-Triassic sediments overlain by thinner Jurassic–Lower Cretaceous syn-rift and thin, condensed, post-rift sediments. Top Triassic fault blocks and their associated overlying drape features, as well as deeper intra-Triassic cross-faults provide numerous proven structural traps. Proven stratigraphic traps include Lower Cretaceous basin floor fans and Upper Jurassic sandstones, while Upper Triassic pinnacle reefs represent a potential new play type.

For more information, go to: http://www.petroleum-acreage.gov.au/2012/release-areas/carnarvon-exmouth.html.

North Perth: W13-19 and W13-20

W13-19 and W13-20 are located in the offshore North Perth Basin (Figure 5) covering large areas of the Houtman and Abrolhos sub-basins and parts of the Gascoyne and Zeewyck sub-basins. The

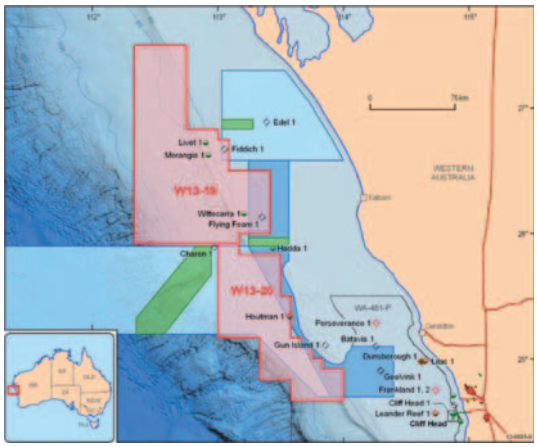

Fig. 5. *Locations of the W13-19 and W13-20 areas (image source: http://www.petroleum-acreage.gov.au/2013/documents/release-area-maps/Release_Area_Map-North_Perth.jpg).*

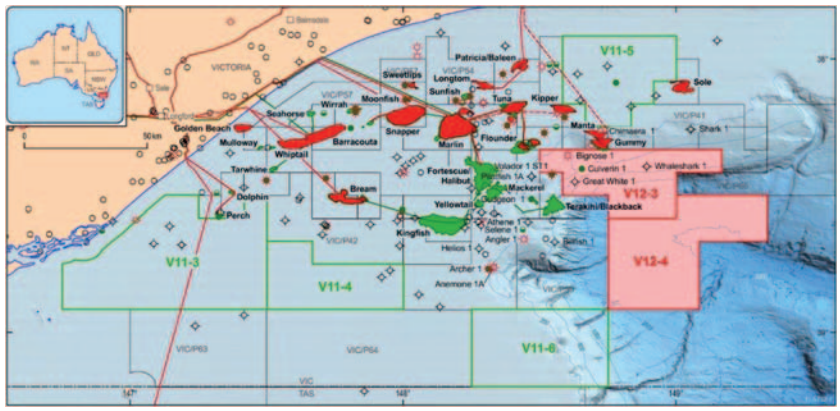

Fig. 7. *Location of the V12-3 area; this is a re-released 2012 area (image source: http://www.petroleum-acreage.gov.au/2012/release-areas/documents/gippsland/Quicklookgippsland_11-5732-7.jpg).*

water depths vary between 70–2500 m and are adjacent to recently awarded permits.

The northern Perth Basin formed through continental extension between the southwestern margin of Australia and Greater India during the Paleozoic to Mesozoic. The Abrolhos Sub-basin contains a Permian–Cretaceous sedimentary section up to 6000 m thick and the Houtman Sub-basin is a predominantly Jurassic–Cretaceous depo-centre. A number of wells within these areas have hydrocarbon shows and paleo-oil columns indicate the presence of mature source rocks, including the Hovea Member of the Kockatea Shale. There are also potential plays are within Triassic to Middle Jurassic strata.

For more information, go to: http://www.petroleum-acreage.gov.au/2013/release-areas/north-perth.html.

Gippsland Basin: V13-2 and V12-3

V13-2 straddles the modern continental shelf edge and extends into the Bass Canyon (Figure 6) where water depth increases to 3000 m. The basin developed during the Early Cretaceous as part of the breakup of Gondwana. Rifting continued into the Late Cretaceous and generated a classic extensional geometry. Sixteen exploration wells have tested top-Latrobe Group and intra-Latrobe Group targets. Several petroleum systems operate in the basin with proven plays in anticlines, tilted fault blocks, stratigraphic pinchouts and channel sandstones. Oil and gas fields have been discovered that are hosted by top-Latrobe Group (Eocene) shallow marine barrier sandstones with additional discoveries made in intra-Latrobe (Paleocene) coastal plain and deltaic channel sandstones.

For more information, go to: http://www.petroleum-acreage.gov.au/2013/release-areas/gippsland.html.

V12-3 offers exploration potential in the underexplored eastern deep-water part of the basin (Figure 7) with water depths ranging 150–3000 m.

The Gippsland Basin was Australia's premier hydrocarbon province until the early 1990s, when large-scale production started on the North West Shelf. Despite its mature age, the basin is still recognised as a world class petroleum province, with annual production rates of around 25 MMstb oil and condensate and 250 MMscf gas.

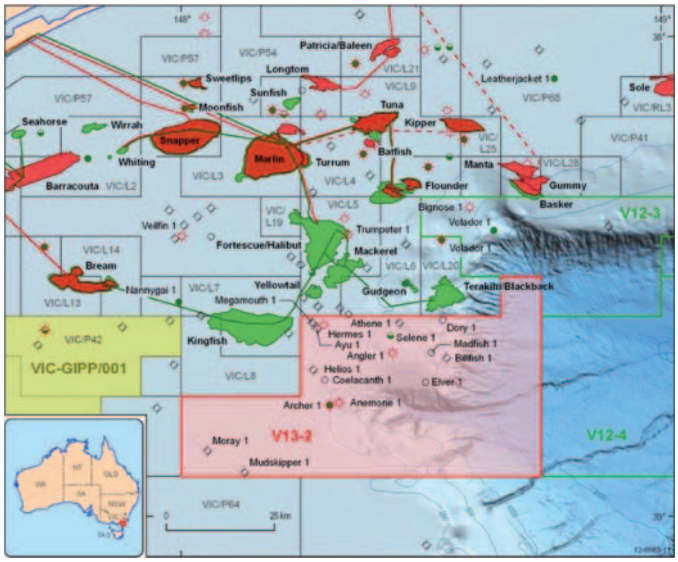

Fig. 6. *Location of the V13-2 area (image source: http://www.petroleum-acreage.gov.au/2013/documents/release-area-maps/Release_Area_Map-Gippsland.jpg).*

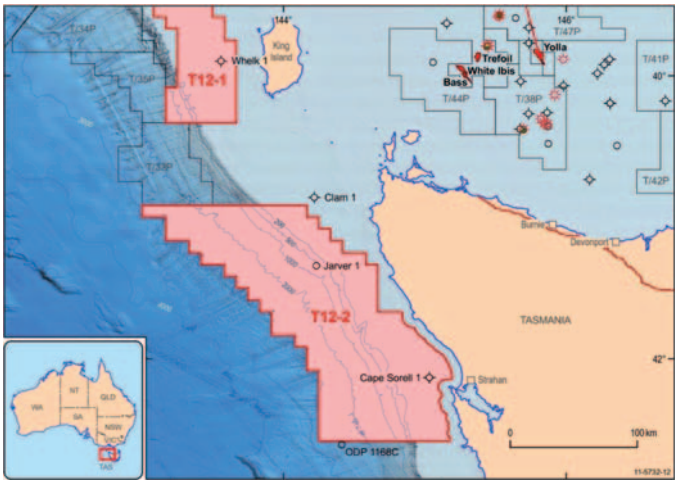

Fig. 8. *Location of the T12-2 area; this is a re-released 2012 area (image source: http://www.petroleum-acreage.gov.au/2012/release-areas/documents/sorell/Quicklooksorrel_11-5732-12.jpg).*

Good geological control is provided by several successful wells indicating the presence of both gas and liquids in the northern area, while the southern area represents the remaining frontier of the basin.

For more information, go to: http://www.petroleum-acreage.gov.au/2012/release-areas/gippsland.html.

Sandy Cape and Strahan Sub-basins: T12-2

Area T12-2 is located over the Sandy Cape and Strahan Sub-basins in the Sorell Basin (Figure 8) in water depths ranging 50–3000 m. It is an underexplored frontier Cretaceous–Cenozoic basin containing up to 6.5 km of sediment with a variety of untested Cretaceous plays.

The Sorell Basin joins the Otway Basin to the north and the basins have a similar geological history and stratigraphy. The complex structural and depositional history of the Sorell Basin reflects its location at the transition from a divergent rifted margin to a transform continental margin. T12-2 is covered by extensive open file 2-D seismic and magnetic data.

For more information, go to: http://www.petroleum-acreage.gov.au/2012/release-areas/sorell.html.

Scott Plateau W12-7

W12-7 is located over the outer, deep-water Scott Plateau in the Browse Basin; water depths range 1400–5000 m (Figure 9). This underexplored part of the North West Shelf lies to the southwest of the Torosa, Brecknock and Calliance gas fields in the Browse Basin, and to the northeast of established oil and gas fields and production infrastructure of the Northern Carnarvon Basin. W12-7 does not contain any wells, but inboard parts of these areas have good coverage of publicly available 2-D seismic reflection data. Nearby wells indicate that there is the potential for active petroleum systems to occur in the area and that a range of structural and stratigraphic plays are possible.

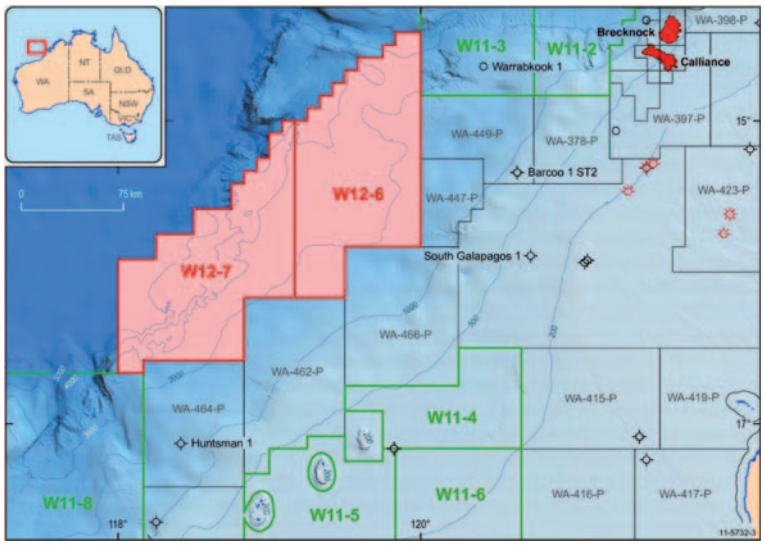

Fig. 9. *Location of the W12-7 area; this is a re-released 2012 area (image source: http://www.petroleum-acreage.gov.au/2012/release-areas/documents/roebuck/Quicklookscottplateau_11-5732-3.jpg).*

For more information, go to: http://www.petroleum-acreage.gov.au/2012/release-areas/roebuck-scott.html.

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Update on Geophysical Survey Progress from the Geological Surveys of Western Australia, South Australia, Northern Territory and WA Department of Water (information current at 21 January 2014)

Tables 1–3 show the continuing acquisition of the airborne magnetic, radiometric, gravity and AEM data of the Australian continent respectively. The accompanying locality map for Table 3 can be found in Figure 1. All surveys are being managed by Geoscience Australia (GA). Further information on these surveys is available from Murray Richardson at GA via email at Murray.Richardson@ga.gov.au or telephone on (02) 6249 9229.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL dir	Area (km²)	End flying	Final Data to GA	Locality diagram (*Preview*)	GADDS release
Browse Basin	GA	Thomson Aviation	21 Aug 13	189 361	800 m 80 m ASL N–S	123 187	100% complete @ 7 Nov 13	Preliminary final gridded data supplied to GA 9 Jan 14	Issue 164 (Jun 13) p. 19	TBA
Menzies North	GSWA	GPX Surveys	7 Aug 2013	93 386	100 m 50 m E–W	8200	100% complete @ 26 Nov 13	TBA	Issue 165 (Aug 13) p. 11	TBA
Kalgoorlie East and Kurnalpi North	GSWA	Thomson Aviation	5 Aug 13	122 000	100 m 50 m E–W	Kalgoorlie: 11 000; Kurnalpi N: 11 000	71.2% complete @ 19 Jan 14	TBA	Issue 165 (Aug 13) p. 11	TBA
Widgiemooltha North	GSWA	UTS Geophysics	25 Jul 13	92 000	100 m 50 m E–W	8200	93.8% complete @ 19 Jan 14	TBA	Issue 165 (Aug 13) p. 11	TBA
Menzies South	GSWA	GPX Surveys	28 Nov 13	92 000	100 m 50 m E–W	8200	46.4% complete @ 19 Jan 14	TBA	Issue 165 (Aug 13) p. 11	TBA
Kurnalpi South	GSWA	UTS Geophysics	Est. late Jan/early Feb	92 000	100 m 50 m E–W	8200	TBA	TBA	Issue 165 (Aug 13) p. 11	TBA

ASL, above sea level; TBA, to be advised.

Table 2. Gravity surveys

Survey name	Client	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
North Perth – Gingin Brook	WA Dept of Water	Atlas Geophysics	9 Apr 13	1230	1.5 km regular grid	3900	100% complete @ 7 Jun 13	29 Jul 13	Issue 163 (Apr 13) p. 17	Currently scheduled for the end of February
Southern McArthur Basin	NT	Atlas Geophysics	15 Oct 13	6270	4 km regular grid with 2 km infill in 2 areas	74 380	100% complete @ 17 Nov 13	19 Dec 13	Issue 166 (Oct 13) p. 34	Final data released via GADDS 8 Jan 14
Goldfields, WA	WA	Atlas Geophysics	8 Nov 13	8100	2.5 km regular grid	51 140	100% complete @ 13 Dec 13	20 Jan 14	Issue 166 (Oct 13) p. 34	Currently scheduled for the end of February

TBA, to be advised.

Table 3. AEM surveys

Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Swan/Scott Coastal Plain and Albany/ Esperance	WA Dept of Water	CGG Aviation (Australia)	25 Mar 13	8607	300/600 m	TBA	100% complete @ 15 May 13	Final data to GA 20 Jan 14	Issue 163 (Apr 13) p. 17	TBA
Capricorn Orogen	WA	CGG Aviation (Australia)	19 Oct 13	29697	5 km N–S	146300	100% complete @ 9 Jan 14	TBA	Issue 166 (Oct 13) p. 34	TBA
Southern Thomson Orogen	GA/ GSNSW/ GSQ	TBA	TBA	6305	5 km E–W	16270	TBA	TBA	This issue	TBA

See Figure 1 for locality of the Southern Thomson Orogen survey. TBA, to be advised.

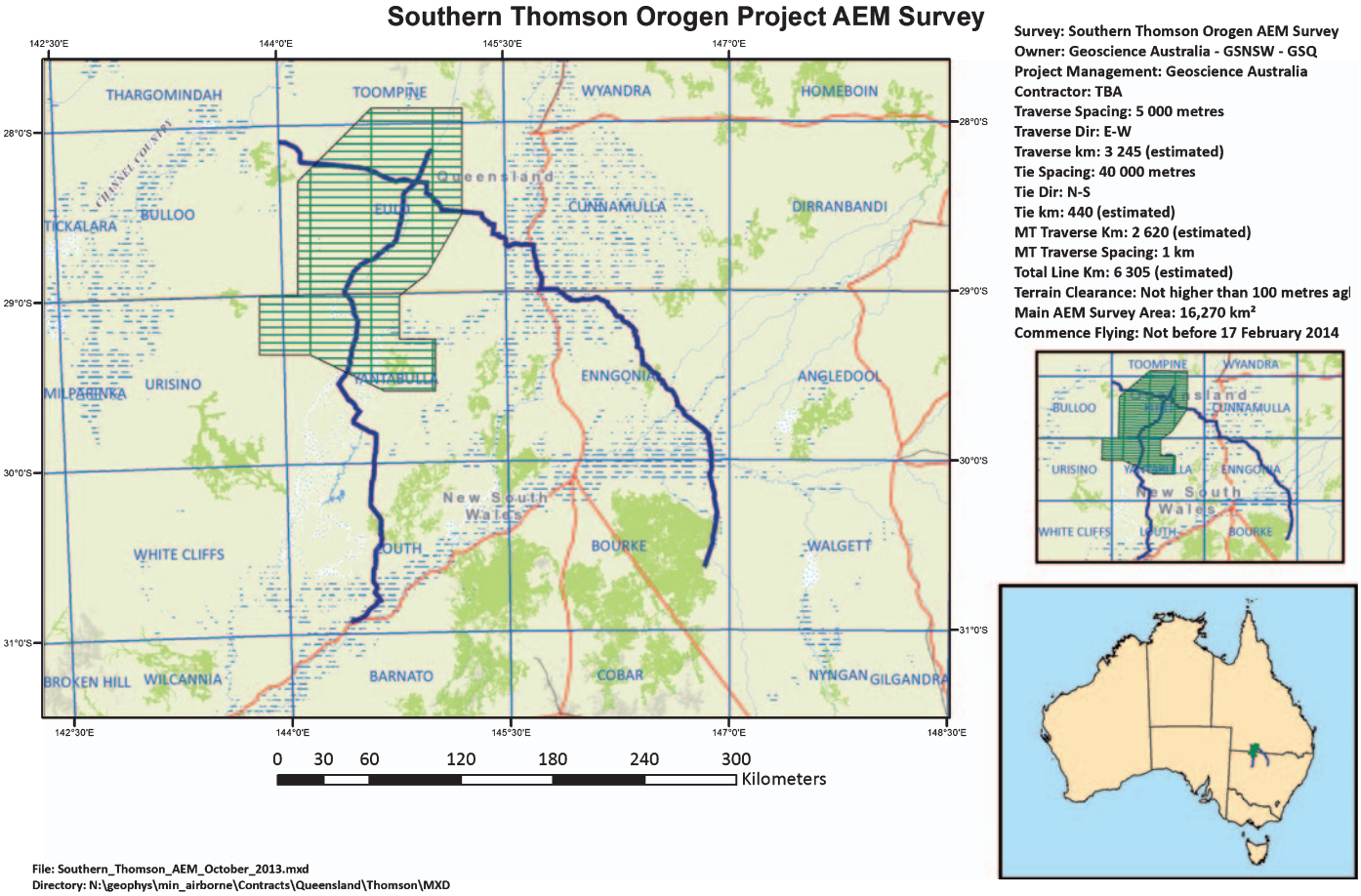


Fig. 1. *Locality map outlining the Southern Thomson Orogen survey (detailed within Table 3).*

News from the surveys: SA

The South Australian Atlas of Geoscience and Mineral Exploration Data – Woomera Prohibited Area within the Gawler Craton

The Woomera Prohibited Area (WPA) is a military testing range covering approximately 127 000 km^2 of the land surface of central South Australia. Underlying it are highly prospective rocks of the Gawler Craton, a major province of the Earth's crust that hosts the world-class Olympic Dam deposit and major mines such as Prominent Hill and Challenger.

This atlas is a collation of mineral exploration information relevant to this geologically important region within South Australia. It displays the extensive range of data resources originating from within the WPA that were available at the time of compilation (November 2013), providing readers with a visual reference to the data which is freely available on SARIG, South Australia's online geoserver.

The WPA has the potential to contain multiple mineral resource commodities and deposit styles, but the most economically significant of these are: (1) iron oxide - associated copper-gold±uranium (IOCG±U) type deposits; (2) globally unusual gold only deposits of the Challenger type; (3) sediment-hosted uranium deposits within sandstones; and (4) unconformity-style uranium deposits. Examples of the first two are known to occur within the WPA, and evidence exists that the potential for finding deposits of the latter two styles is significant.

The atlas also presents information pertaining to land access and administration, including maps about military testing range zones of the WPA, actively explored areas, pastoral landholdings, and native title claims/determinations.

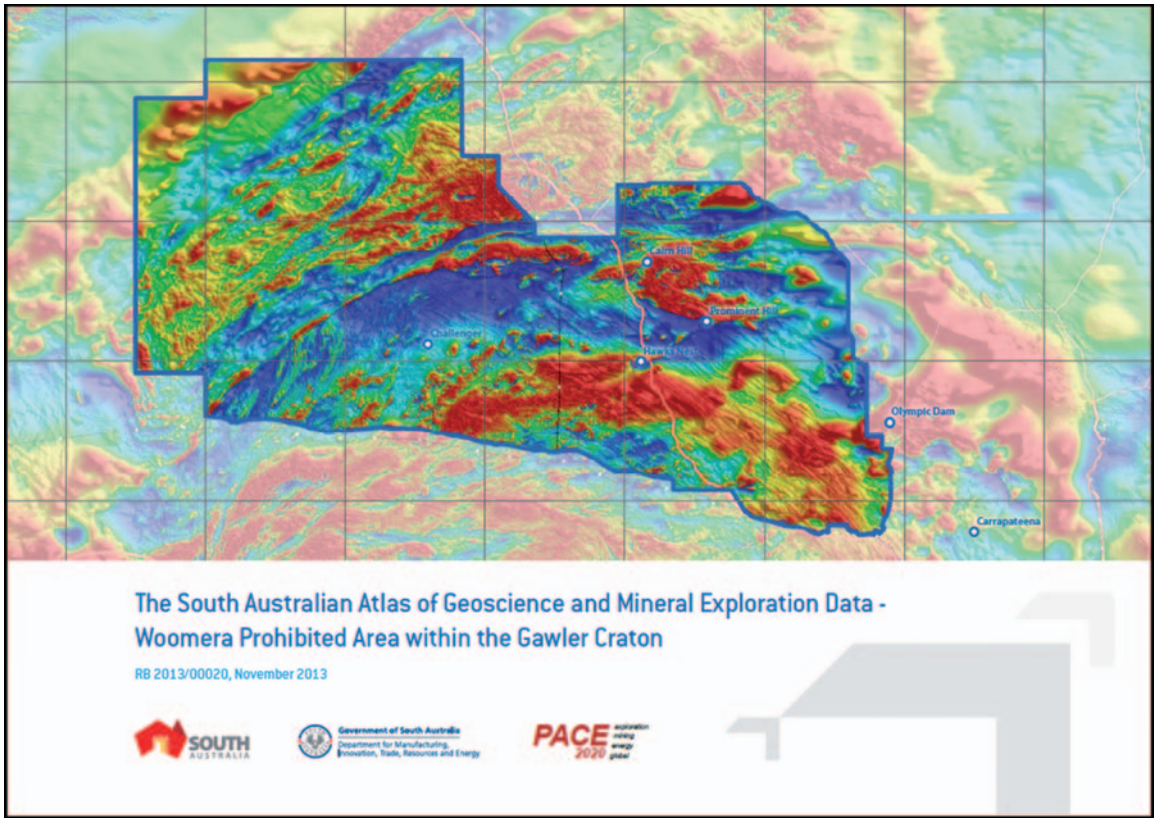
A wealth of geological and geophysical data derived from the WPA is portrayed, from surface to basement geological maps, to state geophysical imagery and derivatives. Coverage of non-potential field data is provided, as well as value-added products, such as the SEEBASE™ Depth to Basement map.

A suite of ASTER-derived surficial mineral distribution maps are contained in the atlas. Note that when interpreting the ASTER mineral maps, information pertaining to the numerical thresholds of the colour stretch should be consulted and can be found in the metadata document for each mineral theme. Metadata is available to download from SARIG.

A vast array of documented historic exploration data obtained by work done across the WPA is available for review through SARIG, accessible by text searching under the Publications and Reports section of the Databases tab. As a way of briefly summarising the exploration history, maps depicting expired/surrendered exploration licences have been compiled to create a spatial representation of exploration by commodity, thus providing insights into the temporal development of mineral exploration for the region.

The Atlas is a Geological Survey of South Australia Report Book (RB2013/00020) and is available for download through SARIG.

Tom Wise, Philip Heath, Gary Reed, Laz Katona, Miles Davies, Andrew Rowett and Ted Tyne
Resources and Energy Group, DMITRE



Tertiary geoscience education at the crossroads?

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The full report, from which this summary article is derived, is available on the AGC website: http://www.agc.org.au/index.php/reports/148-australian-geoscience-council-report-australian-geoscience-education-profile-2013. – Editor

Introduction

With its latest survey (Powell 2013), the Australian Geoscience Council (AGC) has accumulated 10 years worth of data to the end of 2012 on teaching, enrolment and staffing levels in geoscience at Australian universities.

The status of geoscience and geoscience education in universities has continued the improvement recorded in 2010 with further growth in enrolled students, reversing the decade-long decline prior to 2007. However, the minerals industry downturn represents a potential cloud on the horizon for Tertiary geoscience education.

Results

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

These changes in university structures and degrees started a decade ago at a time of static or declining enrolments in geoscience and reflect the economic realities of current university funding. Government funds for teaching are provided on a per-student basis with additional funds being paid by full fee paying students, with the salaries of staff (academic, support and administrative), infrastructure and expendables (including field teaching) being paid from those funds. There has therefore been enormous pressure to improve the economics of teaching.

Fortunately and in contrast to the period prior to 2005, the resources boom has progressively attracted additional numbers of students into geoscience, improving the economics of geoscience teaching and easing the concerns expressed prior to 2007 as to the viability of geoscience in universities. Nationally student enrolments, as measured by Equivalent Full Time Student Load (EFTSL), have increased 14% since 2010 continuing

Table 1. Universities offering Earth Science Degrees in 2012 showing total geoscience staffing, Equivalent Full Time Student Load (EFTSL) and degrees awarded in 2012

University – school or structural unit	Geoscience staff total	EFTSL total	BSc major	BSc Hons	MSc	PhD
Adelaide – Earth & Environmental Science	33	533	76	43	7	5
– Petroleum						
Australian National						
– Research School of Earth Sciences	69	81	4	18	2	16
Ballarat – Science, Information Technology & Engineering	5.5	78	14	3	–	–
Canberra – Education, Science Technology & Mathematics	3	65	6	2	–	–
Curtin – Applied Geology						
– Exploration Geophysics	50	300	94	15	16	2
Flinders* – Environment	22	99	9	9	2	4
James Cook – Earth & Environmental Sciences	17	159	24	10	11	3
Macquarie – Earth & Planetary Sciences	23	227	22	10	17	3
Melbourne – Earth Sciences (includes ocean, atmospheric sciences)	20	115	32	9	13	6
Monash – Geoscience	21.4	238	115	27	1	5
New England** – Rural & Environmental Science	3.5	77	11	3	–	–
Newcastle* – Environmental & Life Sciences	8.6	155	27	3	–	2
New South Wales	22	209	18	16	2	6
– Biological, Earth & Environmental Sciences						
Queensland – Earth Sciences	27.2	228	52	8	5	11
Queensland University of Technology – Earth, Environmental & Biological Sciences	17	93	22	3	2	2
Sydney* – Geosciences (includes geography, environmental sciences)	19	137	14	8	2	5
Tasmania	31.3	81	53	19	5	6
Earth Sciences						
Western Australia – Earth & Environment	33	161	55	22	19	6
Wollongong – Earth & Environmental Sciences	19	181	36	10	6	7

*Notes: Flinders offers geoscience major in BSc Environment Degree. *Denotes enrolments and degrees are from 2010 survey. **Denotes degrees estimated by author from enrolment data.*

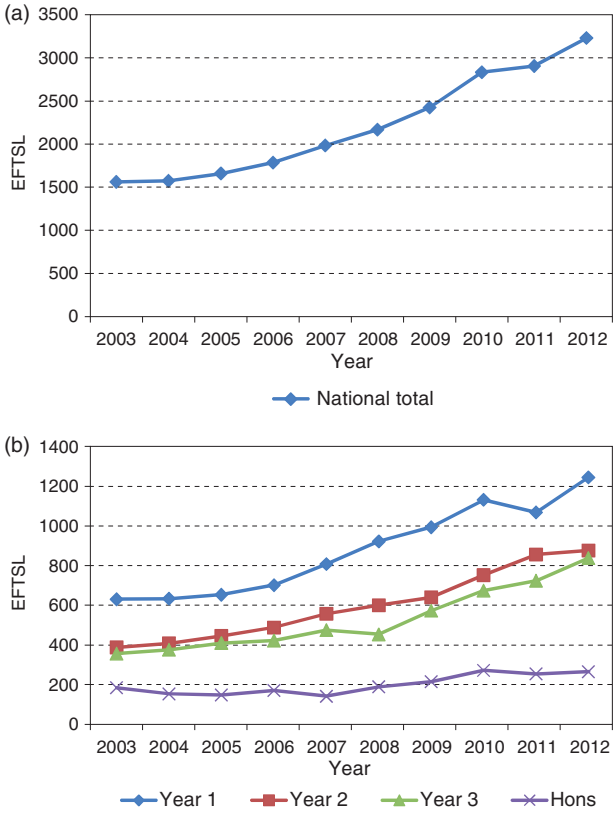

Fig. 1. *National trends in undergraduate enrolment in the geosciences expressed in Equivalent Full Time Student Load (EFTL). (a) National total – all levels; (b) National totals by level. EFTSL, Equivalent Full Time Student Load.*

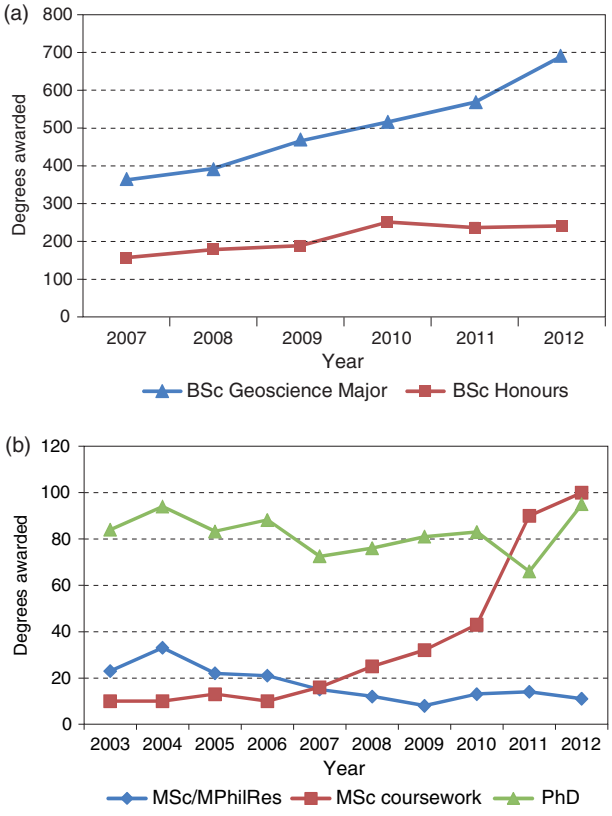

Fig. 2. *National trends in geoscience degrees awarded: (a) Bachelor degrees, national total; (b) Higher degrees, national total. Note data on BSc degrees is only available from 2007.*

the growth recorded in the 2010 survey (Figure 1). This growth is not universal with six universities static or showing declines.

Contrary to the growth in the period 2007–2010, Honours enrolments have stabilised or declined slightly in most universities, although a few are still growing. This has led to an overall slight decline in total Honours enrolments from 2010.

The data show that universities vary widely in their viability as geoscience teaching institutions. There has been a general strengthening of 'geoscience schools' as student numbers have increased and courses re-organised to improve the efficiency of teaching. From 2007, there has been a systematic increase in the EFTSL per teaching staff member with now six universities above 20, five between 15 and 20 and only one below 10 – in 2007 there were only three universities above 15. This indicates improving financial viability for many schools. The growth in Masters degrees involving significant coursework also impacts on teaching loads and contributes to financial viability for those departments where this is occurring. Two universities (Adelaide and Curtin) account for 27 percent of the national student load with EFTSL values of 300 or more. Four universities have values between 200 and 250. The balance has values below 180, of which six are below 100 (Table 1).

The output of Bachelor (BSc) degrees with a major in geoscience has continued to grow to approximately 690 in 2012 (Figure 2), but Honours enrolments and the output of BSc Honours degrees have declined slightly from around 251 in 2010 to around 241 in 2012.

The output of Masters (MSc) degrees by coursework and dissertation, have continued to grow strongly reflecting the change in emphasis to postgraduate coursework at several universities and accounts in part for the levelling off in Honours enrolments and degrees awarded. These coursework degrees are often specifically aimed at training candidates in the knowledge and techniques required for employment in industry, but are also offered as pre-research training. Three universities (James Cook, Tasmania and Western Australia) co-operate in the Minerals Tertiary Education Council (MTEC) Mineral Masters programme. Melbourne and Macquarie universities now offer a 2-year Masters by coursework and dissertation in lieu of an Honours Degree, with Adelaide introducing this option in 2014. Western Australia has this option predominantly for overseas students and retains the Honours and 1-year Masters Courses for domestic students.

In addition to normal curriculum reviews, several universities continue to take specific steps to meet the needs of potential employers by addressing the core skills requirements of graduates:

- Nine universities participate in the MTEC Honours Minerals Short course Programme.
- They have made (or are in the process of making) specific teaching appointments in resource geoscience.
- They have remodelled courses to meet core skills requirements and strengthened some disciplines including geophysics, field geology, digital geology, minerals geoscience and petroleum geoscience.
- Some have placements in industry as part of a course of study.
- Some provide specific options and specialisations in majors and MSc degrees.

Universities in Victoria and Sydney cooperate in the delivery of electives in the Honours year in their respective locations.

The National Centre for Groundwater Research and Training is based at Flinders University with 11 university partners. It seeks 'to improve our understanding of Australia's Groundwater Systems, and by training the next generation of expert researchers and groundwater professionals. It does not produce graduates in its own right but strengthens the capacity of the university partners in this regard. Similarly the ARC Centres of Excellence in 'Ore Deposits' and 'Core to Crust Fluid Systems' centred at the Universities of Tasmania and Macquarie respectively strengthens their capacity and of that of their university partners. The University of Adelaide provides specifically for the petroleum industry through its School of Petroleum, whilst Curtin University provides specifically for geophysics through its Department of Exploration Geophysics.

The decline in output of Masters degrees through research has continued and is now only about 10 per annum compared output of Masters degrees based on coursework and a dissertation which is now around 100. The latter has more than doubled since 2010 following an increase by 250 percent in 2010 compared with 2007 (Figure 2). The output of PhD degrees recorded a drop of 20 percent to about 66 in 2011 before rebounding to 95 in 2012 (Figure 2).

In 2012, 200 academic staff were engaged in some level of teaching of geoscience in Australian universities whilst there are a further 270 staff engaged in research with no formal teaching commitments. Nationally since 2010 the number of teaching position has declined slightly whilst the number of research positions has increased by 35–22% compared with 13% between 2007 and 2010. The combination of teaching and research positions shows a wide range in capability between the 'geoscience' universities (Table 1) with a variation in the size and profile of schools with differing levels of undergraduate and postgraduate output and differing emphasis on teaching versus research.

It is now clear that the resources boom attracted large numbers of students into geoscience. With the current drawback from the very high levels of activity in the exploration and development industry and the increasing uncertainty as to geoscience employment levels (Australian Institute of Geoscientists 2013) it becomes a question as to whether current levels of enrolment will be sustained. Indeed, could we be about to repeat the boom–bust cycle that led to concerns about geoscience education at the turn of the 21st century? If student enrolments fall it is conceivable that some schools could become financially unviable again.

The question asked at the time of the 2007 survey remains highly pertinent: *What is the minimum economic department size that is sustainable in the longer run?*. This has to have consideration of government funded student load, fee paying students, academic staff numbers, service teaching to other degrees, external funding for teaching and research funding. As this survey once again demonstrates, these considerations vary from institution to institution and are not easily compared. However, the current survey has shown again that some larger schools with wide capability are growing from strength to strength, whilst others with lesser capability are static or reducing.

In general the position has improved again since 2010, but it remains clear that a critical mass of teaching and research capability that creates a vibrant and attractive educational experience is fundamental to sustaining Tertiary geoscience educational opportunities in Australia.

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Powell, T. G. 2013. Australian Geoscience Tertiary Education Profile 2012, Australian Geoscience Council Report, 64 p, http://www.agc.org.au/reports.