

# Fieldnotes

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Government of **Western Australia**  
Department of **Mines and Petroleum**

Geological Survey of  
Western Australia



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## Hydrothermal mineral deposits in the central Capricorn Orogen: important new insights for future discoveries

The Capricorn Orogen in central Western Australia records the juxtaposition of the Archean Pilbara and Yilgarn Cratons to form the West Australian Craton over a time period of two hundred million years, followed by one billion years of episodic continental reworking and reactivation. Much of the orogen is a greenfields region and is host to a variety of intrusion- or shear zone-related and sedimentary-hosted mineral deposits. However, owing to the long and episodic nature of intracontinental reworking, the controls on mineralization and the structural evolution of these deposits are poorly understood. Elucidating the architecture and timing of reworking events in the orogen with respect to mineralization is a critical step in greatly improving exploration targeting.

### The Mutherbukin Tectonic Event

Within the Gascoyne Province, mineral assemblages and tectonic fabrics related to the Mutherbukin Tectonic Event occur within a 50 km-wide corridor bounded by the Ti Tree and Chalba shear zones, directly south of the Minnie Creek batholith. However, discrete narrow shear zones are also present within, and to the north of, the Minnie Creek batholith.

The primary expression of this event is a strong, steeply dipping schistosity in metasedimentary rocks, and a widely developed foliation or gneissic banding within metamorphosed granites. The fabrics trend east-southeast and parallel the main structural

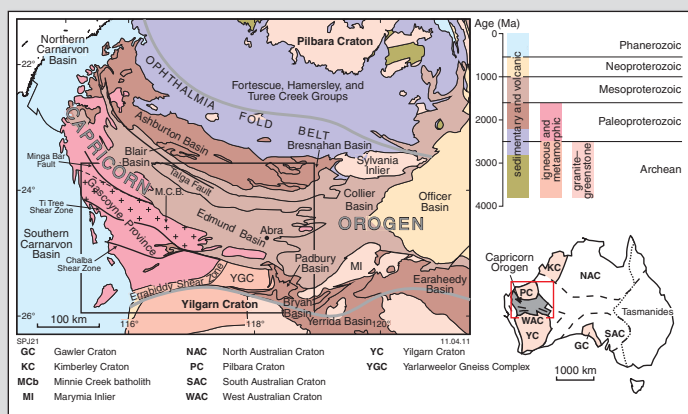


Figure 1. Elements of the Capricorn Orogen and surrounding cratons and basins

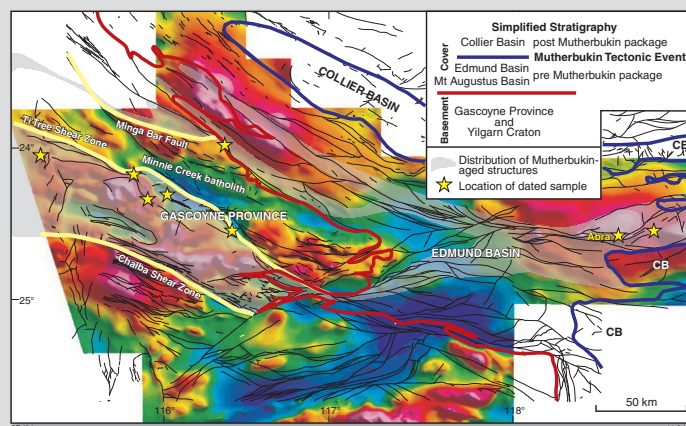
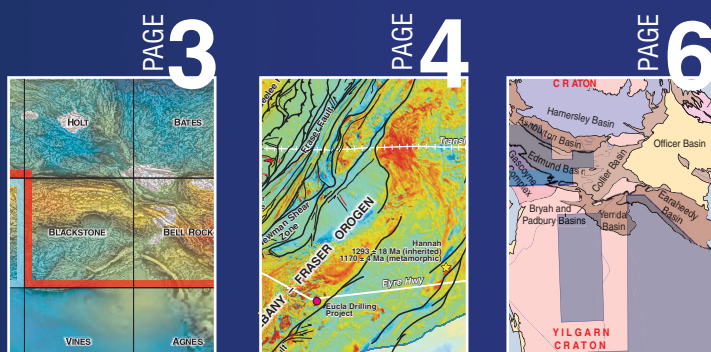


Figure 2. Regional distribution of Mutherbukin-aged structures. The mapped 1:100 000 scale surface structures are overlain on a 2000 m upward continuation model of 400 m line-spaced reduced-to-pole aeromagnetic data. The stratigraphy of the region has been divided into three main packages: Gascoyne Province basement and overlying sedimentary cover rocks, and a division of the cover rocks into pre-Mutherbukin (Mount Augustus and Edmund Basins) and post-Mutherbukin (Collier Basin) packages.

elements of the province. Garnet and staurolite-bearing semi-pelitic schists on the south side of the Minnie Creek batholith pass into upper amphibolite facies granitic gneisses that locally preserve evidence for in situ melting. Abundant shear-sense indicators in both the schists and granitic gneisses reveal sinistral transtensional shear regimes.

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# GSWA technology training in Kalgoorlie

Wednesday 9 November 2011

Website/WAMEX/MINEDEX/GeoVIEW.WA/GeoMap.WA

You are invited to attend a free training session hosted by the Department of Mines and Petroleum to demonstrate updates in its online systems. This is a great opportunity to try these services out in a practical informative session where you'll be able to ask the staff for assistance.

The format is an interactive presentation which includes navigating the DMP website, searching for publications, finding mineral deposits using MINEDEX, finding digital datasets using the Data and Software Centre, open file mineral exploration reports using WAMEX, and bringing it all together with the interactive map viewer (GeoVIEW.WA). GeoMap.WA, a new GIS viewer for Windows, will also be demonstrated.



**Morning session: 9 am – 12 noon**

WA School of Mines, Mine Design Lab, Room 131, Building 703, Odwyn Jones Building, corner Cassidy and MacDonald Streets, central Kalgoorlie. There will be a break for lunch (lunch not provided).

9.00–9.20 DMP website/publications search

9.20–10.00 MINEDEX

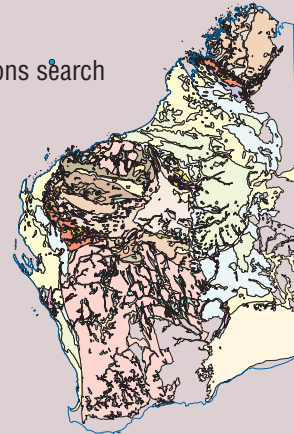
10.00–10.40 WAMEX

**10.40–10.50 break**

10.50–11.20 GeoVIEW.WA

11.20–11.50 GeoMap.WA

11.50–12.00 Questions



**Afternoon session: 1–4 pm**

GSWA Joe Lord Core Library, corner Broadwood and Hunter Streets, West Kalgoorlie

This is a hands-on practical session with individual tutoring for specific questions.

**How to register**

To register, email your details to <publications@dmp.wa.gov.au>.

*Don't miss out!*

## AusGeo News

AusGeo news is Geoscience Australia's (GA's) quarterly online news magazine. Each issue comprises geoscience-related features, brief articles about GA's research and initiatives, news about geoscience products and spatial data, and a calendar of coming seminars and conferences. Included here are topics of interest to Western Australia.

**March 2011 Issue No. 101**



### Mapping the footprint of ore deposits in 3D using geophysical data

Potential field data provides alteration signatures



### Weathering intensity map of the Australian continent

New framework provides new insights into an old continent



### Australia's coastline: adapting to climate change

Assessing infrastructure vulnerability to rising sea-levels



### Onshore Energy Security Program update

Delivering data and improved scientific understanding

Click on <<http://www.ga.gov.au/ausgeonews/ausgeonews201012/>> to view AusGeo news and learn more about these stories.



## Imaging the deep crust beneath the west Musgrave Province

As part of the Exploration Incentive Scheme (EIS), a joint project involving The Centre for Exploration Targeting (University of Western Australia) and GSWA has conducted a magnetotelluric survey in the Musgrave Province in Western Australia. This survey comprised 48 stations along an east–west and north–south traverse which were specifically positioned to cross the major structural boundaries within and marginal to the province (Fig. 1). The aim of the survey is to image the deep crustal

presented in Figure 2. These results show excellent agreement for crustal conductivity, density, and magnetization, and image major crustal features that correspond with significant structures identified in outcrop. Modelling and interpretation of these new data are expected to be complete by mid-2011.

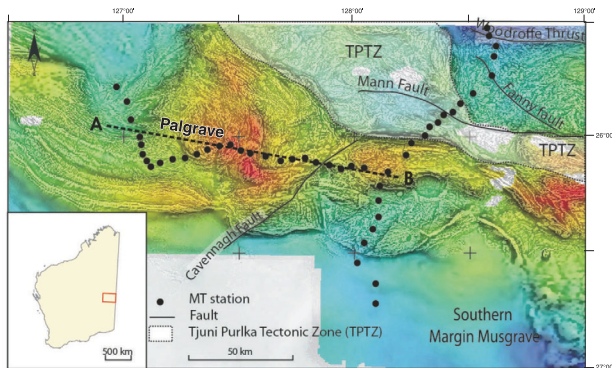


Figure 1. TMI image showing the location of the two magnetotelluric traverses

structure of the province in Western Australia and, along with regional aeromagnetic and gravity data, and detailed geological mapping, to better understand the three-dimensional crustal architecture of the province through time. Preliminary results of a two-dimensional inversion of the east–west traverse are

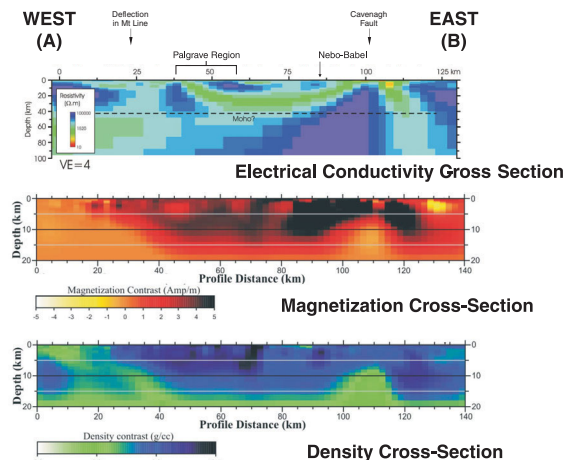


Figure 2. Preliminary results of a 2D inversion



For more information, please contact Mike Dentith (Centre for Exploration Targeting) ([michael.dentith@uwa.edu.au](mailto:michael.dentith@uwa.edu.au)) or Hugh Smithies ([hugh.smithies@dmp.wa.gov.au](mailto:hugh.smithies@dmp.wa.gov.au)).

continued from page 1

Dating of metamorphic monazite, mainly from garnet–staurolite schists at widely spaced localities, provides a range of ages between c. 1280 and c. 1210 Ma, interpreted as the age of deformation and metamorphism.

Field evidence for Mutherbukin-age deformation in the Edmund Basin sedimentary rocks and underlying Mount Augustus Sandstone is more cryptic, because it is of very low metamorphic grade and is restricted to narrow shear zones and faults that were reactivated during the 1030–955 Ma Edmundian Orogeny and c. 570 Ma Mulka Tectonic Event. However, abundant Mutherbukin-aged hydrothermal monazite and xenotime within these sedimentary rocks indicates that they were subject to low-grade metamorphism and hydrothermal alteration during this event.

Abra is a major polymetallic Pb–Ag–Cu–Au deposit within the lower Edmund Group. The deposit has been interpreted as part of a hydrothermal breccia-pipe system related to localized magmatism and possibly associated with the nearby Tangadee Rhyolite. The geochronology of the deposit and surrounding sedimentary host rocks is complex. Hydrothermal monazite and xenotime suggest that mineralization occurred at c. 1385 Ma, but this date is about 150 Ma older than the Re–Os date of c. 1280 Ma obtained on pyrite from the deposit itself. The age of the pyrite is similar to that (at c. 1235 Ma) of concentrically zoned, possibly magmatic, xenotime extracted from the Tangadee Rhyolite. Irrespective of these geochronological complexities, these ages all demonstrate that this part of the

Edmund Basin underwent a prolonged period of low-grade metamorphism, hydrothermal activity, and faulting, at a time when low- to medium-grade metamorphism and deformation was also affecting the underlying Gascoyne Province basement.

### Architecture and mineralization

The 1385–1210 Ma Mutherbukin Tectonic Event may have been a relatively protracted intracontinental oblique strike-slip event, or series of events, the driver of which is currently unknown. The Mutherbukin-aged structures form an anastomosing network of regional-scale shear zones within the basement that extend into the upper crustal sedimentary cover rocks (Mount Augustus and Edmund Basins) where faulting was accompanied by regional-scale hydrothermal fluid flow. Although the structures themselves may not be mineralized, they are essential for ore formation because they provided pathways for magmas, and hence, mineralizing fluids from the middle (and possibly lower) to upper crust. Magmatism, faulting, and the transport of hydrothermal fluids appear to have played a critical role in the formation of the Abra polymetallic deposit. The regional-scale distribution of Mutherbukin-age structures and associated hydrothermal fluid flow potentially makes this one of the most important primary mineralization events in the central part of the Capricorn Orogen, and targeted exploration in this region may lead to significant discoveries.

For more information, contact Simon Johnson ([simonpaul.johnson@dmp.wa.gov.au](mailto:simonpaul.johnson@dmp.wa.gov.au)).

As part of the Exploration Incentive Scheme (EIS), the Geological Survey of Western Australia (GSWA) has released preliminary grids and images from regional airborne magnetic and radiometric surveys covering the eastern Eucla Basin at 200 m line-spacing. Combined with data for the western part of the basin released from the 2009–10 program, these images give a detailed picture of the complex Proterozoic basement rocks buried beneath sand and the relatively thin Cenozoic limestones of the Nullarbor Plain.

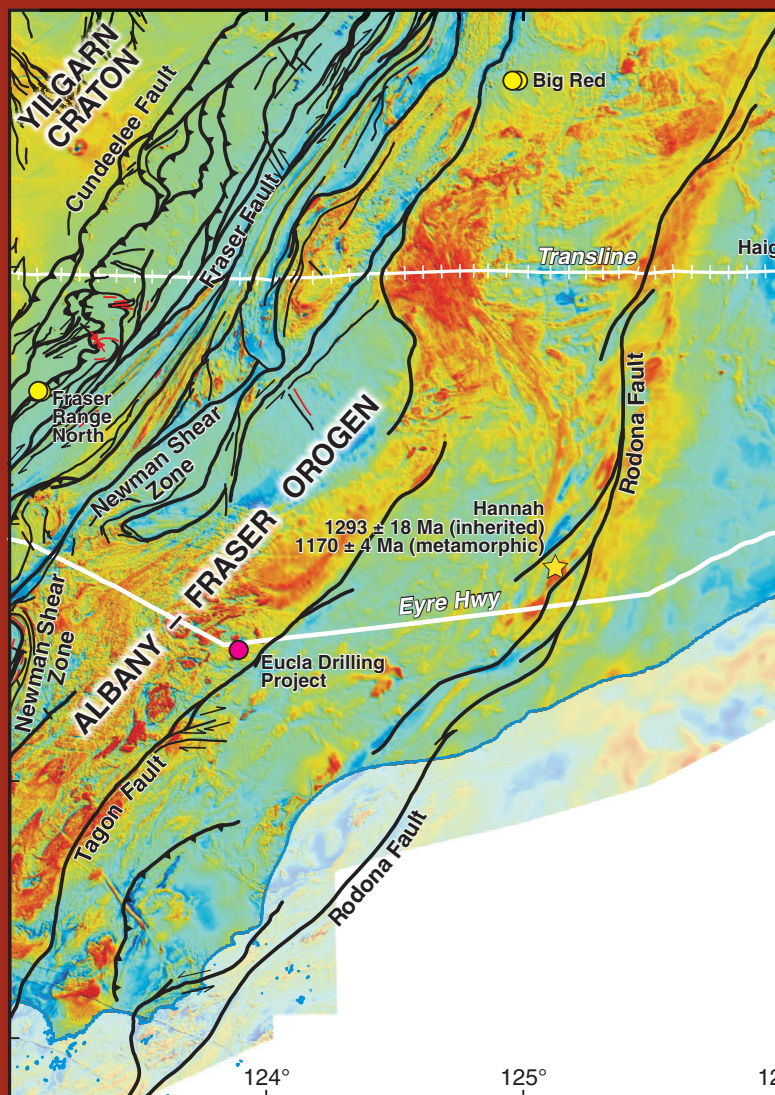
## *‘a challenge for the mineral exploration industry’*

Exploring these basement rocks is clearly a challenge for the mineral exploration industry. All our knowledge of the geological history and geodynamic setting of these rocks will come from geophysical data and drillcore. GSWA is sampling core available in our core libraries for geochemistry, geochronology, and isotopic analysis, particularly the new exploration drilling being co-funded through the EIS. Diamond core from the Burkin, Big Red, and Serpent prospects has already been sampled, and core from 2010–11 EIS co-funded drilling will be sampled when they are delivered. The Burkin drillholes intersected heterogeneous gneissic rocks with quartz veins and local breccia textures. Petrographically, the gneisses are described as banded quartz–chlorite–garnet schists with hematite and magnetite (possibly impure chert), metamorphosed banded iron-formation, and mafic amphibolite. The Big Red core contains interlayered granitic gneiss, metasedimentary gneiss, and mafic amphibolite, similar to rocks of the adjacent Fraser Zone. The Serpent drillcore is dominated by mafic amphibolite. The results from drillcore analysis will help to constrain an interpretation of the bedrock geology, which will in turn be used to choose targets for planned stratigraphic drilling thought to be representative of the ‘background’ geology.

## *‘the results from drillcore analysis will help to constrain an interpretation of the bedrock geology’*

The image shows magnetic anomalies indicating that major structural breaks occur at the Rodona Fault and at the Mundrabilla Fault Zone. The Rodona Fault is currently the inferred ‘edge’ of the Albany–Fraser Orogen, based on c. 1410 Ma dates from Loongana, which is to the east of the fault. This is an age component unknown from the Albany–Fraser Orogen to the west.

# Eucla basement



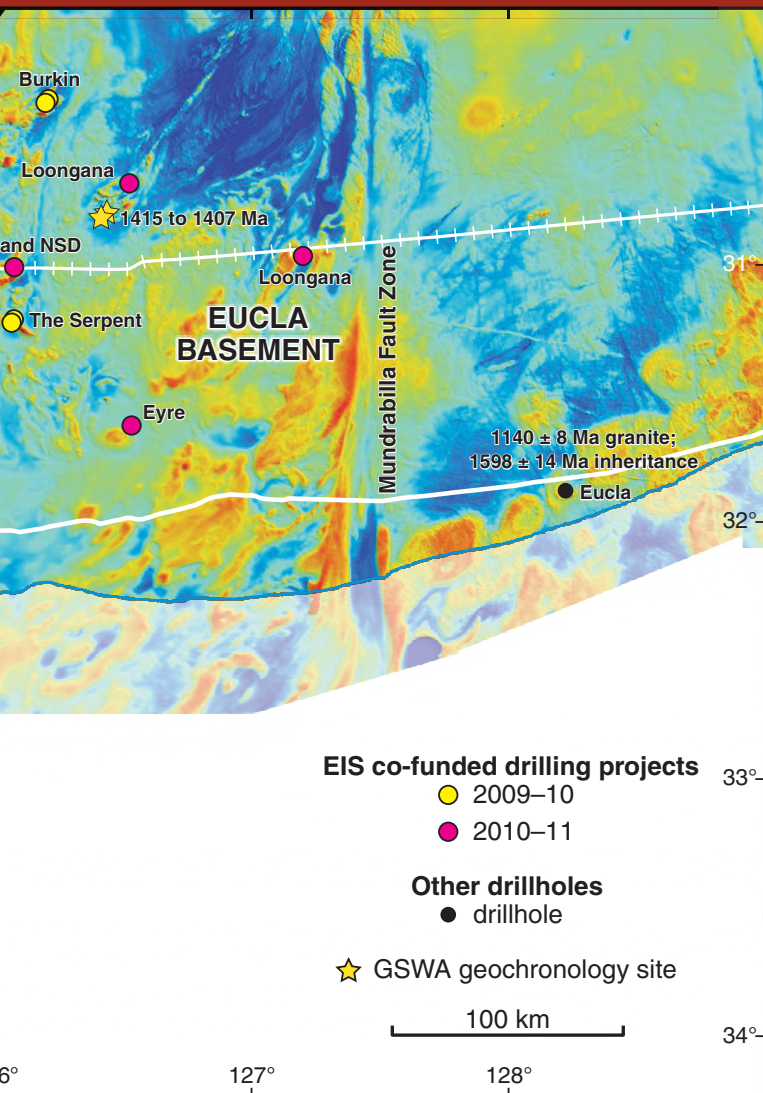
CS119

Aeromagnetic image, including preliminary Eucla data, over the eastern Albany–Fraser Orogen, and

The Mundrabilla Fault Zone is a prominent north–south feature that appears to separate two blocks of crust with different aeromagnetic signatures. The fault zone is very straight, and is interpreted to be subvertical and to have a sinistral shear sense. To the east of the structure, rock chips, interpreted as granite, were recovered from the base of the 700 m deep Eucla 1 drillhole (Alliance Petroleum PCL-2-N 12 00038) drilled in the 1960s. Zircons from these chips (GSWA 194773) yielded a preliminary date of  $1140 \pm 8$  Ma, interpreted as the igneous crystallization age of the granite, and a single zircon dated at  $1598 \pm 14$  Ma, interpreted as an inherited grain that may indicate older basement.



## nt revealed



Eucla Basin showing major structures and locations of drillcore

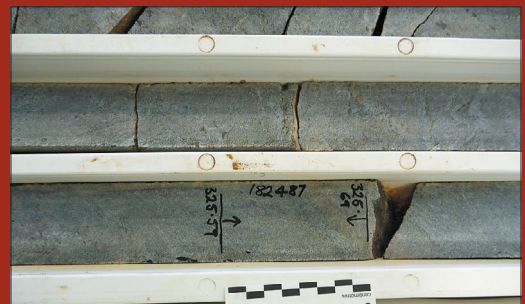
The drillhole is coincident with a distinct, strongly magnetic, ovoid feature consistent with the interpretation that the rock chips were derived from granite. It forms part of a set of northeasterly trending nested plutons with moderate to strong magnetic anomalies. The magnetic signature, together with the c. 1140 Ma age, is consistent with the Esperance Supersuite in the southeastern part of the Albany–Fraser Orogen. The nested plutons are cut by the Mundrabilla Fault Zone, indicating that the structure is a younger feature.

For more information, contact Catherine Spaggiari  
(catherine.spaggiari@dmp.wa.gov.au)  
or Ian Tyler (ian.tyler@dmp.wa.gov.au).

## Burkin prospect

Drillcore from the Burkin prospect intersected heterogeneous gneissic rocks with quartz veins and local breccia textures. Petrographic reports of these rocks described five samples as follows:

1. (182487) Banded quartz–chlorite–garnet schists with hematite and magnetite (impure chert?);
2. (182488) Metamorphosed banded iron-formation with quartz-rich layers, layers of quartz–magnetite–amphibole–garnet with minor altered biotite, sparse hematite, and late crosscutting quartz veins;
3. (182489) Weakly altered massive mafic amphibolite with magnetite, titanium-rich aggregates, epidote, sericite and clinozoisite alteration, and fractures with epidote and feldspar;
4. (182490) Heterogeneous rock with masses rich in hornblende, biotite, epidote, saussuritized plagioclase, chlorite, magnetite and pyrite, with quartz-rich lenses, and a quartz-rich layer with fine-grained garnet, hornblende, biotite, magnetite, and pyrite;
5. (182491) Heterogeneous quartz–chloritized biotite–garnet–magnetite schist with minor apatite: metamorphosed quartz-rich, possibly cherty, sediment.



Banded schist (description 1).



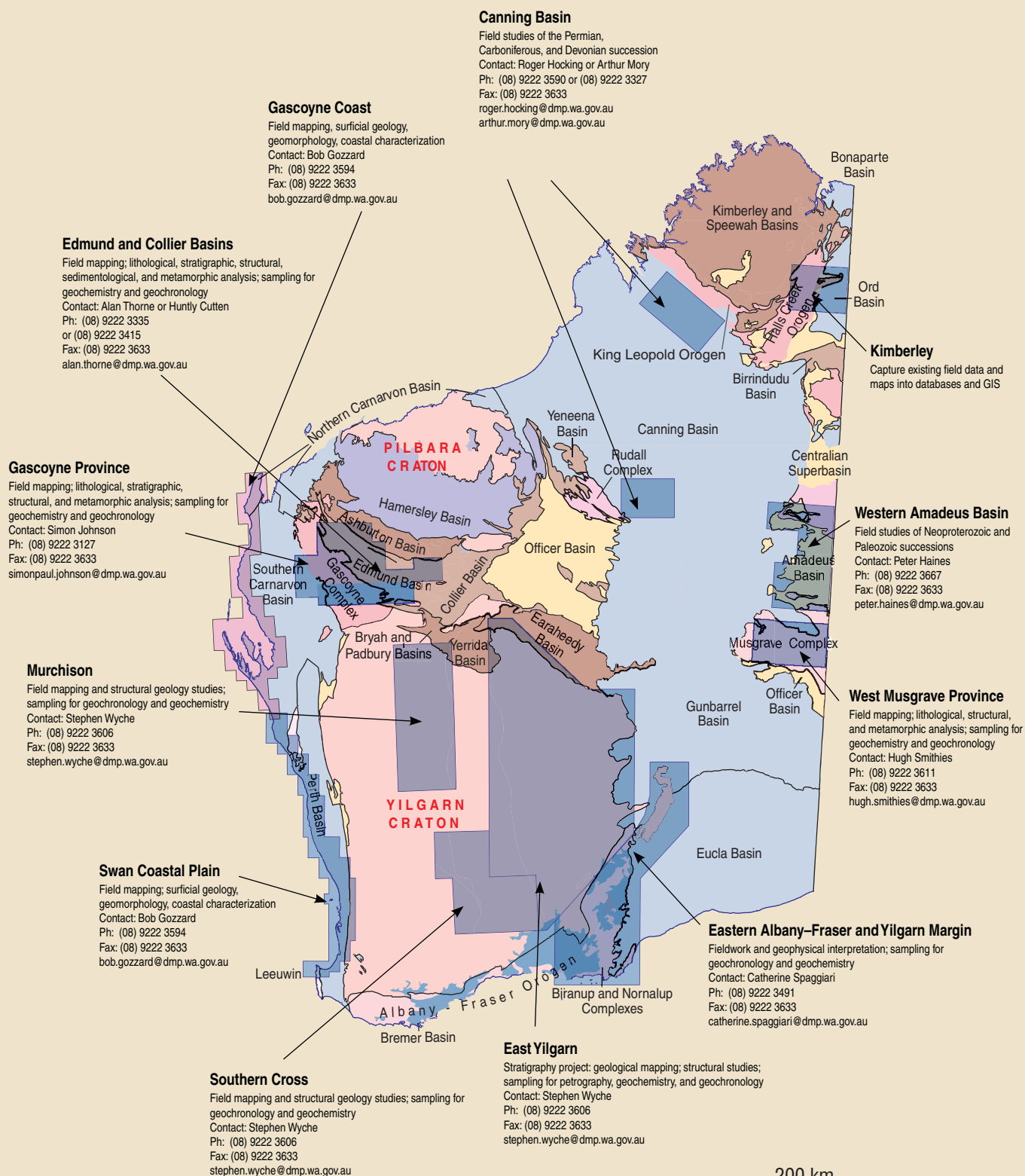
Metamorphosed banded iron-formation with hematite (description 2)



Granitic gneiss cross-cutting gneissic host rock described in (4)



## Where we are working





# Western Australia regional geophysical surveys 2010–11: April update

## Data access

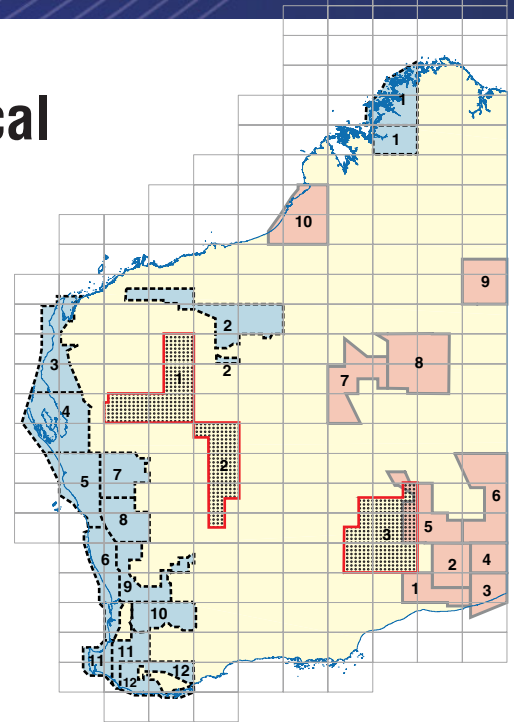
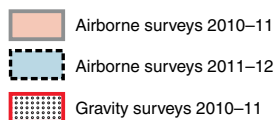
Download final data releases from the Geoscience Australia Data Delivery System at <[www.ga.gov.au/gadds](http://www.ga.gov.au/gadds)>.

Download preliminary and final grids and images from the GSWA website at <[www.dmp.wa.gov.au/geophysics](http://www.dmp.wa.gov.au/geophysics)>.

Subscribe to the GSWA mailing list to keep informed of preliminary and final data release dates.

Survey outline shapefiles available online at <[www.dmp.wa.gov.au/geophysics](http://www.dmp.wa.gov.au/geophysics)>.

For more information, contact David Howard ([david.howard@dmp.wa.gov.au](mailto:david.howard@dmp.wa.gov.au)).



## Airborne Magnetic and Radiometric Surveys

ID	Area/Name	Lines	Size (km)	Status	Start	End	Release
<b>2010–11 Program</b>							
1	Madura 2010	200 m; E/W	102 000	Checking	Jul-10	Nov-10	May-11*
2	Loongana 2010	200 m; E/W	113 000	Processing	Jun-10	Dec-10	May-11*
3	Eucla 2010	200 m; N/S	88 000	Release	Jul-10	Nov-10	14 Apr-11
4	Forrest 2010	200 m; N/S	75 000	Release	Jun-10	Sep-10	14 Apr-11
5	Jubilee 2010	200 m; N/S	180 000	Survey	Jun-10	Jun-11*	Sep-11*
6	Waigen–Mason 2010	400 m; N/S	113 000	Processing	Jun-10	Jan-11	Apr-11*
7	Madley–Herbert 2010	400 m; N/S	95 000	Release	Jul-10	Nov-10	14 Apr-11
8	Morris–Cobb 2010	400 m; N/S	125 000	Processing	Jul-10	Feb-11	Apr-11*
9	Stansmore 2010	200–400 m; N/S	114 000	Checking	Jul-10	Oct-10	May-11*
10	Lagrange–Munro 2010	400 m; N/S	103 000	Survey	Sep-10	May-11*	Jun-11*
<b>2011–12 Program</b>							
1	West Kimberley 2011	200–800 m; E/W	136 000	Contract	May-11*	Aug-11*	Oct-11*
2	South Pilbara 2011	400 m; N/S	134 000	Contract	Apr-11*	Aug-11*	Oct-11*
3	Carnarvon Basin North	400 m; E/W	106 000	Contract	May-11*	Sep-11*	Nov-11*
4	Carnarvon Basin South	400 m; E/W	123 000	Contract	Feb-12*	May-12*	Jun-12*
5	Perth Basin North	400 m; E/W	91 000	Contract	Apr-11*	Jul-11*	Sep-11*
6	Perth Basin South	400 m; E/W	120 000	Survey	Mar-11	Jun-11*	Aug-11*
7	Murgoo	200 m; E/W	129 000	Survey	Mar-11	Jul-11*	Sep-11*
8	Perenjori	200 m; E/W	121 000	Contract	Sep-11*	Jan-12*	Apr-12*
9	Moora	200 m; E/W	130 000	Contract	Jun-11*	Dec-11*	Feb-12*
10	Corrigin	200 m; E/W	114 000	Contract	Sep-11*	Feb-12*	May-12*
11	Cape Leeuwin – Collie	400 m; E/W	95 000	Survey	Mar-11	Jul-11*	Sep-11*
12	Mt Barker	200 m; N/S	120 000	Survey	Apr-11	Apr-12**	Jun-12*

\*\* Survey suspension over winter wet season

## Ground Gravity Surveys

ID	Area/Name	Spacing	Size (stns)	Status	Start	End	Release
1	Gascoyne South 2010	2.5 km grid	9 700	Processing	Aug-10	Oct-10	Apr-11*
2	Sandstone 2010	2.5 km grid	6 300	Processing	Aug-10	Dec-10	Apr-11*
3	Albany–Fraser North 2010	2.5 km grid	9 200	Processing	Oct-10	Jan-11	Apr-11*

Information current at: 6 April 2011

\* Estimated date

## REPORT

110 Temporal and hafnium isotopic evolution of the Glenburgh Terrane basement: an exotic crustal fragment in the Capricorn Orogen  
*by SP Johnson, S Sheppard, MTD Wingate, CL Kirkland, and EA Belousova*

## RECORDS

2011/2 GSWA 2011 Extended Abstracts: promoting the prospectivity of Western Australia

2011/5 Late Devonian (Famennian) facies of the outer Lennard Shelf, Canning Basin, Western Australia — a preliminary study  
*by IA Copp*

2011/6 3D geological model building, and 3D temperature and heat flow calculation for the northern Perth Basin  
*by Geointrepid*

2011/9 CAVEPS Perth 2011 13th Conference on Australasian Vertebrate Evolution Palaeontology and Systematics, Programme, Abstracts

## NON-SERIES BOOKS

Geological Survey of Western Australia Annual Review 2009–10

Geology and Petroleum Prospectivity of State Acreage Release Areas L11-1, L11-2, L11-3, Canning Basin, Western Australia

Geology and Petroleum Prospectivity of the State Acreage Release Areas T11-1 and T11-2/L11-4, Northern Carnarvon Basin, Western Australia

Overview of mineral exploration in Western Australia for 2009–10  
*by PB Abeysinghe and DJ Flint*

Summary of petroleum prospectivity, Western Australia 2011: Amadeus, Bonaparte, Bight, Browse, Canning, Officer, Perth, Northern Carnarvon, and Southern Carnarvon Basins

## GEOLOGICAL MAPS

CUE 1:100 000 Geological Series map, WA Sheet 2443  
*by MJ Van Kranendonk*

## GEOLOGICAL INFORMATION SERIES

MURCHISON 1:100 000 GIS 2010 update

## RESOURCE POTENTIAL FOR LAND USE PLANNING

Aboriginal land, conservation areas, mineral and petroleum titles, and geology, Western Australia — 2011

## NON-SERIES MAPS

Major resource projects, Western Australia, 2011  
*by RW Cooper, PB Abeysinghe, DJ Flint, JH Haworth and WA Preston*

Mineral deposits and petroleum fields 2011 (poster)  
*by RW Cooper, PB Abeysinghe, DJ Flint, and JH Haworth*

Mines — operating and under development, Western Australia — 2011  
*by RW Cooper and DJ Flint*

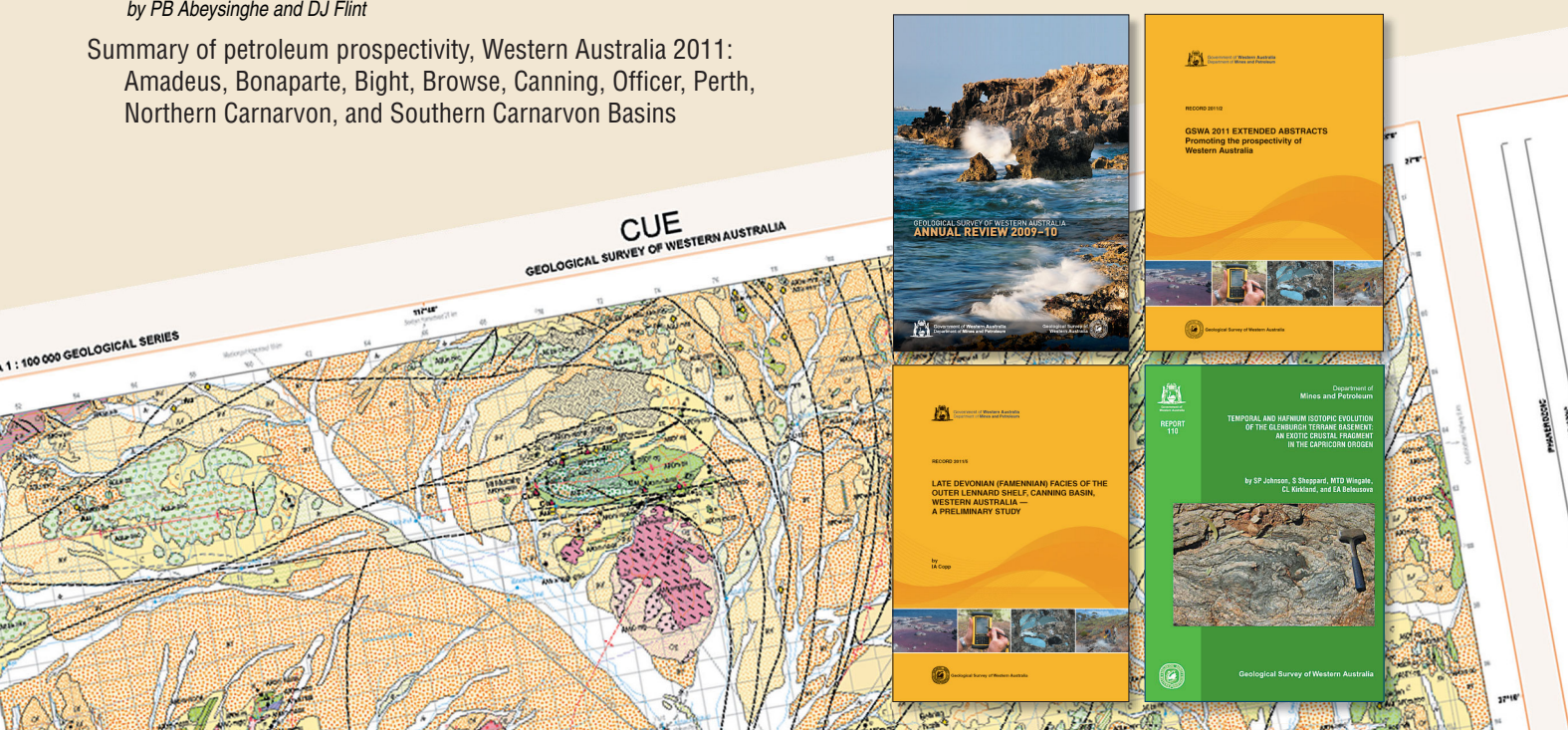
## MISCELLANEOUS DIGITAL PRODUCTS

GSWA Open Day USB 2011

Western Australian petroleum explorers' guide

## DATA PACKAGE

Petroleum state acreage release April 2011



Almost all printed publications are now also available free as PDF files on our website at <<http://www.dmp.wa.gov.au/GSWApublications>>. Further details of geological publications and maps produced by the Geological Survey of Western Australia can be obtained at <<http://www.dmp.wa.gov.au/GSWA>>.

Hardcopy publications including CDs and DVDs are available from the Information Centre, First Floor, Mineral House, 100 Plain St, East Perth, WA 6004, AUSTRALIA Phone: +61 8 9222 3459; Fax: +61 8 9222 3444

or can be purchased online from the bookshop at <<http://www.dmp.wa.gov.au/ebookshop>>.