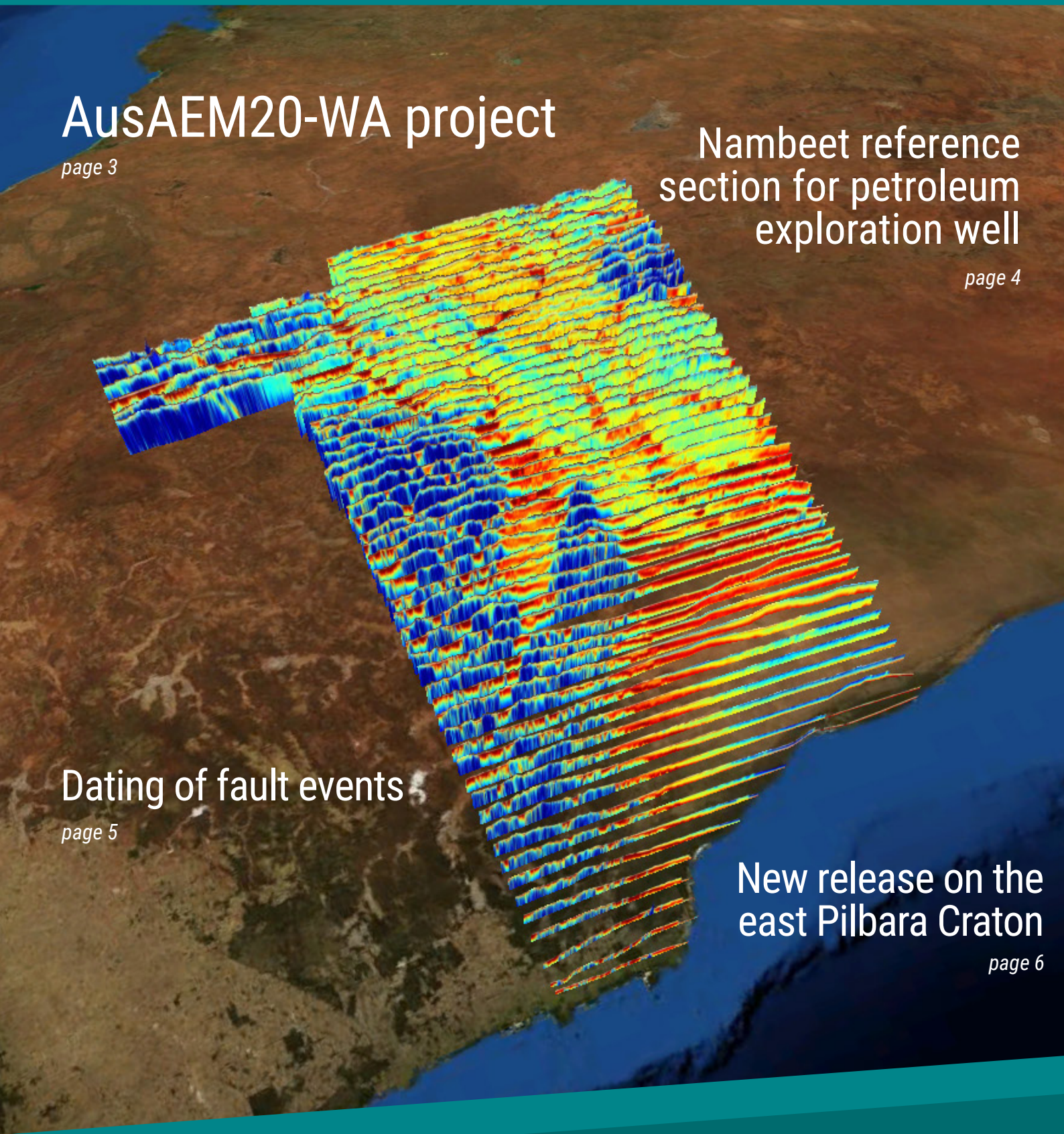
A Geological Survey of Western Australia Newsletter

APRIL 2021 NUMBER 98

Fieldnotes

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

www.dmirs.wa.gov.au/GSWA



AusAEM20-WA project

page 3

Nambeet reference section for petroleum exploration well

page 4

Dating of fault events

page 5

New release on the east Pilbara Craton

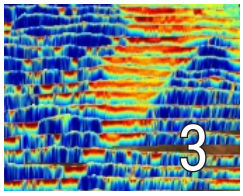
page 6

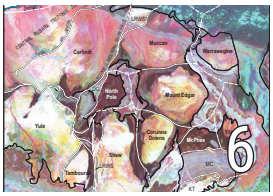
Geological Survey of Western Australia

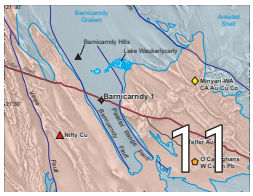
What's inside

FEATURES

REGULARS







EDITORIAL TEAM

Editor

Robin Bower, Manager Editing and Publishing

Design and layout

Bec Hitchings, Desktop Publisher

Graphics

Michael Prause, Graphics Manager

Contributors to this issue

Deidre Brooks
Huntly Cutten
Louisa Dent
Peter Haines
Arthur Hickman
David Howard
Yongjun Lu
Leon Normore

Access publications

All publications

Download maps, reports and digital information free from our **website**.

Hard copies

Maps, USB data packages and various premium publications are available to purchase as hard copies from the eBookshop or the First Floor counter at Mineral House, 100 Plain Street, East Perth WA 6004. An online cart and payment system is in place. Records, Reports, Bulletins and other non-series books cannot be purchased in hard copy but are all available as PDFs to view and download free of charge.

Fieldnotes

Fieldnotes is a free digital-only quarterly newsletter published by the Geological Survey of Western Australia (GSWA). The newsletter provides regular updates to the State's exploration industry and other geoscientists about GSWA's latest work, programs, products and services.

Access Fieldnotes by:

- subscribing to the **GSWA eNewsletter** – there will be a Fieldnotes page with a link to the latest issue
- browsing previous issues from the **eBookshop**.

GSWA eNewsletter

The GSWA eNewsletter is an online newsletter delivered roughly once a month that contains information on workshops, field trips, training, events and the latest releases of maps, books and digital data packages. If you would like to stay informed about new products, services and other news, please **subscribe**.

GSWA publishes a vast amount of pre-competitive geoscience information on the State, contributing to billions of dollars' worth of resources for exploration and development. To find more information about publications and maps we publish, go to our **website**.

Cover image: AusAEM20-WA TEMPEST blocks – stacked profiles of conductivity–depth images (image courtesy of Geoscience Australia)

ISSN 1834-2272 **ISBN 978-1-74168-920-4**

AusAEM20-WA project — March 2021 update

EXPLORATION INCENTIVE SCHEME

The TEMPEST component of AusAEM20-WA Stage 1 is complete (Fig. 1 and front cover). Data from the Eastern Goldfields and the East Yilgarn survey blocks were released on 4 February 2021, followed by the neighbouring Earaheedy–Desert block data set on 25 March 2021.

AusAEM20-WA is a National Collaborative Framework Agreement project between the Geological Survey of Western Australia (GSWA) and Geoscience Australia (GA). Its objective is to complete 20 km airborne electromagnetic (AEM) coverage of those parts of Western Australia that were not surveyed as part of Year 2 of GA's Exploring for the Future AusAEM survey. Figure 2 shows the location of the Stage 1 survey blocks for coverage with the TEMPEST and SkyTEM systems.

Data acquisition with the SkyTEM system in the Southwest block resumed on 8 March 2021, after having been suspended in November 2020 when the survey helicopter was redeployed to summer bushfire work. Acquisition over the Murchison block will follow after the Southwest block is complete. Plans are for the data from both blocks to be available by the end of 2021.

Planning is in progress for coverage of the remaining strip in the southeast of Western Australia, tentatively in the 2021–22 financial year. Ultimately, the coverage of Western Australia will go a long way to attainment of the aspirational national goal of 20 km AEM coverage over continental Australia — AusAEM20.

Funding for AusAEM20-WA is from the Western Australian government's Exploration Incentive Scheme with additional support from the State's COVID-19 recovery plan.

Data from the recently released datasets (and other government-funded regional datasets) may be downloaded from **GeoVIEW.WA** — GSWA's interactive mapping, data discovery and data delivery platform — or from the national **Geophysical Archive Data Delivery System** (GADDS) hosted by GA.

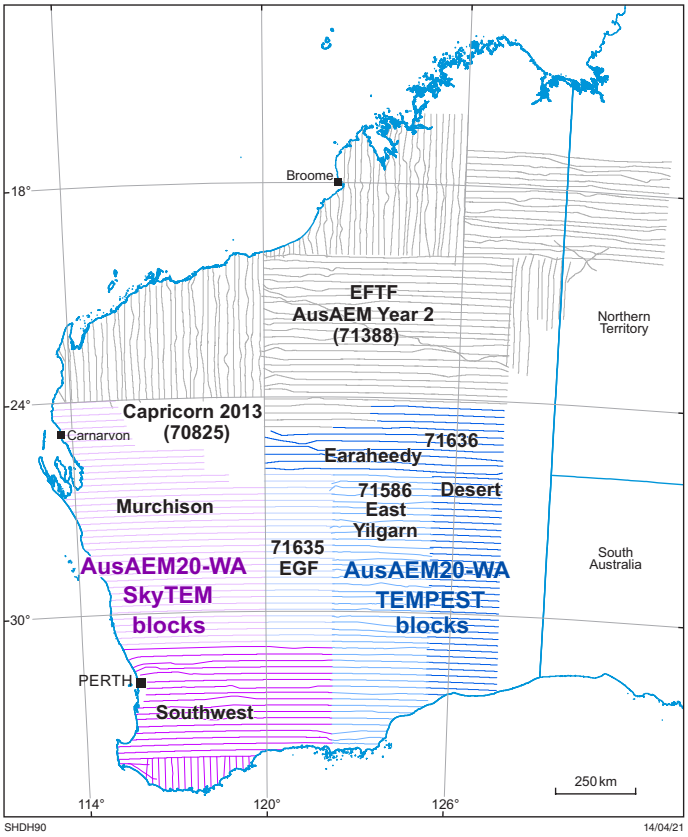


Figure 2. Location of AusAEM20-WA survey areas. Numbers refer to dataset registration numbers in MAGIX data repository

For more information, contact **geophysics@dmirs.wa.gov.au**.

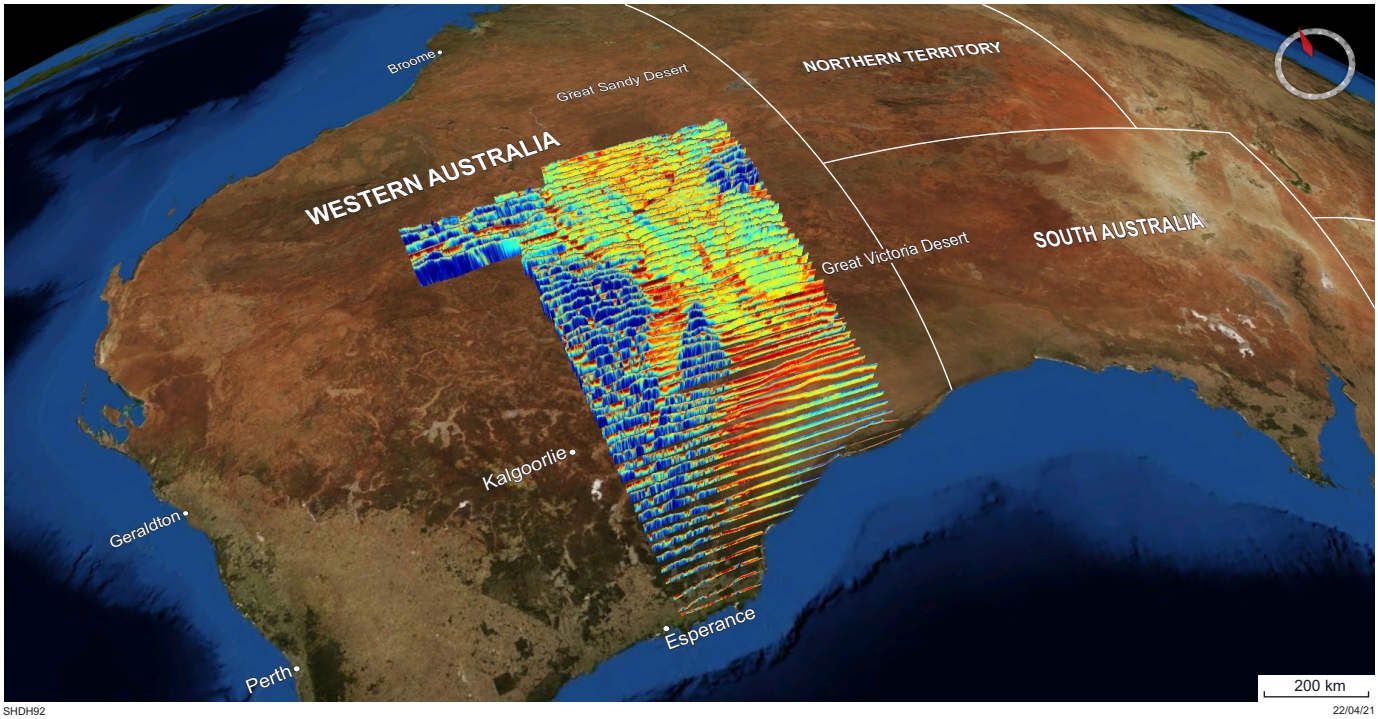


Figure 1. AusAEM20-WA TEMPEST blocks — stacked profiles of conductivity–depth images (image courtesy of GA)

Nambeet Formation reference section defined in petroleum exploration well Olympic 1

A new reference section for the Lower Ordovician Nambeet Formation of the Canning Basin is proposed in the Olympic 1 petroleum exploration well. The well recovered 319.53 m of continuous core (277.53 m of Nambeet Formation) and includes the conformable contact between the Nambeet Formation and overlying Willara Formation. At a total depth of 1447.53 m, the well and base of the core is predicted to be around 20 m above Precambrian basement. Comprehensive geochronological, biostratigraphic and geochemical data has been collected from the new reference section. This data, and the length and quality of core, provide a better constrained reference point than the original Nambeet Formation type section defined in Samphire Marsh 1 well.

From the Olympic 1 cored section, it is proposed that the Nambeet Formation should be divided into two formal members: the upper Samphire Marsh Member and the underlying Fly Flat Member (Fig. 1). The Samphire Marsh Member is dominated by mudstone and carbonate lithologies that record deposition in a low-angle carbonate/epeiric ramp setting. The Fly Flat Member is sandstone dominated and records deposition between upper and lower shoreface environments. The Fly Flat Member comprises the lowstand deposits of the initial second-order supersequence in the Canning Basin. The Samphire Marsh Member makes up the remainder of this supersequence, the transgressive to falling stage deposits, and the beginning of the successive Canning Basin supersequence.

GSWA Report 211 Reference section, revised stratigraphy and facies analysis of the Ordovician Nambeet Formation, Canning Basin, Western Australia is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Louisa Dent**.

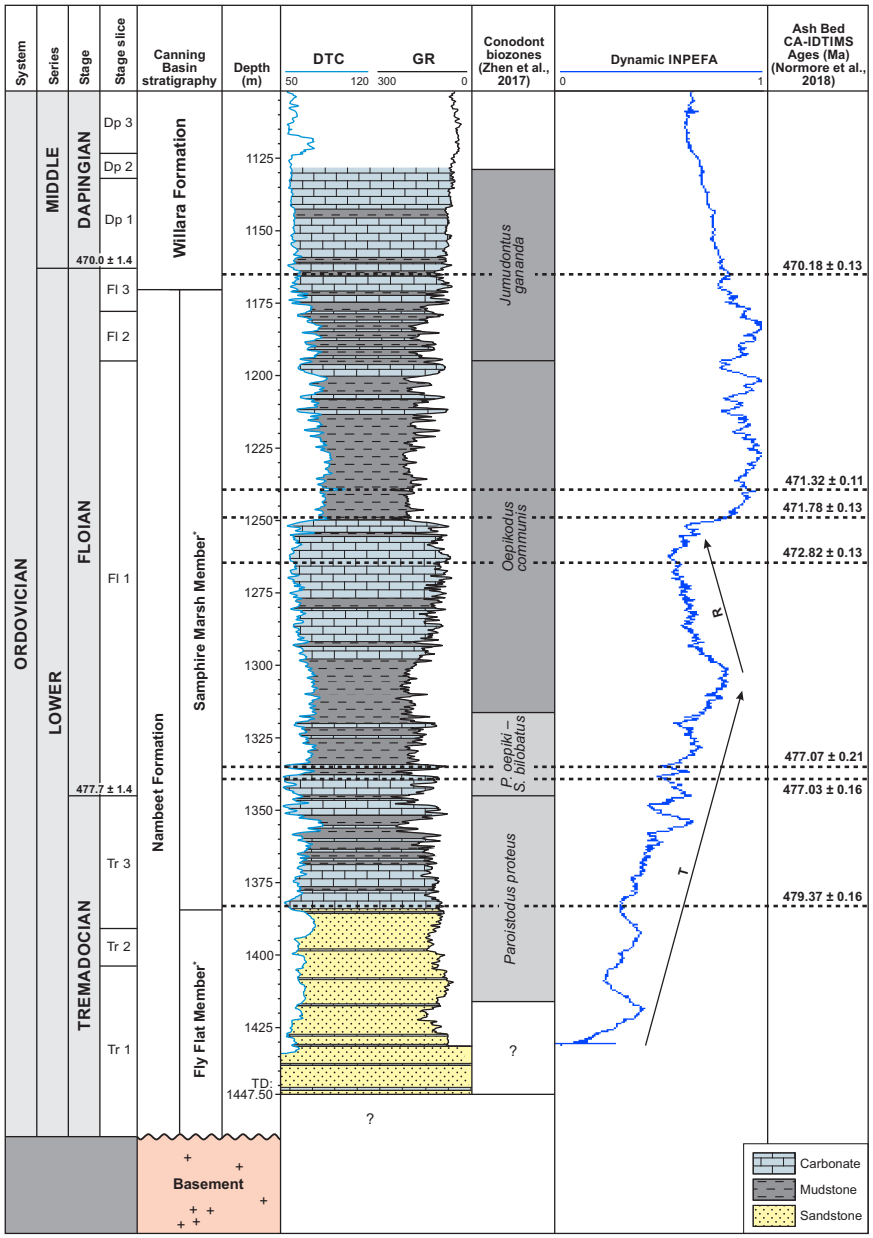


Figure 1. Stratigraphic chart showing the age of formations in the Olympic 1 core. Unit names marked with an asterisk are proposed new members based on new evidence

Dating of faulting events: a global first for low-grade Proterozoic sedimentary rocks

Dating of illite from lithified fault gouge, using the K–Ar method (Fig. 1), has previously been applied to Phanerozoic tectonic events, but this is one of the first examples globally where the method has been used to date Proterozoic faulting. Samples were recovered from the Mount Vernon and Quartzite Well Fault systems, which were instrumental in the formation, inversion and deformation of the Proterozoic Edmund and Collier Basins. K–Ar dating of fine-grained (<0.1 µm) illite, recovered from fault rocks, is more suitable than the $^{40}Ar/^{39}Ar$ method due to the known problems of Ar recoil using clay-sized fractions. Samples were analysed at the K–Ar Geochronology Facility at CSIRO in Perth, Western Australia. Dating of the <0.1 µm clay fraction containing the authigenic 1M illite polytype excluded any coarse-grained $2M_1$ illite polytype inherited from the host rock. The latter contaminates coarser size fractions (Fig. 2) and would otherwise produce a mixed and geologically meaningless age. Determination of the Kübler index, by XRD, has identified faulting events where temperatures have exceeded 250 °C, temperatures which allow the formation of authigenic $2M_1$. The recorded dates thus document the latest fault movements and define the 885–782 Ma Kuparr Tectonic Event, as well as younger, previously unrecognized faulting events in the Capricorn Orogen at c. 663, 346 and 238 Ma.

GSWA Report 214 Dating Proterozoic fault movement using K–Ar geochronology of illite separated from lithified fault gouge is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Huntly Cutten**.

Figure 1. Exposed South Brumby Creek Fault (Mount Vernon Fault system) showing well-developed fault gouge and reverse displacement of sandstone and siltstone beds of the Kiangi Creek Formation (Edmund Group)

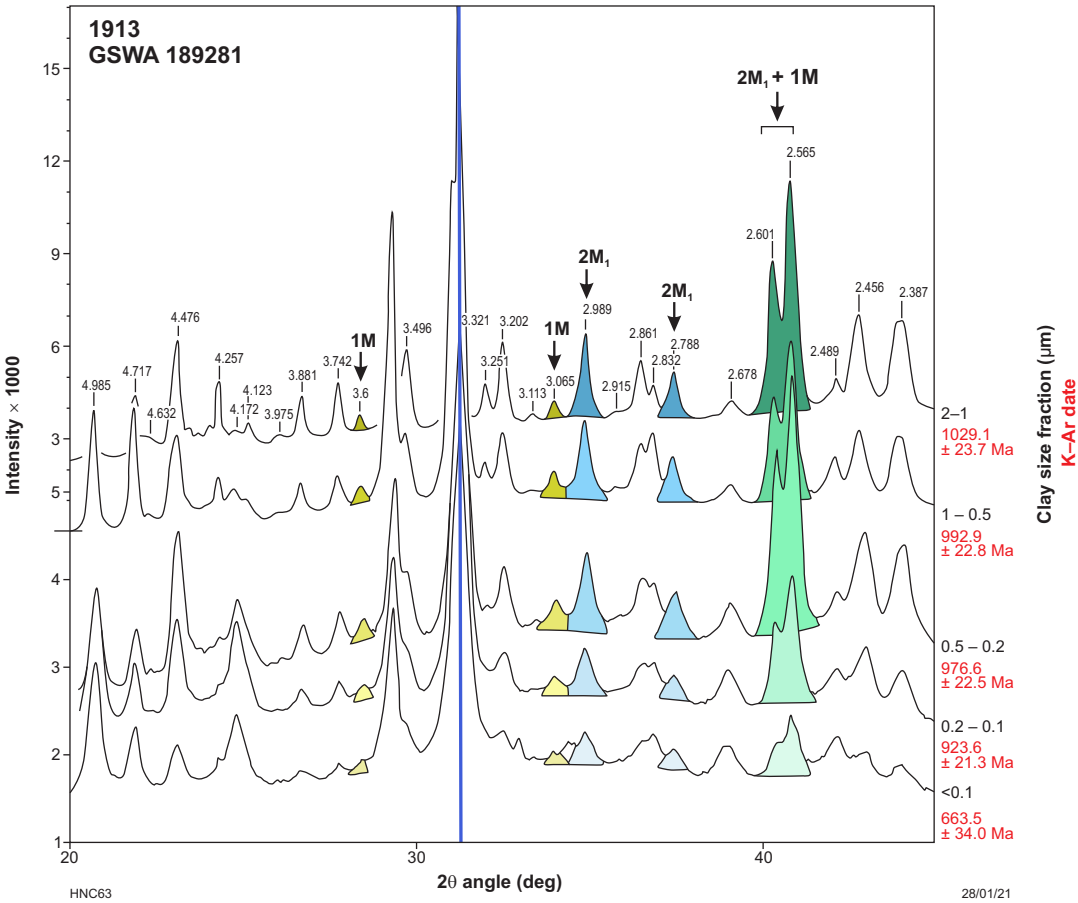


Figure 2. Comparative fault gouge X-ray diffraction charts showing the relative decrease in illite $2M_1$ polytype (largely host rock contaminant) with fining grain size and its effect on the determined K–Ar date. The c. 663.5 Ma date for the <0.1 µm fraction corresponds to the latest fault movement. Remnant $2M_1$ polytype in this size fraction is interpreted to be authigenic. Illite 1M polytype in all of the separated size fractions is authigenic

Newly released GSWA Report on the east Pilbara Craton

Geological Survey of Western Australia Report 143 provides a comprehensive, up-to-date review of the stratigraphy, structure, geochemistry, geochronology, crustal evolution and mineralization of the east Pilbara Craton. The East Pilbara Terrane contains the most complete geological record of Paleoarchean crustal evolution that is available in any of Earth's Archean cratons. Extensive geochemical, geochronological and isotopic evidence indicates that its greenstone succession, the 15 km-thick Pilbara Supergroup, evolved during a series of mantle plume events over 300 Ma. The succession accumulated to form a large continental volcanic plateau overlying Eoarchean to early Paleoarchean sialic crust.

The crust of the East Pilbara Terrane evolved by gravity-driven vertical tectonic processes that produced 11 granite–greenstone domes (Fig. 1). From about 3.45 Ga, the individual domes were intruded by varying volumes of granitic magma, amounts of uplift differed, and major boundary faults resulted. From then on, each dome evolved somewhat independently from its neighbours, although all share the same general stratigraphic succession.

There is no sustainable evidence for plate tectonic process until 3.22 Ga, after which the Paleoarchean continental volcanic plateau broke up and separated into three microplates. Plate separation and subsequent interaction over another 300 Ma led to Mesoarchean plate tectonic processes including subduction, obduction, plate collision and orogeny.

GSWA Report 143 East Pilbara Craton: a record of one billion years in the growth of Archean continental crust is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Arthur Hickman**.

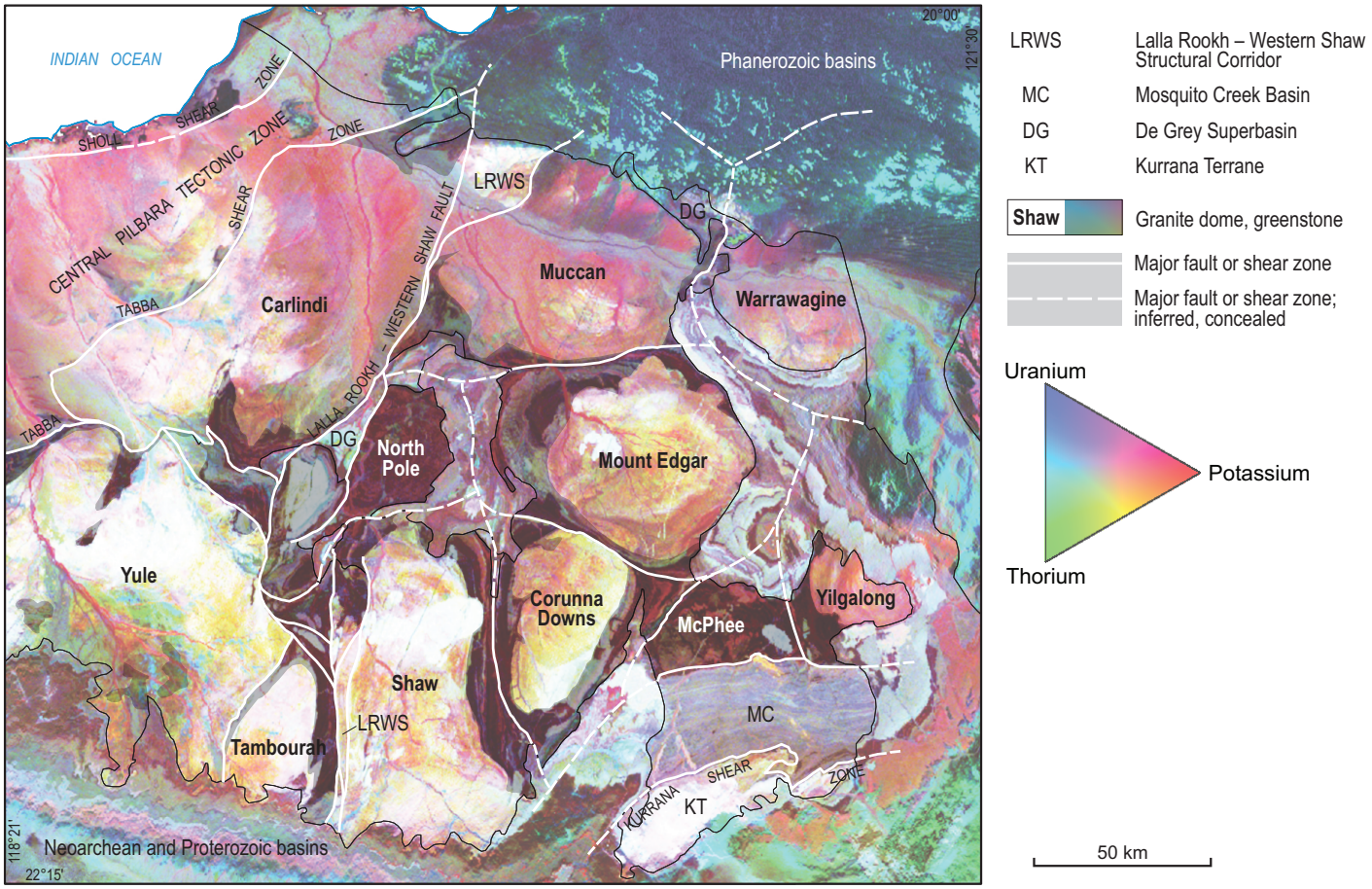


Figure 1. Radiometric ternary image (KTU) of the east Pilbara Craton, showing 11 granite–greenstone domes separated by faults. Nine domes have ovoid granitic cores (orange–yellow–white) surrounded by greenstone belts (dark colours), and two domes expose only greenstones

South West Hub Carbon Capture and Storage Project status

The South West Hub Project led by the Department of Mines, Industry Regulation and Safety (DMIRS) has been investigating the Lesueur sandstone as a potential target for CO_2 injection and storage in the southern Perth Basin since 2007. The objective of the project is to enable industry to make commercial decisions on carbon capture and storage (CCS) for future projects.

To date, operations undertaken include a 2D and 3D seismic survey, a deep well drilled to 2945 m, and drilling three shallow to intermediate depth wells. The 3D modelling showed the site can accept an injection rate of 800 000 t per annum of CO_2 over 30 years, and the plume will remain contained for over 1000 years. The modelling includes uncertainties, and scenarios that are based on assumptions that may not be true.

Drilling one more deep well plus an observation well and extended testing is needed to:

- confirm the continuity of the reservoir properties encountered at Harvey 1
- increase investor confidence in the CO_2 storage model by confirming the modelled containment and movement of injected CO_2.

A workshop, co-hosted by DMIRS and CSIRO, was held in October 2020 to discuss with industry their interest in the project and gauge the level of support for drilling and extended testing of Harvey 5. About 80 in-person and 15 virtual attendees listened to six presentations prior to an open discussion forum. Participants were supportive of the proposed work and saw this information as essential for industry to consider commercializing the site.

For more information, contact **Deidre Brooks**.

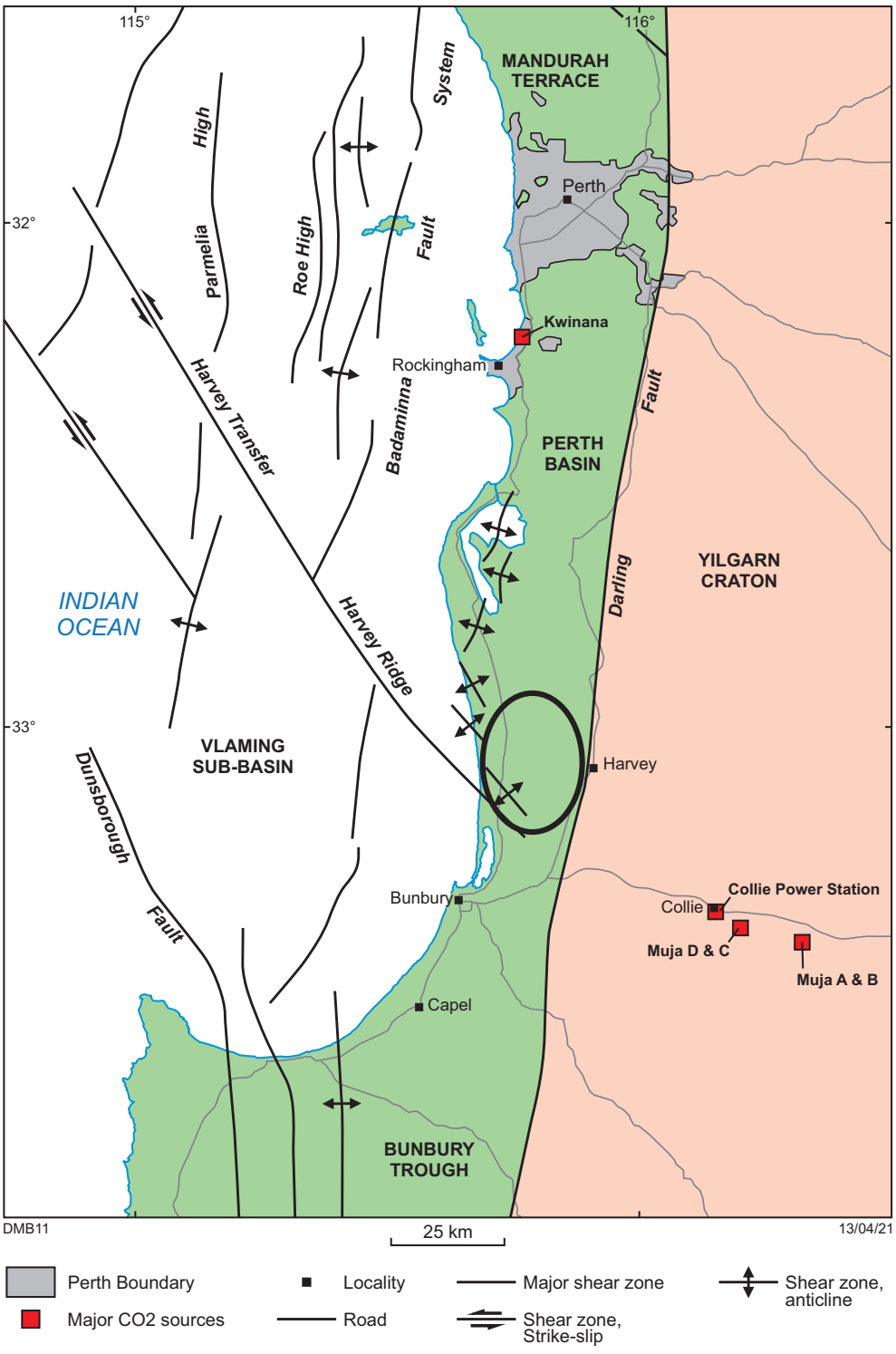


Figure 1. The South West Hub project is located on the structurally high Harvey Ridge near Lake Preston (thick black oval)

Geological hydrogen storage modelling project to develop industry

The Western Australian State Government has established a dedicated Renewable Hydrogen Unit to coordinate the State's work on developing the renewable hydrogen industry, both domestically and for export. The global market for renewable hydrogen is expected to grow significantly over the coming decades. Western Australia is well placed to capture a significant share of this market.

An amount of $22 million is being invested across nine initiatives to accelerate Western Australia's renewable hydrogen future. The geological hydrogen storage modelling project is one of these initiatives. The project is to take a two-stage approach.

Stage 1 is a literature review and scoping study which will commence during the first half of 2021. The literature review will be conducted on the geological underground storage of hydrogen in depleted oil and gas fields, saline aquifers and other examples of underground geological storage of hydrogen. The scoping study will review depleted fields in the northern Perth Basin to identify which fields should be modelled in Stage 2 of the project. Stage 2 is 3D static and dynamic compositional modelling of selected depleted oil and gas fields in the Perth Basin (Fig. 1) for storage capacity estimation and risk. The modelling is expected to be completed during 2022.

For more information, contact **Deidre Brooks**.

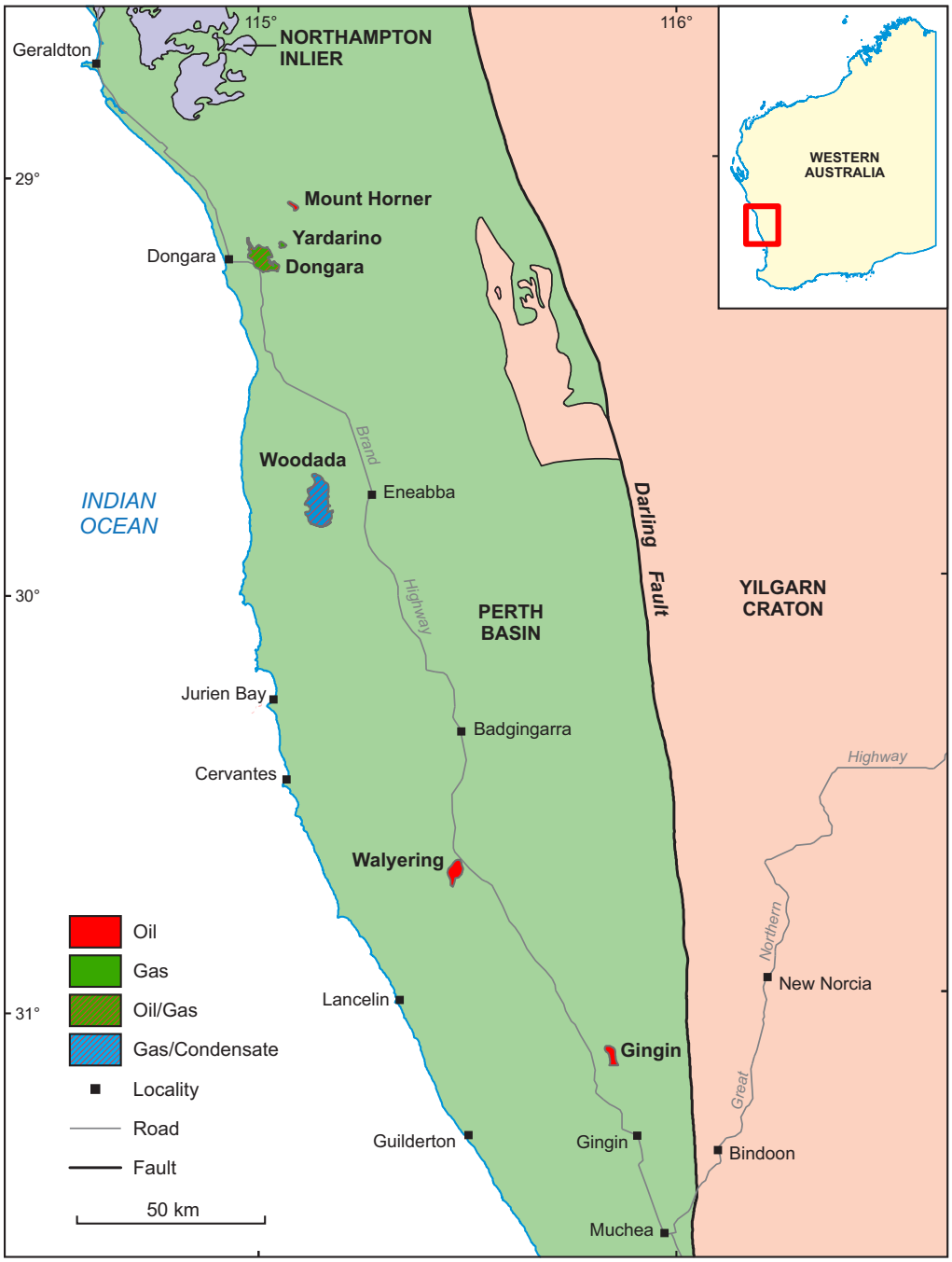


Figure 1. Location of the largest depleted fields in the Perth Basin

Isotope map reveals lithospheric architecture

Isotope maps are used to characterize lithospheric architecture through time, to understand crustal evolution and mineral system distributions, and play an increasingly important role in predictive exploration targeting.

The Geological Survey of Western Australia (GSWA) has released its first statewide samarium–neodymium (Sm–Nd) isotope maps (Fig. 1) under the Accelerated Geoscience Program (AGP).

The maps show two-stage depleted mantle model ages (T_{DM}^2), which is a proxy for the age of the crustal source of the igneous rocks, and crustal residence time (T_{CR}), the difference between T_{DM}^2 and magmatic crystallization age, i.e. how long the source of the igneous rocks has resided in the crust. Significant gradients in the isotope data are typically associated with major crustal structures and are potentially important for localizing mineral systems.

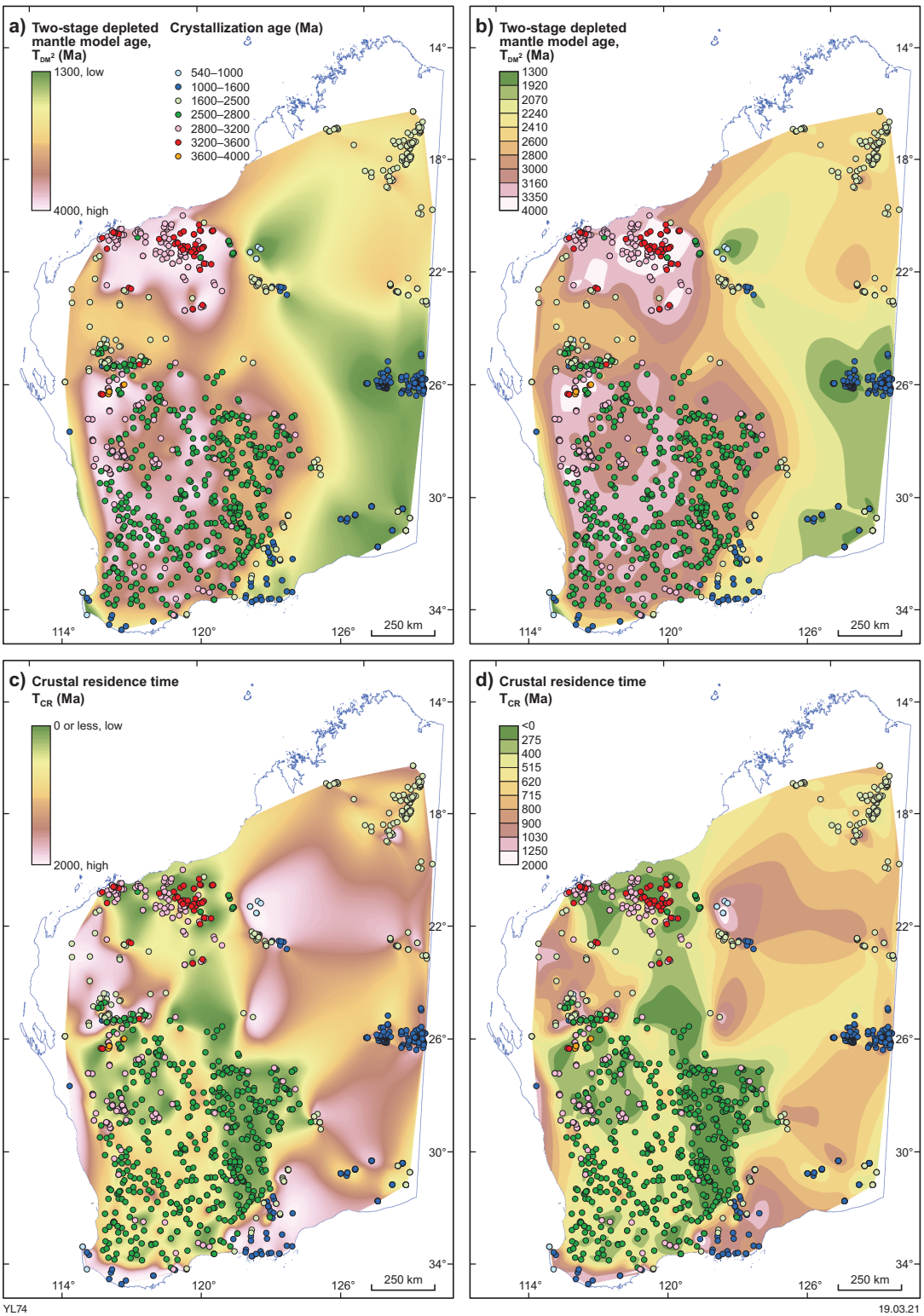


Figure 1. Sm–Nd isotope maps for whole-rock samples of felsic igneous rocks in Western Australia. Two-stage depleted mantle model age (T_{DM}^2) and crustal residence time (T_{CR}) maps are presented as stretched (a, c) and classified (b, d) raster images. Symbols show the locations of samples used for isotope mapping and are colour-coded to indicate their magmatic crystallization ages

The T_{DM}^2 maps clearly image the Pilbara and Yilgarn Cratons, which are surrounded by Proterozoic orogens that have younger T_{DM}^2 values (Fig. 1a,b). The T_{CR} maps highlight predominantly short residence times (<500 Ma) for the Pilbara and Yilgarn Cratons, and much longer crustal residence times (>800 Ma) in the Paterson, Albany–Fraser, Pinjarra and Capricorn Orogens, suggesting decreased juvenile crust generation in these orogens (Fig. 1c,d). For the Yilgarn Craton, both T_{DM}^2 and T_{CR} maps highlight the Cue and Kalgoorlie–Kurnalpi 'rifts', within which rocks are more juvenile and have shorter crustal residence times than surrounding areas (Fig. 1).

These isotope maps are directly applicable to metallogeny. For example, most giant gold deposits in Western Australia are located on or near significant isotopic boundaries and major crustal structures (Fig. 2). The juvenile zones of the Cue and Kalgoorlie–Kurnalpi 'rifts' are where the majority of gold deposits occur (Fig. 2). Interestingly, Telfer, Plutonic and gold deposits in the Murchison are aligned along a northeast-trending isotopic boundary. Similar boundaries occur between the eastern and western parts of the Pilbara Craton, and in the southern Yilgarn Craton. These isotopically defined discontinuities may be important clues to the earliest architectural elements in Western Australia.

Digital data layer Samarium–neodymium isotope map of Western Australia by Y Lu, MTD Wingate, DC Champion, RH Smithies, SP Johnson, DR Mole, M Poujol, J Zhao, R Maas, and RA Creaser 2021 is now available as a free download from the DMIRS **Data and Software Centre**.

For more information, contact **Yongjun Lu**.

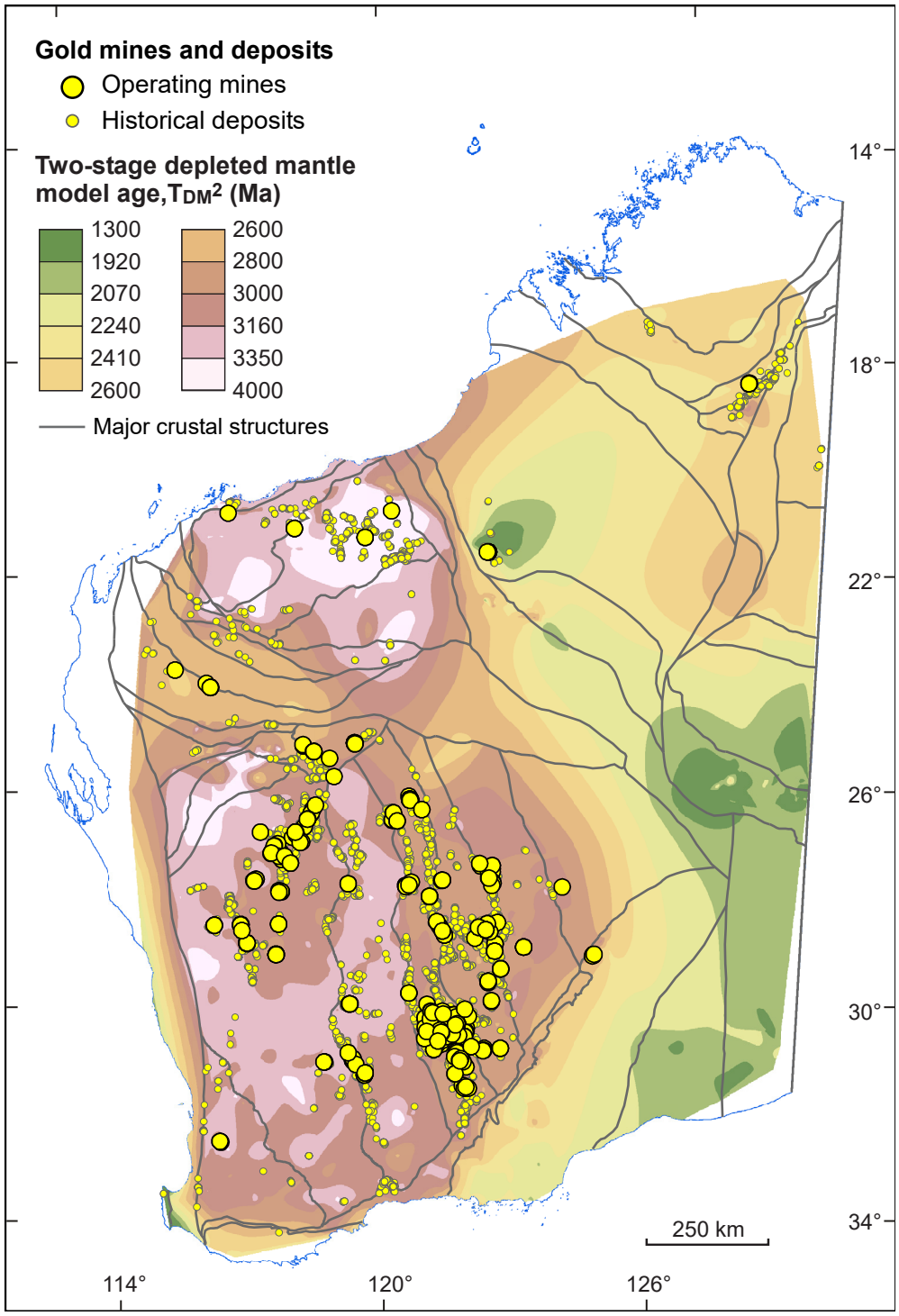


Figure 2. Two-stage depleted mantle model age (T_{DM}^2) map and distribution of gold mines and deposits in Western Australia

GSWA renames stratigraphic well and tectonic element of the southern Canning Basin

In 1994, the Geological Survey of Western Australia (GSWA) named the 'Waukarlycarly Embayment', a mostly concealed fault-bounded tectonic element of the southwestern margin of the Canning Basin west of Telfer gold mine, after nearby Lake Waukarlycarly. This followed the standard geological tradition of naming geological entities after associated topographic features. More recently, a deep stratigraphic well drilled into this tectonic element along the newly acquired Kidson seismic line originally adopted the same name.

Based on consultation with the Western Desert Lands Aboriginal Corporation (WDLAC) on the cultural significance of the name Waukarlycarly, it has been agreed to change the name of the well to Barnicarndy 1 (formerly Waukarlycarly 1) and the tectonic subdivision to Barnicarndy Graben (formerly Waukarlycarly Embayment; Fig. 1). The Barnicarndy Hills are within the graben north of the well locality. A fault along the western edge of the graben has been renamed the Barnicarndy Fault.

Studies of the Barnicarndy 1 drillcore are ongoing and will result in the definition of new stratigraphic units in this previously little-known part of the Canning Basin. The well intersected the Permo–Carboniferous Grant Group, unconformably overlying a thick and atypical Ordovician section, before reaching a total depth of 2680.53 m in metasedimentary basement of the Yeneena Basin. Interpretative results from the well will be published later this year.

For more information, contact **Leon Normore** or **Peter Haines**.

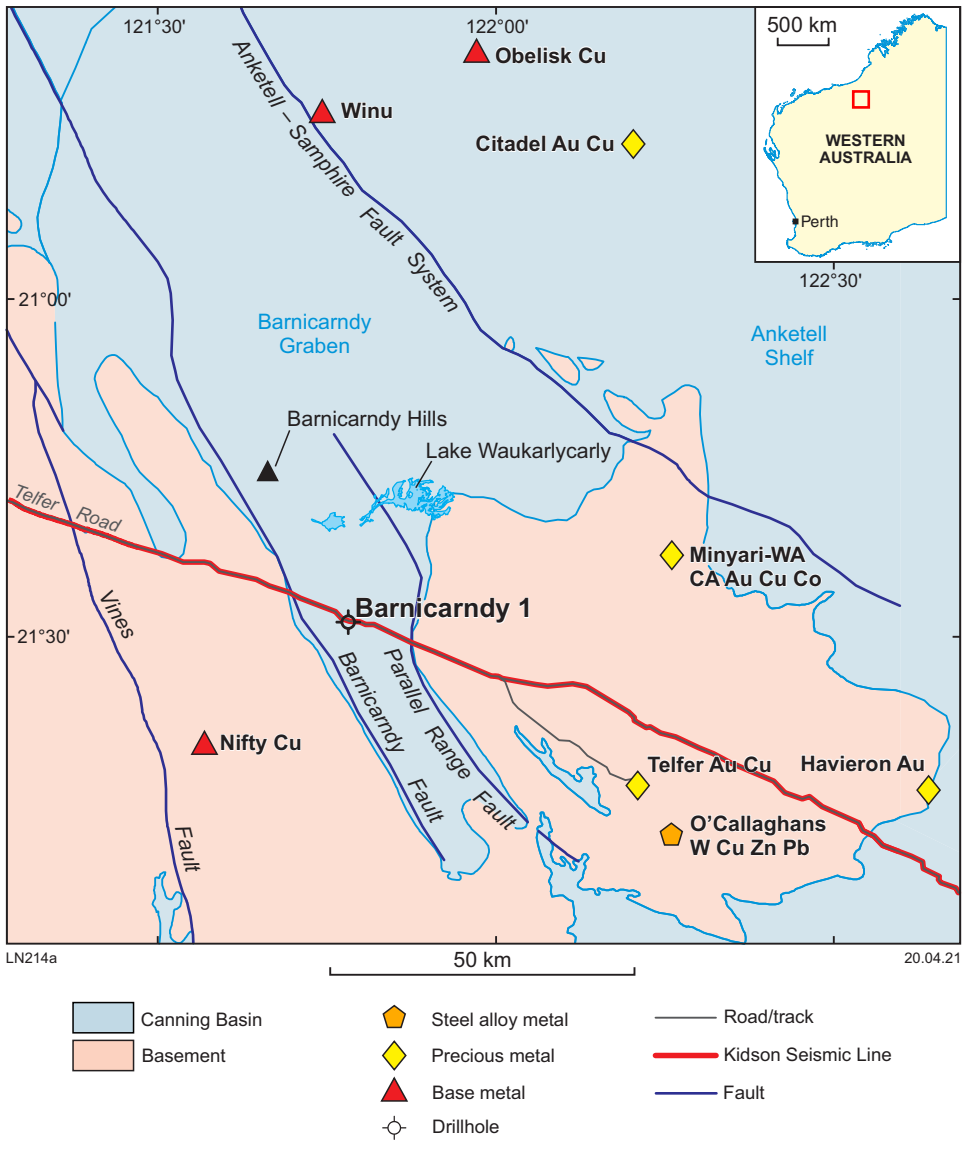


Figure 1. Map of the Barnicarndy Graben, showing Barnicarndy 1 and surrounding tectonic elements, draped over aeromagnetic imagery

Product releases

• ACCELERATED GEOSCIENCE PROGRAM (AGP) •

All products released to date can be found on the **DMIRS website**.

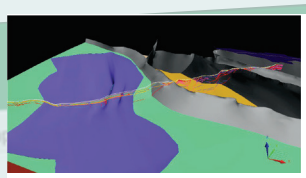
• TEXT PUBLICATIONS •

Report 143 East Pilbara Craton: a record of one billion years in the growth of Archean continental crust
by Hickman, AH

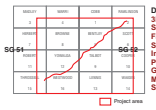
Report 214 Dating Proterozoic fault movement using K–Ar geochronology of illite separated from lithified fault gouge
by Cutten, HN, Zwingmann, H, Uysal, T, Todd, A and Johnson, SP

• 3D GEOMODELS •

Yilgarn– Officer– Musgrave Province 3D, 2013
by Jones, T, Brennan, T, Goodwin, JA, Nicoll, MG and Murdie, RE

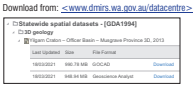


The **Yilgarn Craton – Officer Basin – Musgrave Province 3D, 2013: 3D Geomodel Series** provides a 3D model view of the region from the eastern Yilgarn Craton, across the Officer Basin, and into the western Musgrave Province. The model is centred on the 2011 Yilgarn Craton – Officer Basin – Musgrave Province (YOM) seismic survey (2011GA_YOM, L199 seismic reflection line). The 3D model contains 2D and 3D subsurface horizons and faults which are interpreted from seismic reflection data and gravity modelling.
This model was originally built by Geoscience Australia (GA) in 2013 and released through the GA website Data and Publications search engine. The current release was recompiled in 2020 by the Geological Survey of Western Australia for viewing in Geoscience ANALYST.



Datasets featured:
3D modelling
Subsurface horizons
Faults
Surface geology
Interpreted geology
Petroleum wells
Gravity
Magnetics
Seismic lines

Download from: <www.dmirs.wa.gov.au/datacentre>



Important information for customers

Data in this product are formatted for display in the 3D viewing software Geoscience ANALYST, which can be downloaded from Mira Geoscience www.miageoscience.com.

This software runs as a 64-bit application in the Microsoft Windows 7, 8 or 10 environment only. A modern graphics card or processor that supports at least Open GL 2.0 are need to run this software. Graphics card drivers should be updated to the latest versions available for your computer. At least 4GB of RAM is recommended for efficient operation.

Geoscience ANALYST is the property of Mira Geoscience Ltd. Further information and technical support are available at www.miageoscience.com.

Yilgarn Craton – Officer Basin – Musgrave Province, 2013 — 3D Geomodel Series
Published 2021
Enquiries to Email: gsd.dda@dmirs.wa.gov.au; Phone: +61 8 9222 3459
Cost: Free

• MAPS •

Aboriginal land, conservation areas, mineral and petroleum titles and geology, Western Australia – 2021
by Ridge, KJ

Major resource projects, Western Australia — 2021
by Sargent, SN, Wyche, NL, D'Ercole, C, Jones, JA and Murray SI

Mines — operating and under development, Western Australia — 2021
by Jones, JA, Sargent, SN, Wyche, NL, D'Ercole, C and Murray, SI