A Geological Survey of Western Australia Newsletter

July 2017 NUMBER 83

Fieldnotes

Government of Western Australia
Department of Mines, Industry Regulation and Safety

Geological Survey of Western Australia

Visit our Home Page at <www.dmp.wa.gov.au/GSWA>

ISSN 1325-9377
ISSN 1834-2272

ISBN (PRINT) 978-1-74168-764-4
ISBN (PDF) 978-1-74168-763-7

New Digital Core Atlas for Olympic 1

EXPLORATION INCENTIVE SCHEME

Buru Energy

The Geological Survey of Western Australia (GSWA) has released the first Atlas in a new Digital Core Atlas series. The product was designed to manage and present large volumes of data generated from multiple types of core sample analysis.

The Digital Core Atlas was created to store and display core data recovered from petroleum exploration well Olympic 1 drilled by Buru Energy in 2015, in the Canning Basin.

Key features of the Digital Core Atlas include:

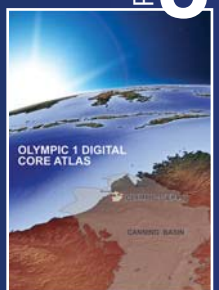
- interactive, user-friendly design
- a centralized location for all data collected from the cored material in the well
- photos of the entire cored section
- UV photos of the entire cored section
- the location of every sample collected, identified on the core photos
- linked pop-ups at sample locations displaying the results of biostratigraphic, geochronological, geochemical, petrographic and petrophysical analyses
- interactive summary sheets of all samples collected and their results
- access to all original data spreadsheets, reports and photos.

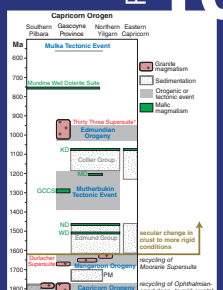
Figure 1. Conceptual image of the various datasets incorporated into the GSWA Digital Core Atlas

continued on page 3

What's inside?

DIGITAL CORE ATLAS 1, 3
TECHNOLOGY NEWS 2
GIBB MAITLAND AWARD 4
WAROX DATABASE 5
CANNING COASTAL SEISMIC SURVEY 6, 7
LAWLERS REGION 8
CORE VALUES 9
CAPRICORN OROGEN 10
GEOPHYSICAL SURVEYS 11
GEOTOURISM 11
PRODUCT RELEASES 12





New Data and Software Centre launched

The Department of Mines, Industry Regulation and Safety (DMIRS) released its new Data and Software Centre in February 2017 in time for the GSWA Open Day. The new release provided a single point for downloading statewide spatial datasets.

There are more than 600 products available for download, including spatial data, software, and training resources such as manuals and videos.

There are over 730 zip files for users to download. This information is licensed under Creative Commons 'Free to use and free to share' agreement (CC BY).

Some spatial datasets, such as Tenements – Current (live and pending), are available in more than one spatial format.

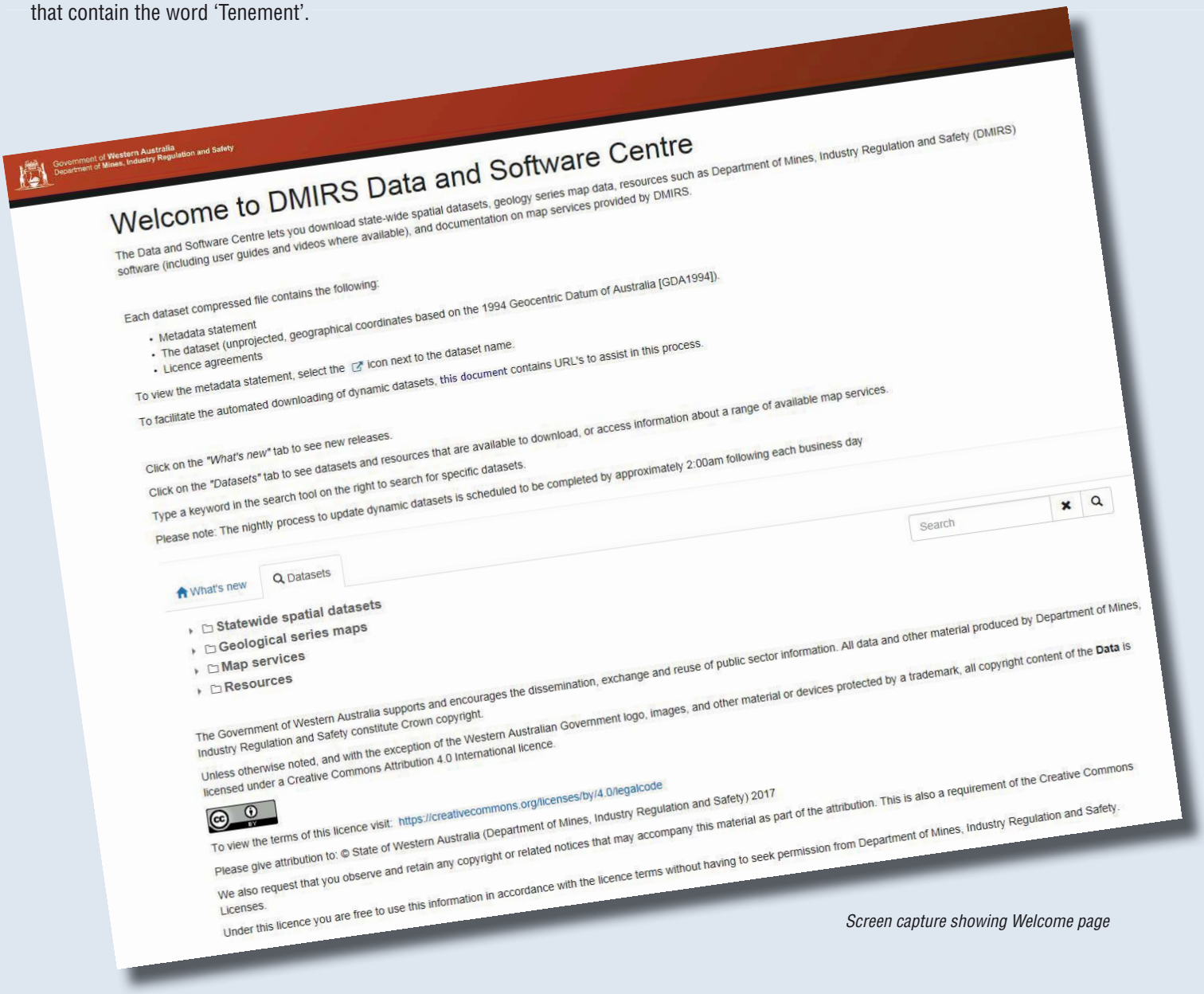
The new Data and Software Centre also features a search facility. Enter 'Tenements' into the search option to find all downloads that contain the word 'Tenement'.

There is a 'What's New' tab where users can see what spatial datasets have been recently released or updated, and when the new information was made available for download.

This is to cater for important datasets such as Interpreted bedrock geology and Tectonic units data that are updated only once or twice every few years.

The latest release of the DMIRS Data and Software Centre has seen significant uptake with more than 36 370 downloads occurring up to 30 June 2017. The search, Tenements – Current (live and pending), remains the most popular with 6600 downloads up to 30 June 2017.

For more information, contact Neville D'Antoine (neville.d'antoine@dmirs.wa.gov.au).



Screen capture showing Welcome page

continued from page 1

The Canning Basin Drilling project

The Digital Core Atlas was developed as part of the Canning Basin Collaborative Core Analysis Project, a collaboration between GSWA and several petroleum exploration companies. The aim of the project was to sample and analyse newly cored sections in the Canning Basin for stratigraphic, petroleum systems and CO_2 sequestration studies. The result was the recovery of 1383.18 m of continuous core and thousands of samples from three wells: Olympic 1, Theia 1 and Senagi 1 (Table 1).

Table 1. Wells studied and sampled in the Canning Basin Collaborative Core Analysis Project, their locations and amounts of core recovered

Well	*Industry partner*	*Date drilled*	*Cored interval – measured depth (m)*	*Total core length (m)*
Olympic 1	Buru Energy	May–June 2015	1128.00 – 1447.20	319.20
Theia 1	Finder Exploration	Aug–Sept 2015	864.00 – 1644.95	777.95
Senagi 1	Buru Energy	Oct–Nov 2015	758.67 – 1044.70	286.03

Product concept and design

The original concept for the Digital Core Atlas was derived from a paper-based Atlas created for the Theia 1 petroleum well, provided by Finder Exploration. The new Digital Core Atlas displays detailed photos of the cored section and all related analytical data in an interactive and easily accessible format in one location. The product features an electronic book design, using FlipBuilder software. The Digital Core Atlas is fully interactive with links and icons that allow for quick and easy navigation of the cored section and direct access to sample results (Fig. 2).

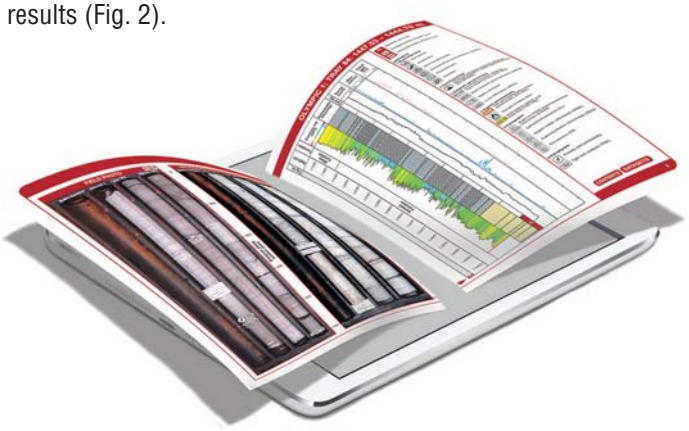


Figure 2. The GSWA Digital Core Atlas is an interactive ebook, displaying sample locations and results for multiple datasets

Product prototype

The Olympic 1 well, drilled on the Broome Platform, was the first well in this program and was used to develop the Digital Core Atlas prototype. The well cored a continuous section through Lower and Middle Ordovician strata, from the base of the Willara Formation through the Nambeet Formation, a total of 319.20 m. The excellent core quality and a nearly complete section through the Nambeet Formation make this interval valuable for stratigraphic and petroleum systems analysis.

Samples were collected for biostratigraphy, geochronology, inorganic geochemistry, organic geochemistry, petrography and petrophysics. More than 400 samples were analysed, resulting in 21 different datasets along the Olympic 1 cored section.

Product functions and features

On the main pages of the Digital Core Atlas, core images are displayed on the left and a well log and legend for datasets are displayed on the right (Fig. 2). The images include both field photos of core taken immediately after retrieval from core barrels and placed into trays, as well as HyLogger photos taken at the Perth Core Library. Icons on the field photos correspond to the analysis types at the exact depths the samples were taken.

Each icon is linked to the analytical data from that sample depth (Fig. 2) and the results can be accessed by a simple mouse click. The location of the individual core trays is marked adjacent to the well log to provide users with a clear understanding of the stratigraphic interval they are viewing.

In addition to the main core images, the Digital Core Atlas includes an appendix and a summary page listing all the samples and analytical results for each dataset. These sample lists link to individual sample results and contain additional links to the raw data reports in the Western Australian Petroleum and Geothermal Information Management System (WAPIMS) where the original reports, photos and data spreadsheets can be downloaded.

The future

The Olympic 1 Digital Core Atlas was released in June. With excellent core sections and numerous samples, Theia 1 and Senagi 1 are the next candidates for future Digital Core Atlas products in the Canning Basin Collaborative Core Analysis Project.

For more information, contact Leon Normore (leon.normore@dmirs.wa.gov.au) or Louisa Dent (louisa.dent@dmirs.wa.gov.au).

Dr Ian Tyler wins prestigious Gibb Maitland medal

Geological Survey of Western Australia's (GSWA) Assistant Director, Dr Ian Tyler, was recently recognized for his substantial contribution to geoscience in Western Australia when he was awarded the Geological Society of Australia's Gibb Maitland Medal. Named for Andrew Gibb Maitland, who was Western Australia's Government Geologist from 1896 to 1926 and who established GSWA, the annual award particularly acknowledges work that impacts on the discovery of mineral and petroleum resources in Western Australia.

Ian was nominated for the medal by eminent geoscientist and former Western Australian Chief Scientist Professor Bruce Hobbs, who presented the citation and outlined Ian's extensive achievements at the awards event on 26 April 2017.

'Since commencing with GSWA in 1981, Ian has worked to understand the State's geology through systematic field mapping, integrated with multidisciplinary studies,' Professor Hobbs said.

'He was a pioneer in applying the plate tectonic paradigm to the assembly of Proterozoic Western Australia, focusing on tectonic evolution and mineral systems. He is recognized as one of Australia's leading regional geologists, and the quality of GSWA work under his leadership is arguably unsurpassed by any other group in Australia.'

Professor Hobbs also praised Ian's leadership and insight when designing and implementing GSWA geoscientific programs funded from the Western Australian Government's $130 million Exploration Incentive Scheme (EIS). These programs have included accelerated acquisition of statewide geophysical, geochemical, geochronological and satellite remote sensed datasets, which provide information fundamental for understanding crustal architecture and associated mineral systems. Industry has enthusiastically reacted to the flood of new information with increased exploration expenditure and the discovery of over 20 new mineral deposits in Western Australia. GSWA geoscience also contributes significantly to the UNCOVER Initiative, which Ian strongly advocates should be central to all Australian geoscience agency programs.

Figure 1. Dr Ian Tyler holding the Gibb Maitland medal

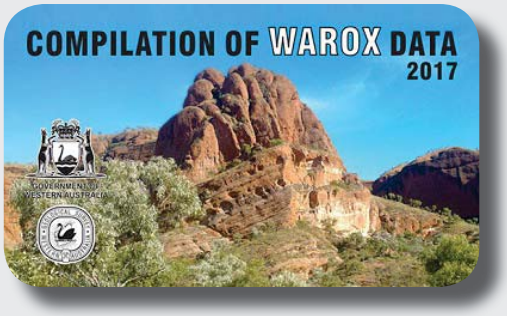
In his acceptance speech, Ian said he was honoured to be included with previous medallists, such as former GSWA geoscientists Alec Trendall (1987), Phil Playford (1990), Wally Witt (1998), Kath Grey (2003), Phil Commander (2009) and Tim Griffin (2010).

'I joined GSWA in 1981 and only intended to stay in Australia for three years, but everything here is so interesting geologically that I've stayed for 35 years, and have no intention of leaving. GSWA really is recognized as a leader in mapping geoscience, and I attribute much of my success to collaborations with all my department colleagues, and also with other government, academic and industry organizations.'

Ian's nomination by Professor Hobbs was made even more special because his early geoscience education was influenced by Professor Hobbs' coauthored textbook 'An Outline of Structural Geology', a first-edition (1976) copy of which he still treasures.

WAROX field and rock observations: statewide data available

The Geological Survey of Western Australia's (GSWA) field and rock observation database (WAROX) contains all of the geological data that are critical for the production of high-quality maps and interpretive products. The database contains geological field observations, structural measurements, photos, sample and lithological descriptions, as well as follow-up petrological and analytical work. Although parts of this database have been released for individual project areas in Geological Information Series packages, this new USB product is the first-ever release of statewide data. The package contains the most recent field observation data, collected during the 2016 field season, as well as legacy data captured from field photographs and handwritten notebooks. The data are viewable in both GeoMap.WA and ArcMap. The package will be updated yearly after the completion of each field season.

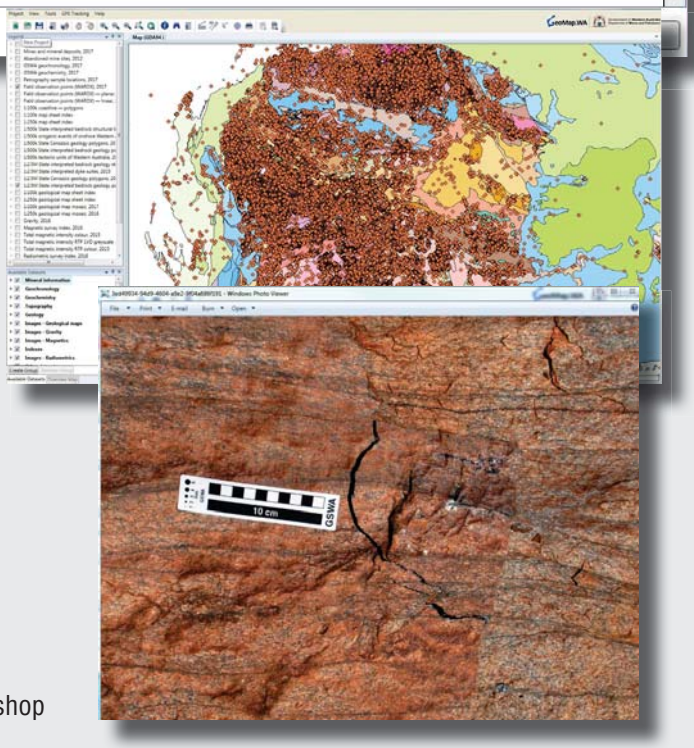


The WAROX 2017 release contains:

- 237 089 field observation sites
- 10 077 linear structural measurements
- 55 412 planar structural measurements
- 47 931 field photos and site sketches
- sample location information
- petrography reports
- regolith and landform information.

More details

Field	Value
Site ID	FJKGAS000081
Observation Date	5/24/2012 12:00:00 AM
Site Type	Warox
Latitude	-23.518410
Longitude	115.328340
East	329330
North	7398095
MGA Zone	50
Accuracy	10
Location Method	GPS observation (WGS-84/GDA-94)
Location	
Notes	strongly sheared porphyritic monzogranite. K-feldspar augen up to 3 cm and thin quartz seams with biotite defining the foliation. augen gneiss can be followed into very strongly sheared biotite-rich high strain zones with only few phenocryst relics and thinner quartz seams (now a biotite-quartz schist). all fabrics seem to be transposed into direction of shear. intruded by less deformed equigranular muscovite (less biotite) monzogranite. late thin cross cutting tourmaline-pegmatite. just NW (across cattle trail that we drove in on) whaleback of medium grained equigranular muscovite-sparse tourmaline monzogranite. large clots and trains of biotite. likely same phase intruding augen gneiss across trail.
Regolith Description	
Land Element	
Land Parent	
Land Composition	
Rock Type	meta-igneous felsic intrusive
Lithology Name	metagranodiorite
Exposure	subcrop
Weathering	distinctly weathered
Grain Size	medium - coarse
Composition	
Description	
Structure Category	Metamorphic fabrics
Structure	Metamorphic foliation; inclined
Azimuth	
Plunge	
Strike	110
Dip	66
Local Event	
Regional Event	
Photo (Click To View)	E508A341-6533-4AF6-8179-7995C3F184FE.jpg
Field ID	FJKGAS000081_1
Description	strongly sheared porphyritic monzogranite. K-feldspar augen up to 3 cm and thin quartz seams with biotite defining the foliation.
Keywords	



Example data from the WAROX digital data package

The package also contains additional statewide data layers that include:

- 1:2.5M and 1:500k geology
- GSWA geochronology, 2017
- GSWA geochemistry, 2017
- Abandoned mine sites, 2012
- Mines and mineral deposits, 2017
- Explanatory Notes
- Geophysical datasets.

The WAROX 2017 digital package can be purchased from the eBookshop <www.dmp.wa.gov.au/ebookshop> at a cost of $55 including GST.

For more information, contact Simon Johnson (simonpaul.johnson@dmirs.wa.gov.au).

An overview of the Canning Basin

EXPLORATION INCENTIVE SCHEME

A regional seismic reflection survey was conducted along the coast of the Canning Basin, across the strike of the major structural subdivisions, in order to investigate the tectonic architecture and stratigraphy of the basin. The Geological Survey of Western Australia (GSWA), in collaboration with Geoscience Australia (GA), contracted Terrex Seismic to collect the data in May–June 2014. The acquisition was funded by the Western Australian State Government's Royalties for Regions Exploration Incentive Scheme (EIS).

The survey (Fig. 1) commenced on line 14GA-CC1 about 20 km northwest of Pardoo roadhouse, ~170 km west-northwest of Port Hedland on the Great Northern Highway, and finished on line 14GA-CC2 across the northwest boundary of the Canning Basin on the Gibb River Road about 20 km northwest of Napier Downs homestead. The two lines are separated by a 4 km data gap around Derby and have numerous bends along the route, particularly about 50 km east of Broome where the acquisition diverges from the Great Northern Highway to follow station tracks. The recording system used 600 live channels spread over 12 km with geophone groups spaced 20 m apart. The energy source was an in-line array of three Hemi-60 vibrators with single linear sweep (6–96 Hz and 28-second duration) per vibration point (VP). The seismic data averaged 150-fold coverage with a 20 m station interval and a 40 m shot interval. The survey cross-correlated each of the sweeps for each VP with the reference sweep and recorded a total of 705 km of 20-second reflection data.

Processing

The Canning Coastal seismic dataset was processed from SEGD field tapes by DownUnder GeoSolutions. The crooked acquisition line geometry was manually corrected to redefine the midpoint position between the source and receiver points. First break statics were picked and computed to compensate the effects of variations in surface elevation and base of weathering. Adjacent well checkshot data were projected onto the line to control the velocity modelling for the shallow basin. Both Kirchhoff pre-stack time and depth migration were utilized to produce stacked sections for the basin and deep crustal structures. The final data were processed with minimum phase, normal SEG polarity, a datum of 200 m above mean seal level and replacement velocity of 2000 m/s.

Interpretation

The final data required a bulk shift of 200 milliseconds upwards based on the final datum and replacement velocity. This enables the coastal line to be correlated with other nearby seismic profiles for which the variable datum has been corrected to mean sea level. In general, the new seismic lines are of reasonable quality,

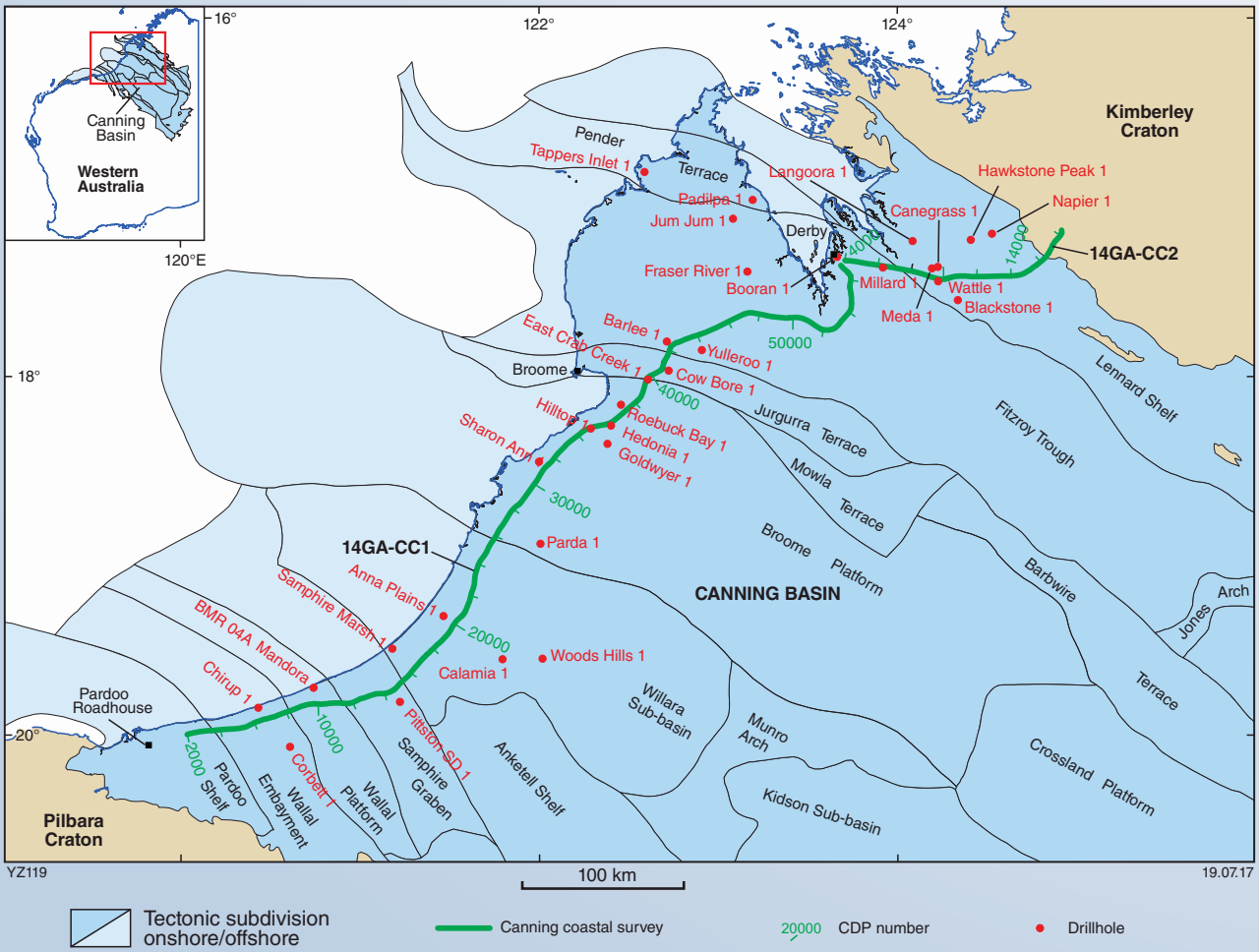


Figure 1. Location diagram of the Canning Coastal seismic survey

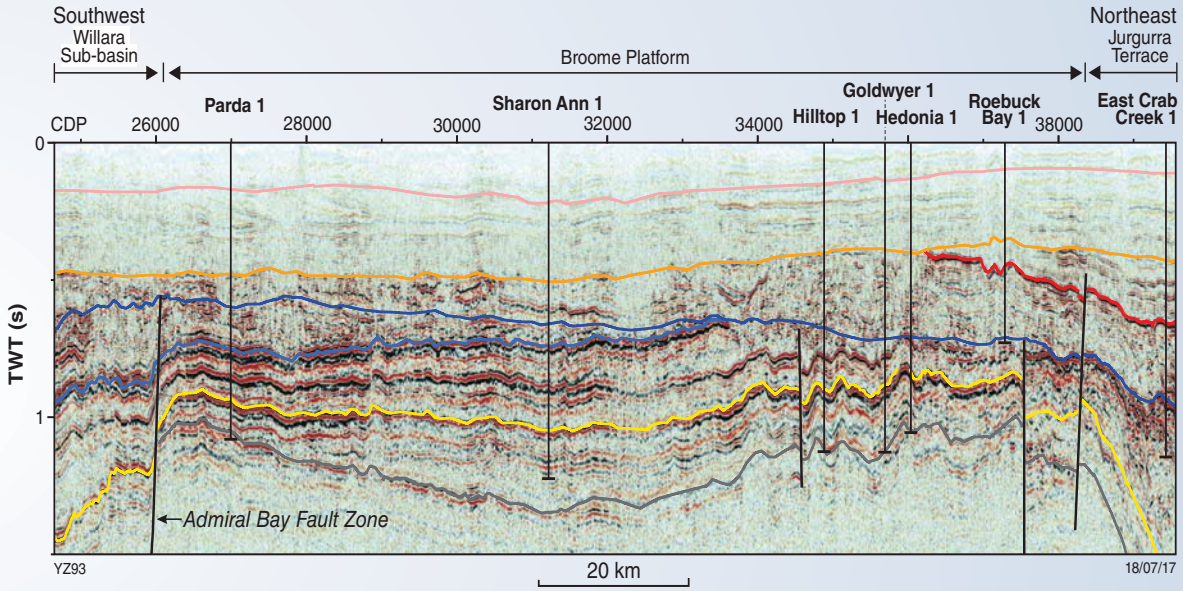


Figure 2. Interpreted seismic section (14GA-CC1) across the Broome Platform

particularly for the southwestern part where the lowermost stratigraphic units within the basin are well imaged. Data quality is poor in the central part of the line, reducing confidence in the interpretation. The survey locally shows that the Precambrian basement is internally highly deformed, although across most of the line the basement data are generally of low amplitude or display few reflections. As a result, it was difficult to interpret the structure below the base of the Canning Basin.

An essential precursor to the seismic interpretation was the establishment of precise well–seismic ties along the Canning Coastal survey. Twenty-eight drillholes that penetrate below the prominent Base Jurassic Unconformity seismic horizon were used to tie the seismic profiles using sonic logs and velocity surveys to constrain the interpretation. Some of the wells are close enough to the Canning Coastal seismic line that they can be directly used to calibrate to the seismic profile. Other wells are either too distant or are located in structurally complicated areas. These wells cannot be directly tied to the survey; hence, they were tied to other nearby seismic lines which were then correlated with the Canning Coastal survey data. The seismic interpretation (Fig. 2) divided the Phanerozoic succession of the Canning Basin into four megasequences, separated by major angular unconformities as follows:

1. Ordovician to Middle Devonian: this megasequence generally extends throughout the southern Canning Basin but is only locally preserved in the north. The Upper Ordovician – Middle Devonian part of this megasequence has been removed by erosion in the coastal area.

2. Middle Devonian to mid-Carboniferous: this megasequence is only present in the northern Canning Basin, and varies significantly in thickness, reaching its maximum in the Fitzroy Trough and thinning towards the Jurgurra Terrace in the southwest and Lennard Shelf in the northeast.

3. Mid-Carboniferous to Triassic: this megasequence is laterally extensive and unconformably overlies Lower Ordovician to Middle Devonian rocks in the south, and Middle Devonian to mid-Carboniferous rocks in the north. It was truncated by erosion during the Late Triassic to Jurassic Fitzroy Transpression movement.

4. Jurassic to Cretaceous: this megasequence is characterized by a package of flat-lying seismic reflections along the coastal seismic survey. It has a relatively uniform thickness in the south but pinches out northwards in the Fitzroy Trough.

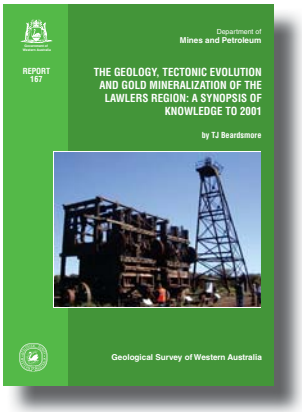
Interpretation of basin architecture from the Canning Coastal seismic survey suggests that the Wallal Embayment is one of the basin outliers in the western Canning Basin, isolated from the major depocentre by tectonics and extensive erosion across the basin's western margin. The Samphire Graben is mostly filled with Permian to Mesozoic sedimentary rocks and apparently lacks an Ordovician to Devonian succession. The Willara Sub-basin and Broome Platform are both interpreted to have been uplifted after the deposition of the Nita Formation, leading to increased erosion of the Mid-Ordovician to Mid-Devonian succession towards the northern margin of the Broome Platform in the coastal area. The Paleozoic succession in the Jurgurra Terrace thickens northeastwards to the Fenton Fault and incorporates two megasequences: the Lower Ordovician to Middle Devonian, and the Middle Devonian to lower Carboniferous, mainly present in the south and north of the Canning Basin, respectively. Interpretation of the depth of the Fitzroy Trough is difficult due to ambiguous seismic reflections and lack of well penetration. There are two alternative interpretations for the depth to Top basement in the trough: the deep option is characterized by a strong acoustic response below a thick interval of no reflection; and the shallow option is correlated using offset seismic profiles and the intersection of metasedimentary rocks in Padilpa 1. Either interpretation implies a considerable amount of reverse movement along the Fenton Fault and a complex history of fault movement.

Record 2017/5 Canning Coastal seismic survey — an overview of the Canning Basin is available as a free download (with accompanying plate) from the eBookshop at <www.dmp.wa.gov.au/ebookshop>.

For more information, contact Alex Zhan (alex.zhan@dmirs.wa.gov.au).

Company geological knowledge sees the light of day

Resource industry geoscientists commonly make important contributions to knowledge of the geology and mineralization of regions in which their companies operate, but such knowledge is often retained 'in-house' in technical reports that are unavailable in the public domain.



A rare exception is Geological Survey of Western Australia (GSWA) Report 167. This Report is a recently published reproduction of one such technical report that describes the state of geological and metallogenic knowledge at the close of the 20th century for the highly gold-endowed Agnew–Lawlers region. It is based on compilation of all available regional- to mine-scale geological information from corporate and public-domain sources, and a program of systematic, regional- and mine-scale geological mapping by the author.

The aim of the work was to test a geological model and conceptual targets for gold mineralization developed by other geologists using previously acquired geological and geophysical data, and inferences regarding the deformation history and geological settings of known gold deposits. Results included the definition of a coherent, albeit informal lithostratigraphy, confirmation that all known gold mineralization occurred late in the deformation history, and development of a new model that better explained the known geological and metallogenic features of the Agnew–Lawlers region, assuming several reasonable but at-the-time unconfirmed inferences about the relative and absolute ages of particular rock units.

Geological research has continued in the Agnew–Lawlers region in the years since completing this report, providing new information on lithostratigraphy nomenclature and petrogenesis; on the regional structure; on particular gold deposits; and on the absolute ages of particular events. However, the information contained in Report 167 remains largely valid, and the corporate owner gave subsequent researchers access to it to provide context for their work. It was consequently often cited, but until now has been unavailable to the geoscientific community at large.

Permission to release the original company technical report as a GSWA publication was granted by current owner Gold Fields Australia, which sees that making fundamental geological information more widely available serves its own interests as well as those of others. GSWA welcomes the opportunity to publish other, similar corporate reports, and asks that resource companies consider publishing other hidden treasures of geological data and knowledge that are currently found only on company bookshelves.

Report 167 The geology, tectonic evolution and gold mineralization of the Lawlers region: a synopsis to 2001 is available as a free download from the eBookshop at <www.dmp.wa.gov.au/ebookshop>.

For more information, contact Trevor Beardsmore (trevor.beardsmore@dmirs.wa.gov.au).

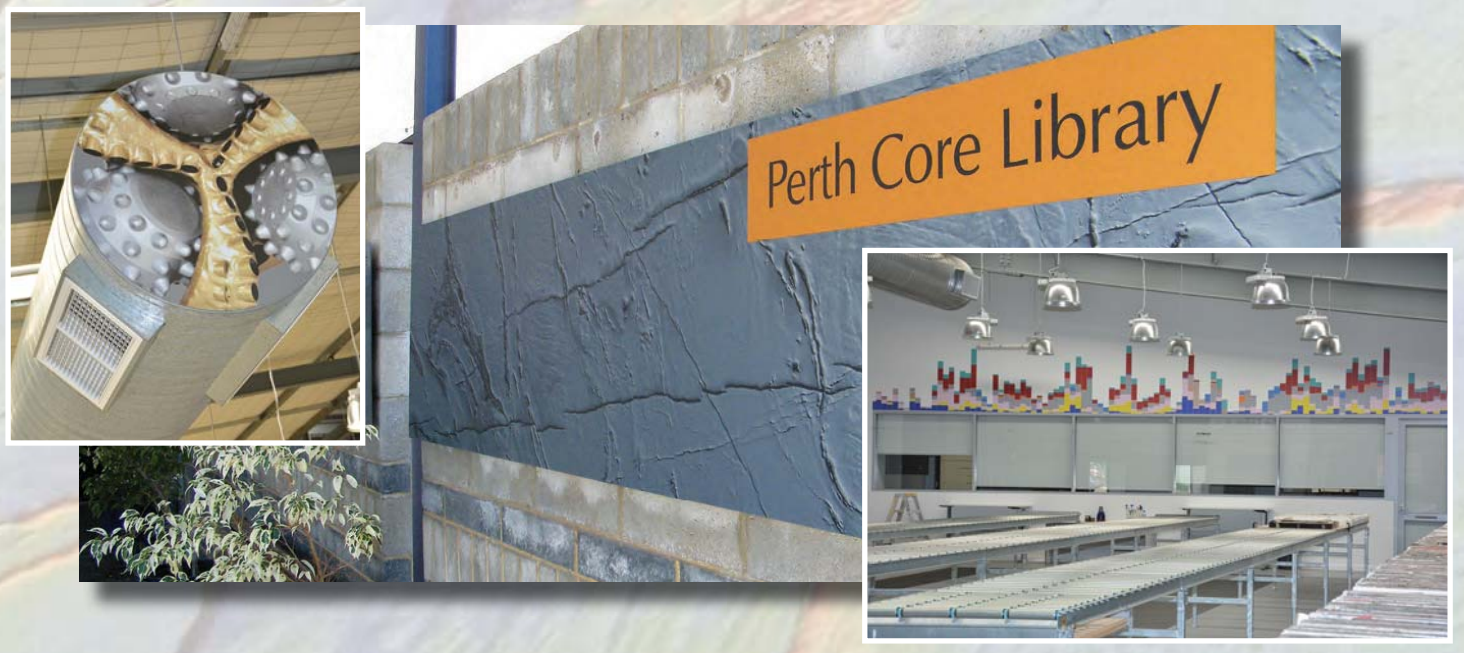
Core Values: new artworks enhance the Perth Core Library

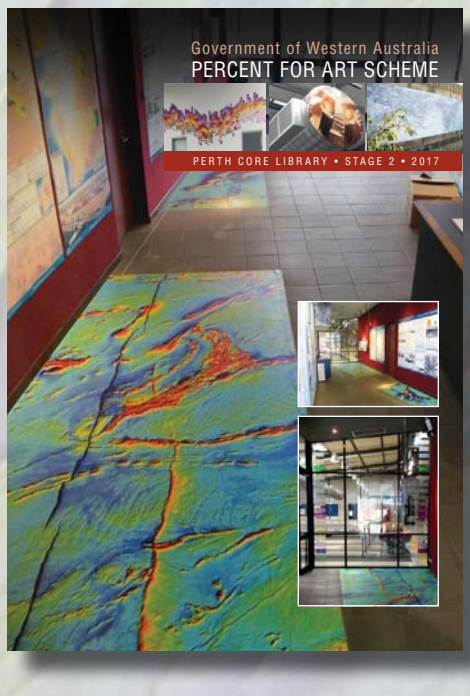
Core Values, by Perth artist Dr Nien Schwarz, presents a visual and material journey across a range of scales, from remotely sensed imagery to detailed core analysis, incorporated within ten interrelated artworks across four areas of the Department of Mines, Industry Regulation and Safety's (DMIRS) Perth Core Library. The artworks were inspired by the beauty of the Earth and a fascination with geology and modern and historical mining technologies. They highlight the library's core business of storing mineral and petroleum drillcore and other rock samples, conducting HyLogger spectral scanning of drillcore, and providing viewing areas for researchers and explorers to examine drillcore archives.

The site-specific art project enhances the recent $7.3 million expansion of the Perth Core Library, and was undertaken through the Western Australian Government's Percent for Art Scheme.

Operated by the Department of Finance and the Department for Culture and the Arts, the scheme contracts Western Australian artists to deliver artwork for major new public facilities.

Nien Schwarz is a Senior Lecturer in visual arts at Edith Cowan University, and pursues interdisciplinary projects that link art and science. Her site-based installations, performances, sculptures, and publications investigate relationships between physical and human geographies. Nien grew up in Canada in a science-oriented family. Her lifelong interest in geology drew her into working in remote regions across the Canadian arctic and also as a volunteer with Australian scientific crews. Her time in the field provides opportunities to explore ideas and gather materials for her artworks.





'Working on the core library project has been a great experience and being able to collaborate closely with department staff in creating site-specific pieces has been a highlight of my career,' said Nien.

Visitors to the Perth Core Library are welcomed by a series of aluminium panels that feature deep crustal seismic and aeromagnetic images. Inside the core library, the viewer encounters a range of artistic highlights. The vinyl artwork 'Aerial Tread' on the foyer floor creates a three-dimensional sensation using colourful aeromagnetic imagery from the Eastern Goldfields. There are also recent and historical drilling photos, poetry, paintings created using hand-prepared natural rock pigments, and HyLogger graphic logs in the new core viewing area that depict mineralogical analysis of exploration drillcore.

For more information, contact Paul Stephenson (paul.stephenson@dmirs.wa.gov.au).

Crustal differentiation in the Proterozoic Capricorn Orogen

The in situ chemical differentiation of continental crust ultimately leads to the long-term stability of the continents. This process, more commonly known as ‘cratonization’, is driven by deep crustal melting with the transfer of melts to shallower regions, resulting in a strongly chemically stratified crust in which a refractory, dehydrated lower portion is overlain by a complementary enriched upper portion. Importantly, differentiation leads to the heterogeneous distribution of metalliferous ore deposits throughout the lithosphere and so has important implications for understanding mineral systems.

The Proterozoic Capricorn Orogen of Western Australia is ideally suited to study these processes because it preserves a long history of magmatism that records a progressive evolution from subduction and continental convergence through to intraplate reworking, ultimately leading to thermally stable crust that responds similarly to the adjacent Archean Pilbara and Yilgarn Cratons (Fig. 1). However, since the lower to middle portions of this crust are not exposed, investigation of the cratonization process must be through indirect methods. In this study, hafnium and oxygen isotope compositions of both magmatic and inherited zircons from the well-dated felsic magmatic suites in the Capricorn Orogen are used to highlight the differentiation and cratonization history of this portion of crust.

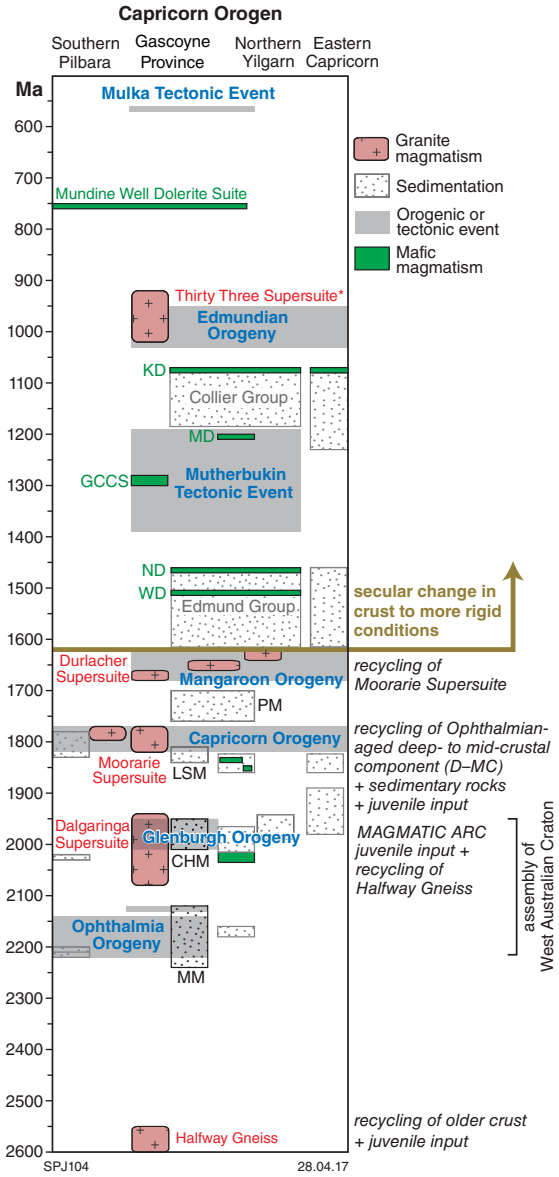


Figure 1. Time–space event summary of the Capricorn Orogen. Abbreviations: CHM, Camel Hills Metamorphics; GCCS, Gifford Creek Carbonatite Suite; KD, Kulkatharra Dolerite; LSM, Leake Spring Metamorphics; MD, Muggamurra Dolerite; MM, Moogie Metamorphics; ND, Narimbunna Dolerite; PM, Pooranoo Metamorphics; WD, Waldburg Dolerite

The isotope data reveal that the 1820–1775 Ma Moorarie Supersuite was generated from three main source components including minor amounts of mantle-derived material, shallow crustal rocks and a significant contribution from an unknown crustal reservoir with ages between c. 2280 and 2115 Ma (D–MC, Fig. 2). This unknown crust may represent the remnants of a buried or reworked Ophthalmian-age magmatic arc. Granitic rocks of the 1680–1620 Ma Durlacher Supersuite show no isotopic evidence for the involvement of mantle-derived source components, and appear to have been generated by the direct melting and recycling of rocks similar in isotopic composition to the Moorarie Supersuite (Fig. 2). The progression from an active continental margin to reworking with minor amounts of new crustal growth (Moorarie Supersuite) to exclusive reworking (Durlacher Supersuite) was accompanied by a progressive decrease in the contribution from mantle-derived sources resulting in the greatest phase of crustal differentiation. The generation of voluminous felsic magmatic rocks during intraplate reworking led to a complementary and rapid depletion in the lower crust, eventually leading to completely refractory lower crust during the generation of the Durlacher Supersuite rocks.

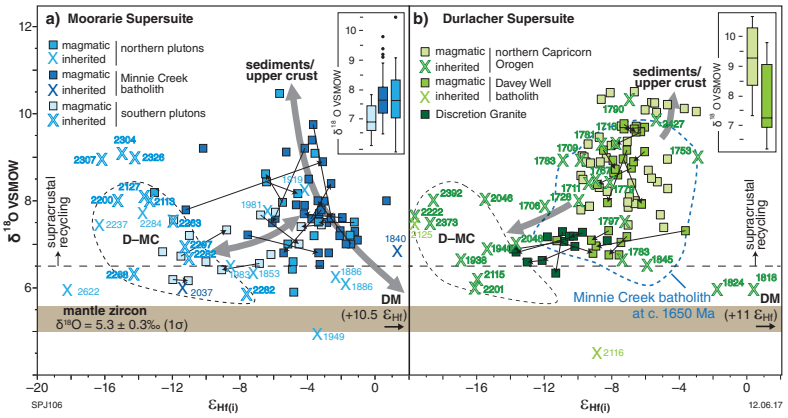


Figure 2. $\delta^{18}O$ vs $\varepsilon_{Hf(i)}$ plot for magmatic zircons in granitic rocks formed during intracontinental reworking: a) Moorarie Supersuite; b) Durlacher Supersuite. Analyses were made in central and edge regions of magmatic grains where possible to track the isotopic evolution of individual magma pulses and batches — thin arrows show centre–edge pairs

Report 168 Crustal differentiation in the Proterozoic Capricorn Orogen is available as a free download from the eBookshop at <www.dmp.wa.gov.au/ebookshop>.

For more information, contact Simon Johnson (simonpaul.johnson@dmirs.wa.gov.au).

GSWA regional geophysics surveys: 17 July 2017 update

Data downloads

Located data — Geophysical Archive Data Delivery System <www.ga.gov.au/gadds>.

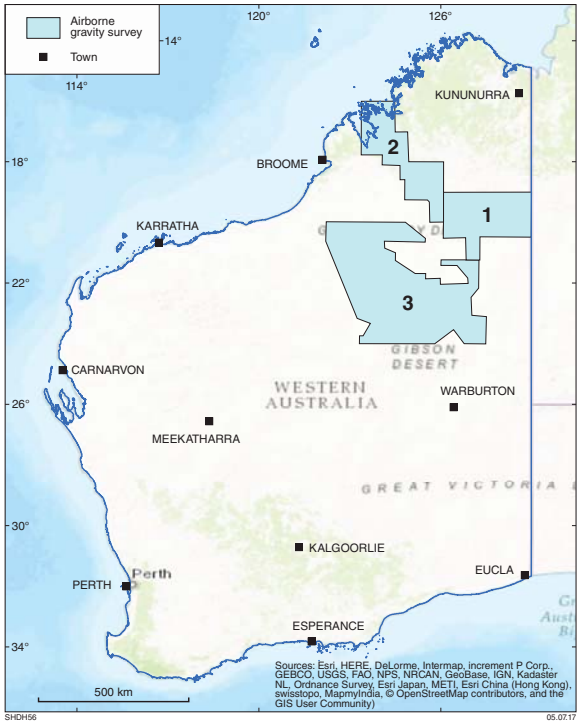
Grids and images — search in GeoVIEW.WA under Government Surveys layers.

Subscribe to the GSWA eNewsletter for alerts of preliminary and final data release dates. Go to <www.dmp.wa.gov.au/gswaenewsletter>.

Survey outline shapefiles are available online at <www.dmp.wa.gov.au/geophysics>.

For more information, contact David Howard (david.howard@dmirs.wa.gov.au).

EXPLORATION INCENTIVE SCHEME



ID	Area/Name	Method	Configuration	Size	Status	Start	End	Release
1	Tanami 2016	Air Grav	2500 m, N-S	26 000 km	Survey 45%	15-06-17	(Aug-17)	(Nov-17)
2	NE Canning 2017	Air Grav	2500 m, N-S	24 000 km	Pending	(Aug-17)	(Oct-17)	(Jan-18)
3	Kidson 2017	Air Grav	2500 m, N-S	70 000 km	Survey	(Jul-17)	(Nov-17)	(Feb-18)

Dates in parentheses are estimates.

Geology in your pocket, and on your tablet

Everythere

The Geological Survey of Western Australia (GSWA) has once again teamed up with Everythere to use a Beta version of its app to explore a geology trail around Perth city using smart devices.

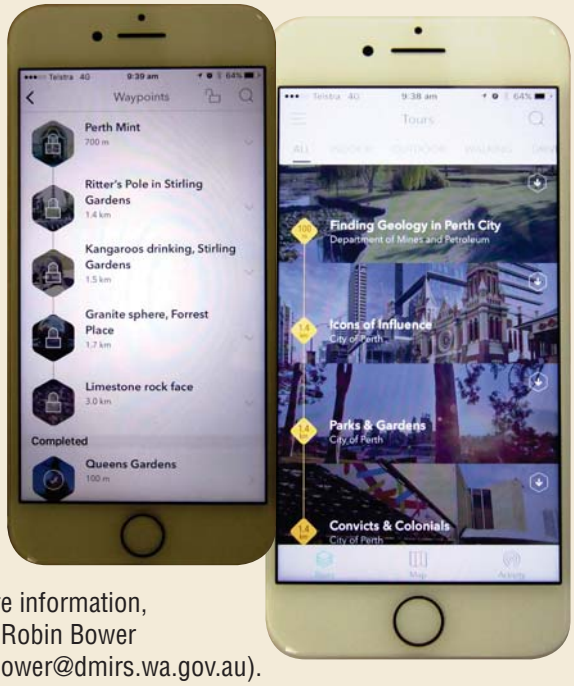
'Finding Geology in Perth City' is a self-guided walking or biking trail stopping at geological features in the city. As you visit several key locations around Perth, you'll get notifications about them, a description of the feature, and a photo.

Download the Everythere app for Apple from the iTunes App Store, or for Android from the Google Play Store, ensuring that the GPS location services are active. Then follow appropriate instructions.

Please note that the locations will not be visible until you are within range.

We would love your feedback. Just follow the prompts on the app and leave your comments.

Paper copies of GSWA's pamphlet 'Stepping stones' include this trail and are available at the Perth Mint (Site 2) or the visitor booth in Forrest Place (next to Site 5) should you prefer to follow the tour using a hardcopy pamphlet.



For more information, contact Robin Bower (robin.bower@dmirs.wa.gov.au).

Product releases

ISSN 1325-9377 ISBN (PRINT) 978-1-74168-764-4
ISSN 1834-2272 ISBN (PDF) 978-1-74168-763-7

REPORTS

Report 167 The geology, tectonic evolution and gold mineralization of the Lawlers region: a synopsis to 2001
by Beardsmore, T

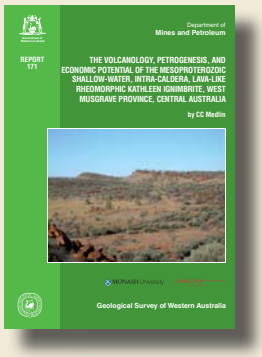
Report 168 Crustal differentiation in the Proterozoic Capricorn Orogen
by Johnson, SP, Korhonen, FJ, Kirkland, CL, Cliff, JA, Belousova, EA and Sheppard, S

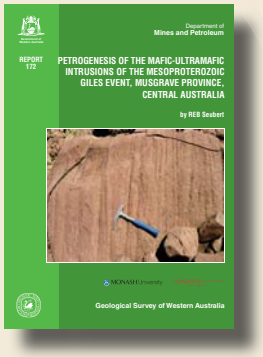
Report 169 Petroleum source potential of the Ordovician Nambeet Formation
by Normore, LS and Dent, LM

Report 170 Assessment of thermal maturity using bitumen, graptolite and bioclast reflectance
by Dent, LM and Normore, LS

Report 171 The volcanology, petrogenesis, and economic potential of the Mesoproterozoic shallow-water, intra-caldera, lava-like rheomorphic Kathleen Ignimbrite, west Musgrave Province, central Australia
by Medlin, CC

Report 172 Petrogenesis of the mafic-ultramafic intrusions of the Mesoproterozoic Giles Event, Musgrave Province, central Australia
by Seubert, REB

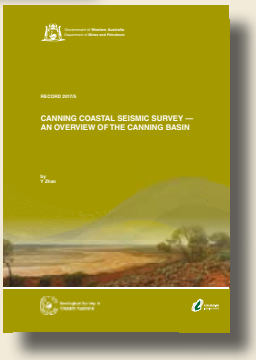




RECORDS

Record 2016/1 Geological Survey work program for 2016–17 and beyond

Record 2017/5 Canning coastal seismic survey — an overview of the Canning Basin *with accompanying plate, Geological interpretation of the Canning Basin*
by Zhan, Y



PALEONTOLOGY REPORT

An Early Devonian fish fauna from an unnamed sandstone in petroleum exploration well Wendy 1, northern Perth Basin
by Allen, HJ and Trinajstic, K

EXPLANATORY NOTES SYSTEM ONLINE

58 lithostratigraphic units in Murchison region
Available at <www.dmp.wa.gov.au/ens>

BOOKS — OTHER

Specifications for 3D models submitted to GSWA
by Murdie, RE and Lindsay, MD

1:100 000 GEOLOGICAL SERIES MAPS

Thundelarra, WA Sheet 2340
Meekatharra, WA Sheet 2544
Uaroo, WA Sheet 1952

MAPS — OTHER

Iron ore deposits of the Pilbara region — 2017
by Cooper, RW

1:100 000 GEOLOGICAL INFORMATION SERIES

Kimberley, 2017

DATA PACKAGES

Compilation of geochronology information, 2017
Compilation of WAROX data, 2017
East Yilgarn, 2017
Iron ore deposits of the Pilbara 2017
Murchison, 2017
Olympic 1, Canning Basin, Digital Core Atlas
West Musgrave, 2017

VIRTUAL TOUR

State meteorite impact structures

Welcome to DMIRS

On 1 July 2017, the Department of Mines and Petroleum and the Department of Commerce amalgamated to form the Department of Mines, Industry Regulation and Safety (DMIRS). The Geological Survey of Western Australia (GSWA) continues as a division of DMIRS and all our online applications will remain on DMP's website for the time being.

The Geological Survey of Western Australia (GSWA) has released almost 5000 geological products including books, maps and data packages. These can be found on our website at <www.dmp.wa.gov.au/GSWApublications>.

Maps, USB data packages, and selected premium publications are available to purchase as hard copies via the online cart on the eBookshop at <www.dmp.wa.gov.au/ebookshop>. Alternatively, these products can be purchased from the Information Centre, First Floor, Mineral House, 100 Plain Street, East Perth, WA 6004, Australia, Phone: +61 8 9222 3459; Fax: +61 8 9222 3444.
Records, Reports, Bulletins and non-series books cannot be purchased in hard copy but are all available as PDFs to view, and as a free download.