A Geological Survey of Western Australia Newsletter

JULY 2024 NUMBER 111

Department of Energy, Mines, Industry Regulation and Safety

GOVERNMENT OF WESTERN AUSTRALIA

# Fieldnotes

www.demirs.wa.gov.au/GSWA

BUMPER ISSUE!

## Can't see for Miles:
In situ mica Rb–Sr geochronology from the Rudall Province

## New EIS co-funding

## National Drilling Initiative in the Eucla Basin

## New geophysical surveys for West Yilgarn Project

## WA Array joins StoryMap series

Geological Survey of Western Australia

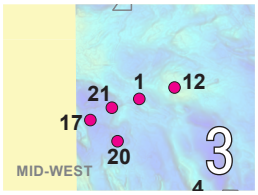
# What's inside

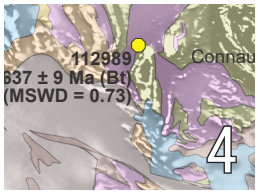
## FEATURES



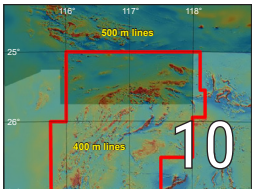
## REGULARS











## EDITORIAL TEAM

**Editor**

Bec Hitchings, Manager Editing and Publishing

**Design and layout**

Bec Hitchings, Desktop Publisher

**Graphics**

Michael Prause, Graphics Manager

Adam Symonds, Graphics Officer

### Contributors to this issue

Trevor Beardsmore

Richard Chopping

Louisa Collins

David Howard

David Kelsey

Ruth Murdie

Warren Ormsby

Hugh Smithies




**Acknowledgement of Country**

We respectfully acknowledge Aboriginal peoples as the Traditional Custodians of this land on which we deliver our services to the communities throughout Western Australia. We acknowledge their enduring connection to the lands, waterways and communities and pay our respects to Elders past and present.

# 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**: Outcrop of folded Yandagooge Formation in Tracy Hills, about 1.5 km north of the Kintyre U prospect.


**ISSN 1834-2272** **ISBN 978-1-76148-038-6**

# EIS announces successful applicants to the inaugural Co-funded Geophysics Program

The new Co-funded Geophysics Program (CGP) was added to the Exploration Incentive Scheme (EIS) in 2024. The program launched in February when it opened to applications and Minister Michael announced the first suite of successful projects in April.

Twenty-three applicants were granted over A$3 million in EIS co-funding in April this year to undertake geophysical surveys in selected central and eastern areas of the State.

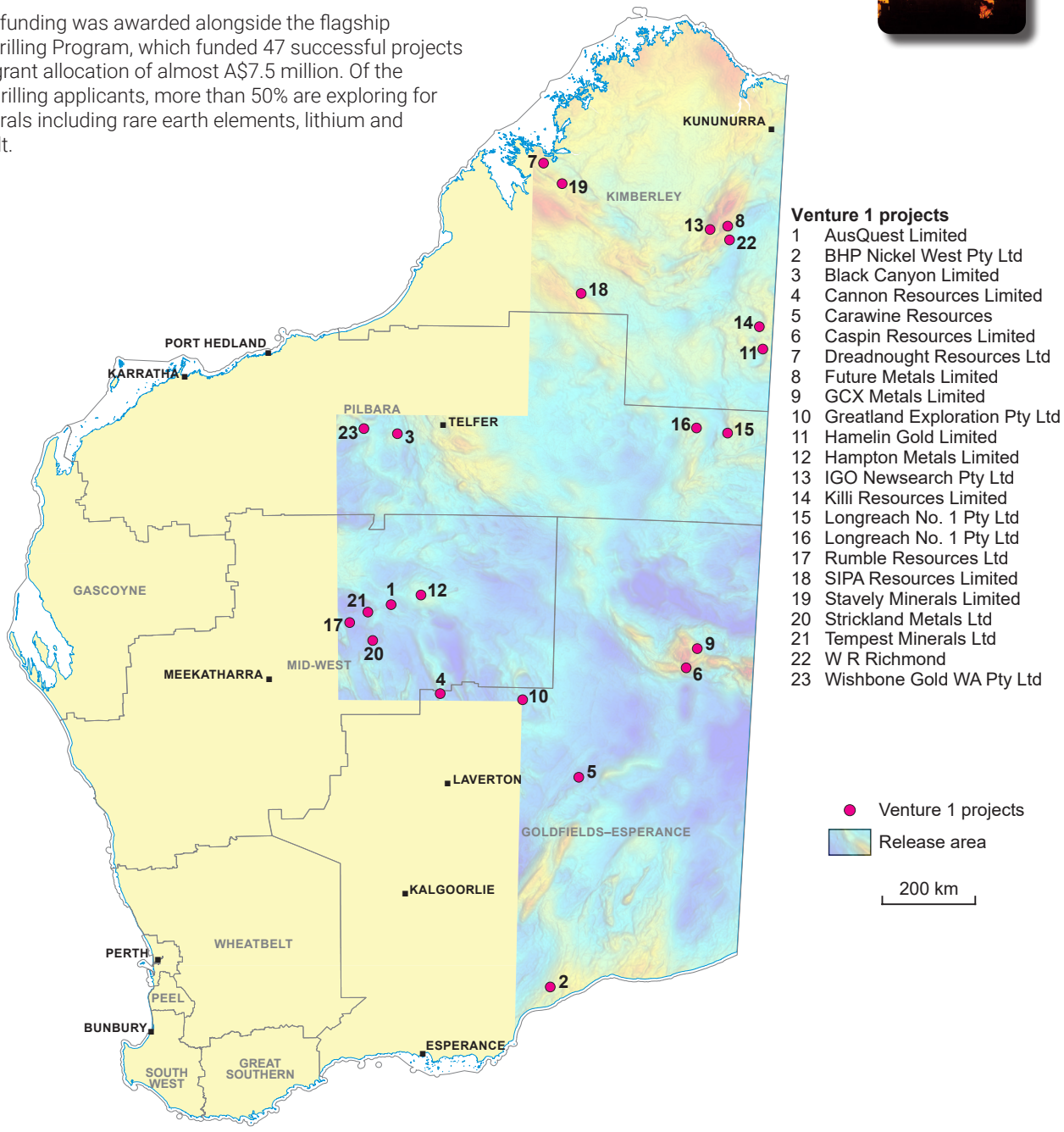
The geophysics co-funding is a new initiative to support greenfields exploration at its most frontier level. In Venture 1, 75% of successful applicants are actively searching for critical minerals and supports the State's Battery and Critical Minerals Strategy 2024–30.

The CGP co-funding was awarded alongside the flagship Co-funded Drilling Program, which funded 47 successful projects with a total grant allocation of almost A$7.5 million. Of the successful drilling applicants, more than 50% are exploring for battery minerals including rare earth elements, lithium and nickel–cobalt.

Projects from both the Round 29 drilling and Venture 1 geophysics programs will run between June 2024 and May 2025.

Applications for Round 30 of the Co-funded Drilling Program will open **5 August 2024** and applications for Venture 2 of the CGP will open in February 2025.

For more information on the EIS and this round's successful applicants, visit **Exploration Incentive Scheme**.




**Venture 1 projects**

1 AusQuest Limited
2 BHP Nickel West Pty Ltd
3 Black Canyon Limited
4 Cannon Resources Limited
5 Carawine Resources
6 Caspin Resources Limited
7 Dreadnought Resources Ltd
8 Future Metals Limited
9 GCX Metals Limited
10 Greatland Exploration Pty Ltd
11 Hamelin Gold Limited
12 Hampton Metals Limited
13 IGO Newsearch Pty Ltd
14 Killi Resources Limited
15 Longreach No. 1 Pty Ltd
16 Longreach No. 1 Pty Ltd
17 Rumble Resources Ltd
18 SIPA Resources Limited
19 Stavely Minerals Limited
20 Strickland Metals Ltd
21 Tempest Minerals Ltd
22 W R Richmond
23 Wishbone Gold WA Pty Ltd

# Can't see for Miles: In situ mica Rb–Sr geochronology from the Rudall Province

John de Laeter Centre

EIS EXPLORATION INCENTIVE SCHEME

A longstanding point of conjecture in the evolution of the Paterson Orogen in northern Western Australia is the age of the Neoproterozoic Miles Orogeny. The Miles Orogeny is thought to be characterized in outcrop by regional $D_3$ and $D_4$ structures that are were subsequently overprinted by $D_5$ and $D_6$ structures during the 654–509 Ma Paterson Orogeny. However, existing quantitative age constraints for the Miles Orogeny have large uncertainties and define a time frame of approximately 840–750 Ma.

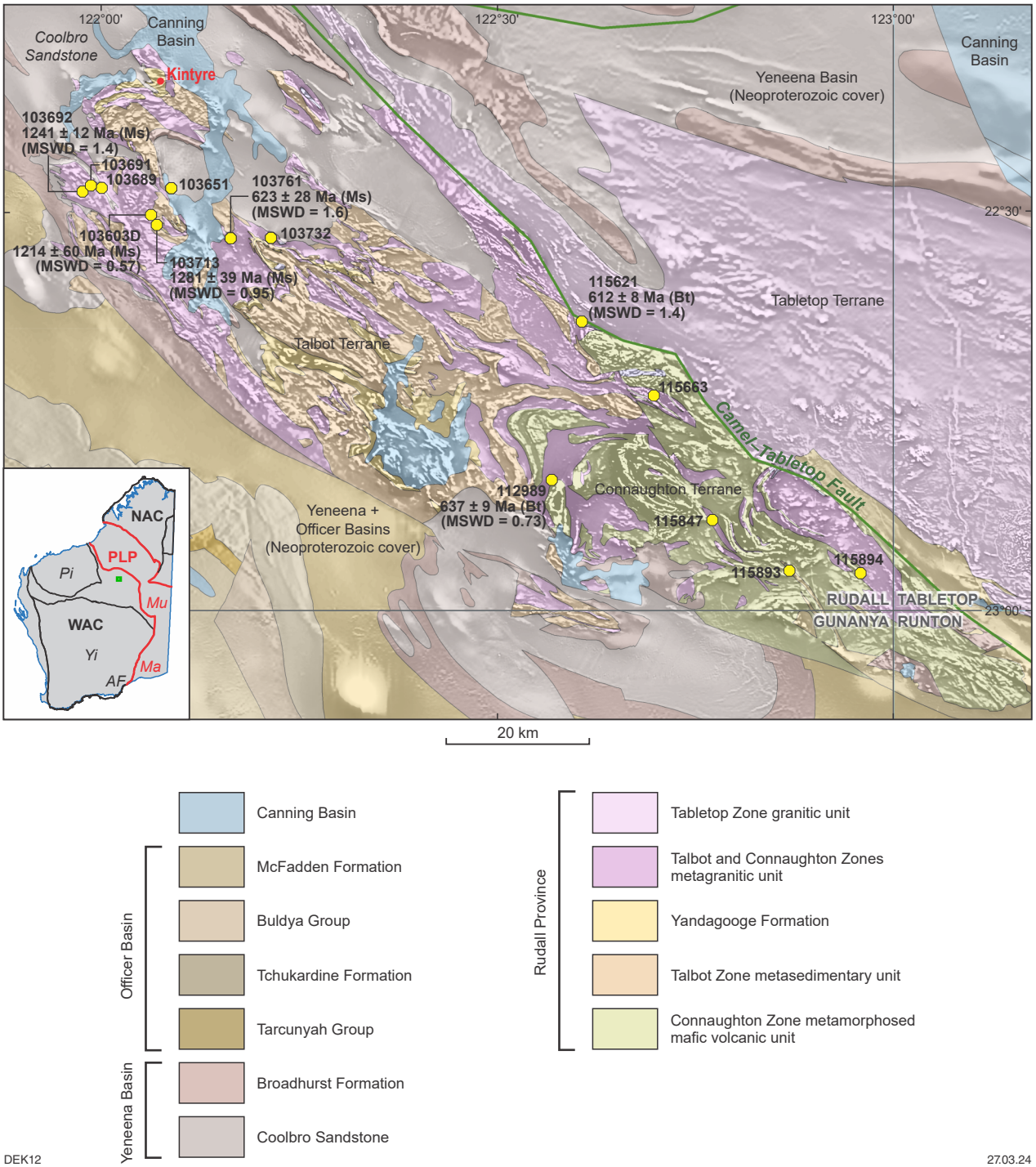



*Figure 1. Location map of the Rudall Province, showing the three terranes and the analysed sample locations. Coloured geology polygons are taken from the State interpreted bedrock geology polygons 1:500 000 (2016) GIS layer. Map sheet names in capital letters refer to 1:250 000 scale. Green boundaries, e.g. Camel–Tabletop Fault, are taken from the GSWA 2021 major crustal boundaries GIS layer. GIS layers are available at* **GeoVIEW.WA**. *Abbreviations: Bt, biotite; Ms, muscovite. Inset shows State tectonic domains. Abbreviations for inset: AF, Albany–Fraser Orogen; Ma, Madura Province; Mu, Musgrave Province; NAC, North Australian Craton; Pi, Pilbara Craton; PLP, Percival Lakes Province; WAC, West Australian Craton; Yi, Yilgarn Craton. Green box in inset shows location of the main images*

These have been obtained exclusively from mineralized veins within low- metamorphic grade host rocks of the Neoproterozoic Yeneena Basin; that is, from the shallow crustal portion of the orogen.

This study obtained in situ mica Rb–Sr geochronology from rocks representing deeper parts of the Paterson Orogen — that is, from crystalline metaigneous and metasedimentary rocks within the Rudall Province — to try to constrain the age (and existence) of the Miles Orogeny. Muscovite and biotite were analysed from 14 rocks and muscovite yielded a higher rate of isochrons than biotite. Isochrons were obtained from six samples (muscovite n =4 and biotite n = 2) whereas all remaining samples yielded a wide dispersion of Rb–Sr data. The isochrons yielded three Paterson Orogeny ages (623 ± 28 Ma muscovite, 637 ± 9 Ma biotite and 612 ± 8 Ma biotite) and one Parnngurr Orogeny age (1281 ± 40 Ma muscovite). The other two isochrons were 1214 ± 60 Ma (muscovite) and 1242 ± 12 Ma (muscovite), which could perhaps relate to disturbance of Parnngurr Orogeny ages by activity related to the recently identified c. 1185 to c. 1165 Ma **Kalyukuyarra Suite**. Strikingly, no isochron ages, nor definitive Rb–Sr model ages, were obtained for the Miles Orogeny. Therefore, it is likely that existing and new age data for the proposed Miles Orogeny represent either a hydrothermal fluid flow event, in which case 'Orogeny' is not appropriate terminology, or that it represents mixing of Paterson Orogeny and Mesoproterozoic age components. The latter possibility implies that the Miles event does not exist, in which case $D_3$–$D_6$ structures likely all represent progressive deformation during the Paterson Orogeny. This is plausible given the location of the Paterson Orogen within a complex curved restraining bend type geometry adjacent to the Pilbara Craton.

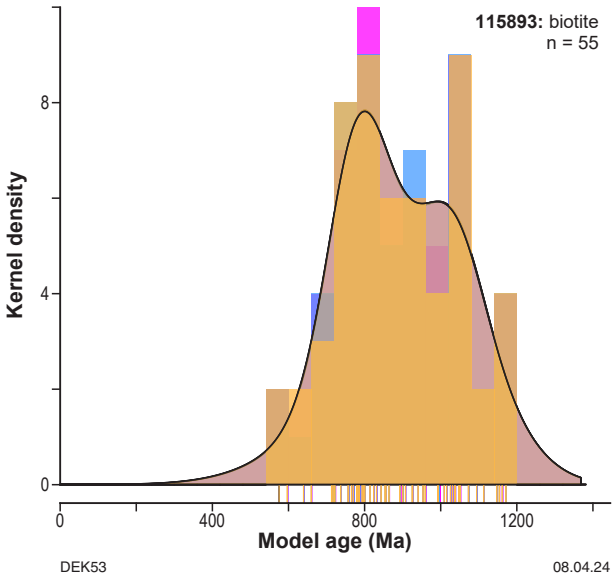



*Figure 2. Example of Rb–Sr model age distributions for one sample, 115893 (biotite) biotite-bearing metagranodiorite augen gneiss, calculated using $^{87}Sr/^{86}Sr_0$ ratios of 0.70 (pink), 0.73 (blue) and 0.76 (orange), to highlight the spread of model ages spanning the proposed Miles Orogeny timeframe, that we interpret to be due to mixing between the 654–509 Paterson Orogeny and older Mesoproterozoic events. Histogram bin width is based on the average 2σ uncertainty for model ages for individual analyses*

## How to access

**GSWA Report 250 In situ mica Rb–Sr geochronology from the Rudall Province: searching for Miles** by D Kelsey et al., is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **David Kelsey**.

# Critical minerals: Intrusion-hosted nickel–copper–PGE system

Relevance of the Mineral System Atlas (MSA) as an exploration and research tool continues to grow with the release of this second major nickel system. Known deposits of mafic-ultramafic intrusion-hosted Ni–Cu–PGE mineralization include Savannah, Nova Bollinger, Julimar and West Musgrave. Active exploration for this mineralization style is ongoing throughout the State.

The MSA seeks to help anyone who wants to find exploration-relevant spatial data and information presented in a logical mineral systems-based framework. Each system is accompanied by an online MSA Guide and GSWA Record. The online guide presents information on each spatial layer, the primary data from where it was derived, and any filters or query models used. The Records provide a succinct overview of the mineral system, along with a mineral system tree, which for each part of a system (e.g. source, pathway) denotes the critical processes, their constituent process, the targeting elements, and their mappable proxies.

The latest release comprises several new universal data sets with applicability beyond the new system — including for the previously published komatiite-hosted nickel system:

- maximum grade in-hole drilling data — presenting smoothed updated images at three scales (100 m, 300 m and 5 km cell sizes) from public exploration data for Ni, Co, Pt and Pd
- a transported regolith layer
- images depicting structural complexity and dyke density respectively
- the 1:2 500 000 major crustal boundaries mapping.

New layers within the mafic-ultramafic intrusion-hosted Ni–Cu–PGE system include:

- mineralization style identifying known mineralization of this type
- geochemical data from mafic-ultramafic intrusions (e.g. MgO > 32%, Mg#) and derived information such as the classification of cumulates
- field observations of indicator minerals, cumulates, mantle-derived rocks, sulfidic sedimentary rocks
- relevant lithological information from regional geological mapping, including the identification of units that contain mafic intrusive rocks.

The **MSA** is a browser-based viewer (similar to GeoVIEW.WA). Data are available for downloading from the Data and Software Centre 'Statewide spatial datasets' section. Records are available as a free downloadable PDF from the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) **eBookshop**.

For more information, contact **Warren Ormsby**.

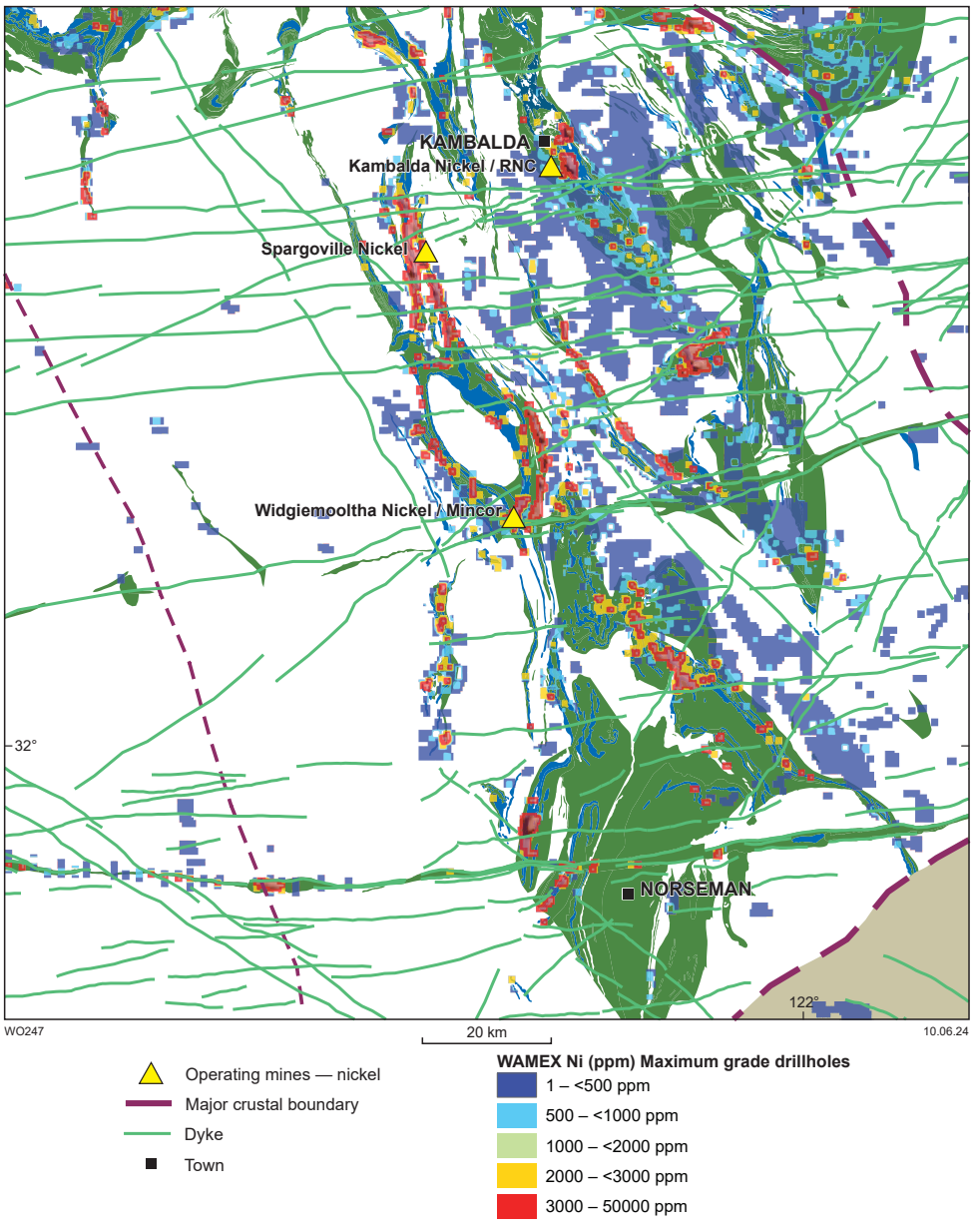



*Figure 1. Drillhole maximum grade data for Ni using a 300 m cell size, overlain by a mineralized drillhole density hill-shaded drape in which the highest elevations represent a higher concentration of anomalous drillholes (Ni >300 ppm). The 1:2 500 000 dykes and major crustal boundaries layers are shown for context. Note the relationship between higher Ni grades and the east–west trending dykes*

# Celebrating GSWA's finest with well-deserved recognition

On the evening of Wednesday 5th June, Dr Hugh Smithies, Manager of Archean Geodynamics at GSWA, was awarded the 2024 Gibb-Maitland Medal by the Geological Society of Australia – WA Division, for a lifetime of outstanding and substantial contributions to the field of geochemistry in Western Australia.

He started at the Survey in 1992 initially mapping the Roe 1:100 000 sheet in the Kurnalpi Region of the Eastern Goldfields. From there he spent over a decade mapping in the Rudall Province and northwest Pilbara. In the mid 2000s he managed the West Musgrave Province mapping program, which naturally continued into the Albany–Fraser Orogen. More recently, Hugh has worked exclusively on the State's Archean rocks, establishing the geochemical barcoding project which has analysed over 16 000 rocks to understand the chemical variation across the Eastern Goldfields greenstone stratigraphy and the granitic rocks across the entire Yilgarn Craton. He is now applying the same techniques across the Pilbara Craton with a focus on understanding the evolution of lithium-bearing pegmatites across the State.

Through his work, Hugh has demonstrated that high-quality geochemistry is an essential component that helps link deep-scale geophysics, geochronology, whole rock and mineral isotopes, petrology, and surface mapping, ultimately to better understand crustal-scale geodynamic processes. His work has contributed to a better understanding of Earth's early evolution; the processes of construction of continental crust and associated greenstones; the switch in the Mesoarchean to more modern-style plate tectonic processes, and the origin of ultrahigh-temperature magmatism associated with the largest super volcano to have ever existed on this planet. His seminal work on the relationship between sanukitoids and gold mineralization has recently been cited by numerous exploration companies as a major contributing factor in the discovery of several new gold deposits.

GSWA wishes to congratulate Hugh on his achievement and to thank him for his dedication to the Survey and to the science that he so passionately pursues.


*A well-deserved moment of recognition, Hugh's medal was presented to him by Simon Johnson, GSWA's Director Regional Geoscience*

# National Drilling Initiative campaign offers new insights into drilling in the Eucla Basin

EXPLORATION INCENTIVE SCHEME

As the world turns its attention to the supply of critical and strategic minerals, it is important to address the challenges of exploration for such commodities in the undercover portions of the world. Much of Western Australia's bedrock geology that hosts many ore bodies is obscured by deep weathering or younger sedimentary basins. Techniques to map beneath this cover can include geophysical surveys but also require investigation through stratigraphic drilling campaigns.

Undertaken in 2014–15, the Eucla Basement drilling campaign was carried out by the Geological Survey of Western Australia (GSWA) to investigate geophysical anomalies beneath the Eucla Basin (**Fieldnotes 75**). Twelve drillholes were completed by GSWA and drilling contractors in this vast region, inevitably leaving some areas unexplored. In addition to better defining the stratigraphy beneath the Eucla Basin, this campaign also provided other precompetitive insights to the requirements for drilling in the region. The methods used for drilling and an understanding of the challenges posed by the limestone lithologies have been some of the key results used by industry to undertake exploration in the region.

GSWA is a key participant in Program 3 of the MinEx CRC National Drilling Initiative (NDI), which aims to conduct research on mapping undercover using novel drilling techniques and analyses of recovered samples (**Fieldnotes 89**). An opportunity arose to utilise the RoXplorer™ CT500 drill rig — which offers cheaper, quicker and more environmentally friendly drilling — to undertake a targeted campaign within the Eucla Basin to:

- Understand how to apply this novel technique to the drilling conditions of the Eucla Basin;
- Obtain samples of the near surface, basin and (ideally) basement.

The selected site was on Moonera Station, near the Eyre Highway (Fig. 1), with a pronounced but poorly understood geophysical anomaly and favourable access. Crucially, this region also fills in a gap in the precompetitive drilling undertaken previously by GSWA.

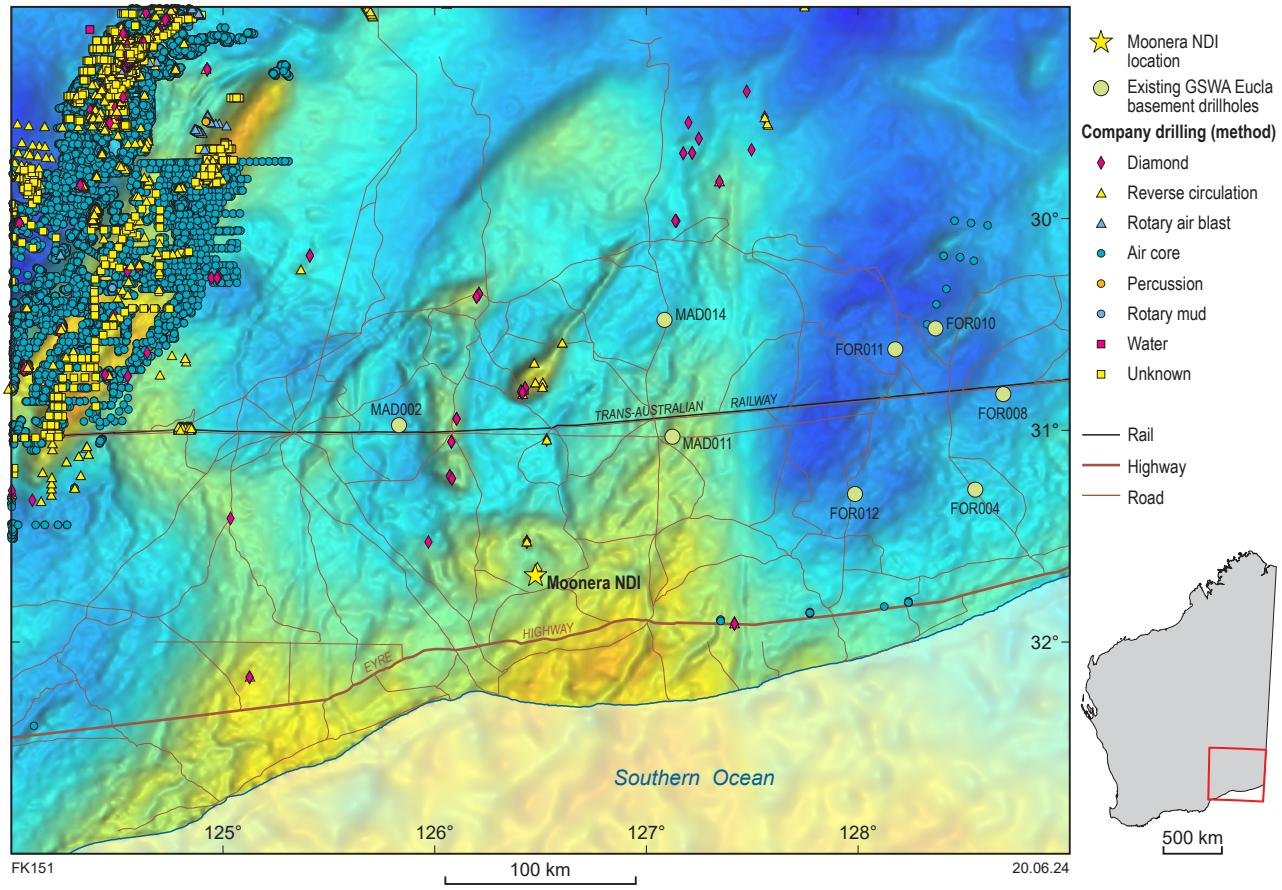



*Figure 1. Prior GSWA drilling, reported exploration drillholes and the location of the Moonera program (star), all underlain by the gravity data for the region*

The CT500 rig is designed to rapidly reach basement and provide chip samples every 1 m, but it is also possible to core at selected intervals. While this impacts drilling productivity, 3 m of core has successfully been obtained every ~50 m to a total depth of just beyond 500 m from borehole MOON08 (Fig. 2). However, chip samples have been more difficult to retrieve in this program. The CT500 uses an openhole drilling method, so that sample return requires positive circulation to be maintained. This can be difficult in areas with extensive near-surface fractures as is common in the region, but the Moonera drilling has shown that the CT500 can reach near basement relatively quickly if basin samples are not prioritized, and thus would be suitable for pre-collaring a deep diamond hole while also permitting intervals of core to be obtained.

The program is yet to conclude but has already demonstrated the methods needed to successfully drill to nearly 500 m in the region using the coiled-tube drilling technique. One of the challenges seen with industry drilling near Moonera is that, to date, only one borehole has successfully been completed to basement, reaching it at 456 m depth (drillhole 22MEDD001). Other boreholes became stuck and were unable to be completed without reaching basement, including a hole exceeding 500 m depth.

With one more hole to complete drilling at the time of writing, the program will be wrapped up for the RoXplorer™ to travel north to the Nifty mine and continue our research on the regional distal footprint of copper mineralization (**Fieldnotes 107**).


*Figure 2. Field photo example of core obtained from depth 170 m beneath the surface near Moonera*

## How to access

More information will be released on the **GSWA–MinEx NDI webpage** as it becomes available.

For more information, contact **Richard Chopping**.

# New regional geophysical coverages for GSWA's West Yilgarn Project

EXPLORATION INCENTIVE SCHEME

Of the more than twenty of the Geological Survey of Western Australia's **(GSWA) varied project areas** in Western Australia, the **West Yilgarn Project** is one of the largest.

To support the geological mapping program, GSWA has allocated resources to the acquisition of new regional geophysical datasets within and adjacent to the project area (Figure 1).

During 2023–24, three deep crustal 2D seismic traverses were completed in the South West and Mid West regions (Fig. 1) to image the crustal structure and geological domains in this, one of the oldest parts of the Australian landmass, and its juxtaposition with the much younger sedimentary rocks of the Perth Basin. With a total length of 1200 km, the new lines bring aggregate seismic coverage in the State to greater than 8500 line-km.

Data acquisition by contractor HiSeis Pty Ltd occurred between September 2023 and January 2024, with the following survey parameters:

- Source: 3 x INOVA AHV-IV Vibroseis trucks @ 40 m vibration point spacing, 1 x 24 s sweep
- Receiver: 1600 x INOVA Quantum 5 Hz nodes @ 10 m spacing (nominal 200-fold), 20 s listen time.

Data processing of the South West line is complete, and data were released on 30 May 2024 (Fig. 2). Full stack time and depth migrated sections are available for download through GSWA's online delivery platforms **MAGIX**, **GeoVIEW.WA** and **WAPIMS**. The complete field and processed data packages are available on request for delivery on hard drive media. Final data from the Mid West lines should be available in August 2024. **Subscribe** to the GSWA eNewsletter for advance notice of the release date.

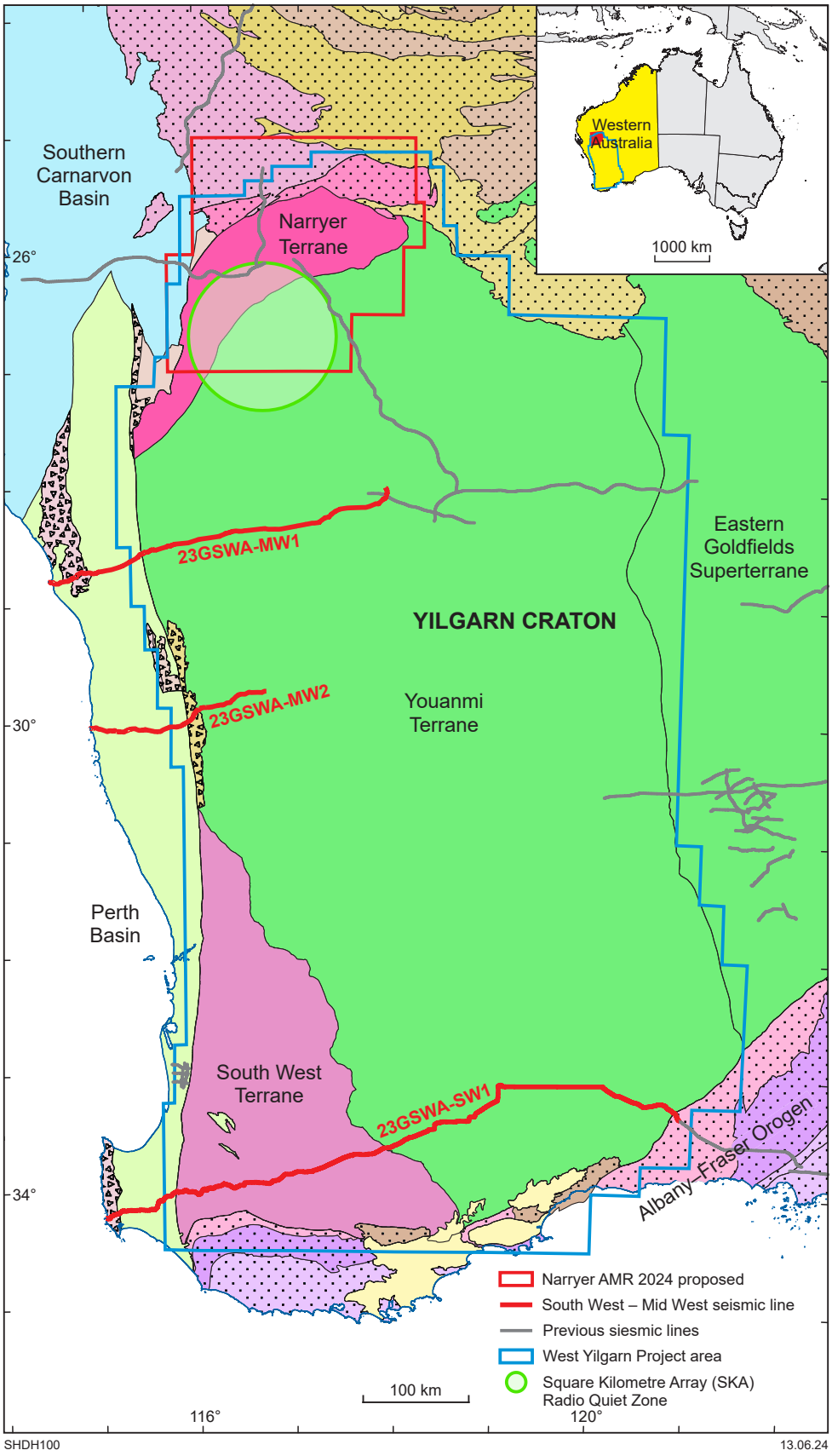



*Figure 1. West Yilgarn project area showing location of new geophysical surveys in 2023-24 and proposed for 2024–25*

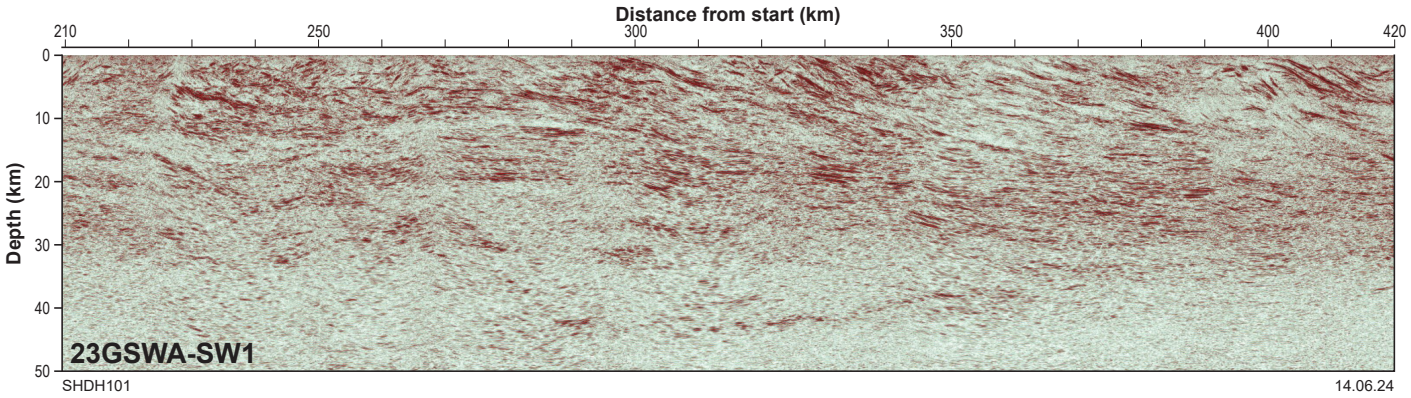



*Figure 2. Central section of seismic image along line 23GSW-SW1 to 50 km depth*

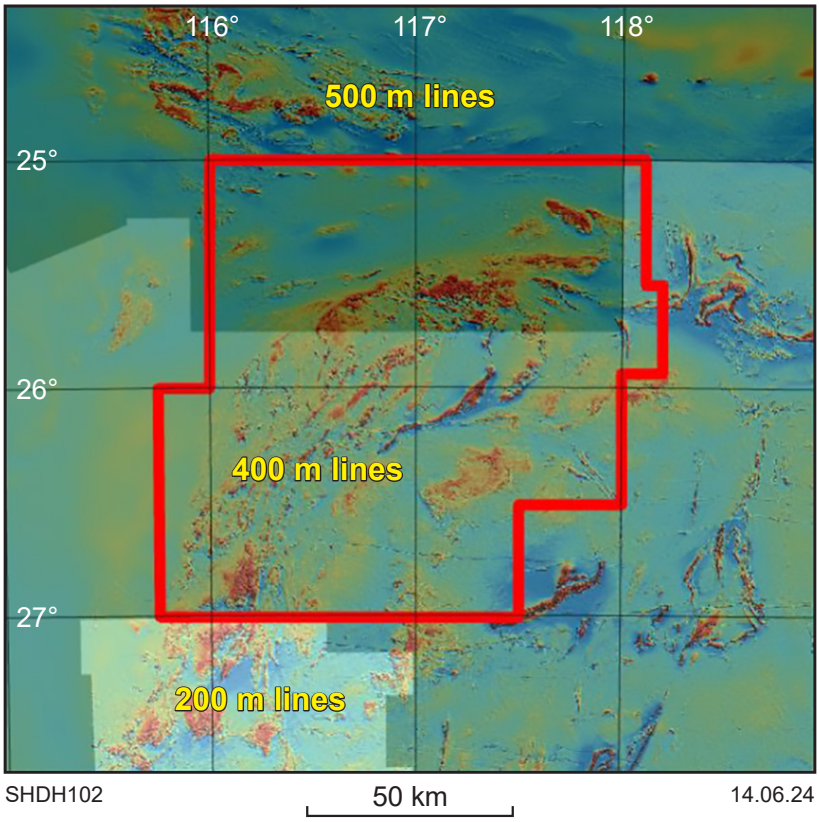



*Figure 3. Narryer 2024 aeromagnetic and radiometric (AMR) project area showing existing AMR survey coverage resolution (line spacing)*

In 2024–25 preparation is underway for an aeromagnetic and radiometric (AMR) survey at the northern extreme of the West Yilgarn Project area, over the complex 'triple junction' between the Archean Yilgarn Craton, the Proterozoic Capricorn Orogen in the north, and the Palaeozoic sedimentary basins in the west.

The new survey at 100 m line spacing will provide substantially improved data resolution beyond that which is presently available in the current State AMR coverage (Fig. 3). While the existing degree of resolution is adequate for broad regional geological mapping at scales smaller than 1:500 000, it is quite inadequate for mapping at scales of 1:100 000 or greater which is the focus of the latest generation of GSWA field geology programs.

Subject to contractor availability and weather depending , it is anticipated that the airborne operations will occur between August and November 2024, with release of the new data by June 2025. Follow progress updates via **MAGIX** and **GeoVIEW. WA** by searching on Registration Number 72696.

For further information contact **geophysics@demirs.wa.gov.au**.

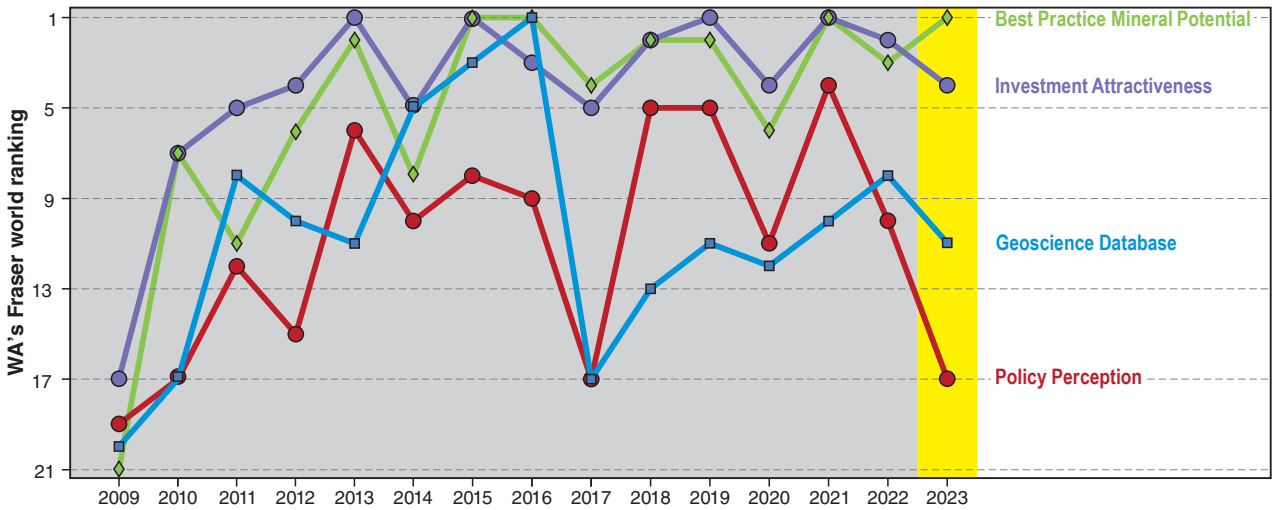
# Western Australia still attractive for mining investment

The Fraser Institute, a Canadian public policy think tank (ranked in the top 20 think tanks in the world) recently published its annual global 'Survey of Mining Companies', which ranks the investment climates of mining jurisdictions around the world. The ranking is based on mining industry executive and manager opinions on the effects of public policy factors such as taxation and regulatory uncertainty on exploration investment decisions. In 2023, the Fraser Institute circulated its survey to 2045 individuals, and received 293 responses, providing sufficient data to rank 86 jurisdictions.

Western Australia continues to maintain a high investment attractiveness, a composite rating that combines the Best Practice Mineral Potential Index, or perceived geological prospectivity, and the Policy Perception Index, a measure of a government's attitude towards exploration and mining investment. The state has remained in the top five jurisdictions globally for investment attractiveness for 13 consecutive years, and has been first amongst Australian jurisdictions for the past 14 years – a truly remarkable achievement in such a competitive investment climate (Figs 1, 2).

Western Australia's best practice mineral potential was ranked first globally in 2023, and historically has been in the top 10 jurisdictions for 13 of the past 14 years (Fig. 1). However, the state's relative global ranking in the Policy Perception Index fell sharply in 2023 to 17th (from 10th in 2022) – the lowest this has been since 2017. The Fraser Institute deduced from its survey that Western Australia's mining and environmental regulatory environment and overall legal system and 'security' strongly favour exploration, but also that there is increasing concern about the quality of infrastructure, uncertainty over disputed land claims and protected areas, the availability of skilled workers, and (somewhat surprisingly) political stability. The net result has been a small decline in global investment attractiveness relative to 2022.

A policy factor of particular interest to the Geological Survey of Western Australia (GSWA) is the Geoscience Database Index. Western Australia's global geoscience database ranking rose from 20th to 1st between 2009 and 2017, attributed to the surge in volume of pre-competitive geoscience data and knowledge produced with funding assistance from the Exploration Incentive Scheme.




| Fraser Index | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number Of Jurisdictions Surveyed | 72 | 79 | 93 | 96 | 112 | 122 | 109 | 104 | 91 | 83 | 76 | 77 | 84 | 62 | 86 |
| Best Practice Mineral Potential | 21 | 7 | 11 | 6 | 2 | 8 | 1 | 1 | 4 | 2 | 2 | 6 | 1 | 3 | 1 |
| Investment Attractiveness | 17 | 7 | 5 | 5 | 1 | 5 | 1 | 3 | 5 | 2 | 1 | 4 | 1 | 2 | 4 |
| Geoscience Database | 20 | 17 | 8 | 10 | 11 | 5 | 3 | 1 | 17 | 13 | 11 | 12 | 10 | 8 | 11 |
| Policy Perception | 19 | 17 | 12 | 15 | 6 | 10 | 8 | 9 | 17 | 5 | 5 | 11 | 4 | 10 | 17 |

SPJ160 02.07.24

*Figure 1. Western Australia's Fraser world ranking by year for Investment attractiveness, Best practice mineral potential, Policy perception and Geoscience database*

**Fraser Institute's Investment Attractiveness — Australian States only**

| RANKING | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NT | WA | WA | WA | WA | WA | WA | WA | WA | WA | WA | WA | WA | WA | WA |
| 2 | SA | SA | SA | Qld | NT | SA | NT | Qld | Qld | Qld | SA | SA | SA | NT | NT |
| 3 | Qld | Qld | NT | SA | Qld | Qld | SA | SA | SA | NT | NT | Qld | NT | SA | Qld |
| 4 | WA | Tas | Qld | NT | SA | NT | Qld | NT | NT | SA | Qld | NT | Qld | Qld | SA |
| 5 | NSW | NT | NSW | NSW | NSW | Tas | Tas | Tas | Tas | NSW | Tas | NSW | Tas | NSW | NSW |
| 6 | Tas | NSW | Tas | Tas | Tas | NSW | NSW | Vic | NSW | Vic | Vic | Vic | NSW | Vic | Tas |
| 7 | Vic | Vic | Vic | Vic | Vic | Vic | Vic | NSW | Vic | Tas | NSW | Tas | Vic | Tas | Vic |

SPJ161 18.06.24

*Figure 2. A comparison of Western Australia's perceived Investment Attractiveness relative to other Australian jurisdictions*

In 2017, however, Western Australia's global ranking declined sharply, and in 2023 has only improved to 11th place. GSWA believes that this is at least in part due to increased competition from other jurisdictions, which have accelerated the digital collection and online provision of their pre-competitive geoscience data at nominal or no cost, following the model pioneered by Western Australia.

The Fraser Institute also canvasses the mining industry's perceptions of permitting times in Canada, the US, Australia and Europe, and the impact of permitting processes on investment decisions. Western Australia generally performs well in all these surveys, with 44% of respondents to the 2023 survey indicating they received their permits in less than six months, and 89% indicating confidence that they would be granted the necessary permits – but there is still room for improvement, with more than half of respondents indicating that permit approval times had not changed for many years.

Notwithstanding the ongoing positive investment outlook for Western Australia, GSWA remains committed to the collection of new, cutting-edge, high-quality precompetitive geoscience datasets, such as the A$12 million, decade-long WA Array passive seismic survey being progressively rolled across the state to reveal the composition and structure of the lithosphere. GSWA is also continuing its five-year, A$10.6 million Geoscience Data Transformation Strategy, which will transform the collection, storage and delivery of all precompetitive geoscience and statutory datasets, ensuring that the data are FAIR (findable, accessible, interoperable and reusable) and accessible to machine learning and artificial intelligence.

For more information, contact **Trevor Beardsmore**.

# WA Array exploring Western Australia's earthquakes

**WA Array: listening to the Earth** is a new StoryMap which takes us through the background behind the WA Array project. Earthquakes are surprisingly common in Western Australia (Figure 1). But why is the Geological Survey of Western Australia (GSWA) monitoring these and earthquakes from around the globe in such high resolution? This StoryMap looks into the history of earthquakes in Western Australia and how we can use them for seismic hazard mapping, imaging of the structure of the Earth, mineral exploration and land use planning.

It contains external links guiding the reader to websites such as the Geoscience Australia Earthquakes@GA site where you can see the earthquake activity almost as soon as it happens, where it was recorded, see the seismograms and submit your felt report of an event.

It puts Australia in context of a world view regarding earthquake activity and seismic hazard (Figure 2).

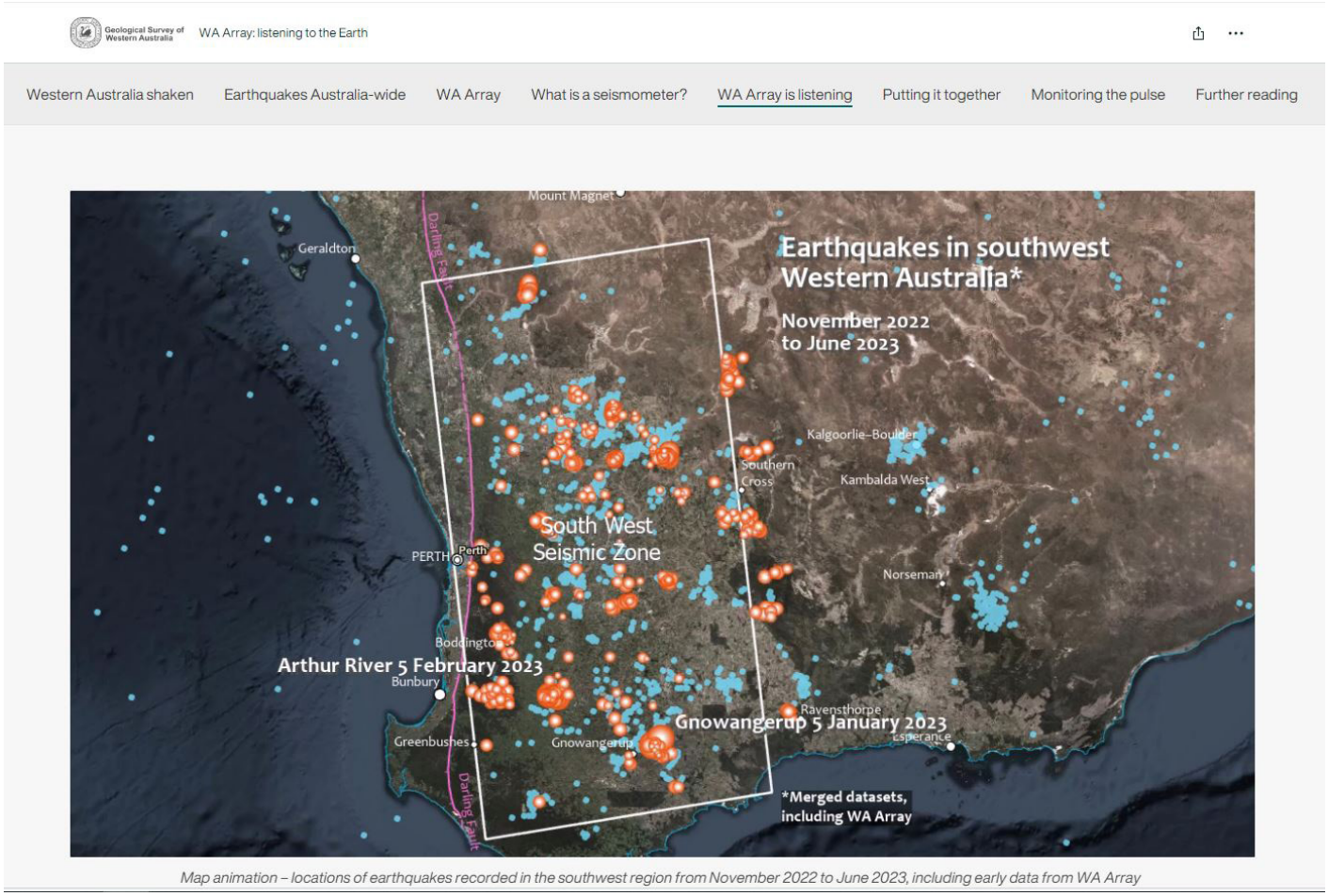
Current GSWA research into the earthquakes and crustal structure of Western Australia is the focus of the WA Array project. The storymap explains where, why, and how the project will work with animations of the rationale behind the WA Array project, how a seismometer works and what does the data look like. Of course, not all shaking events are caused by earthquakes and the StoryMap explains the origins of other sources of the signals received (Figure 1).

The obvious use of the project is to determine seismic hazard, but it is the imaging of deeper parts of Western Australia, i.e. down a couple of hundred kilometres to depths greater than other geophysical methods, that is the real motivation behind the project which is illustrated to help explain the concepts. With a better understanding of the deep structure of Western Australia, we can better predict where mineral deposits may occur, encouraging exploration and being able to set aside areas for other uses which do not look so prospective for minerals.

## How to access

**WA Array: listening to the Earth** *compiled by* Stephen White is available to view on the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) eBookshop.

For more information, visit **WA Array**.




*Map animation – locations of earthquakes recorded in the southwest region from November 2022 to June 2023, including early data from WA Array*

*Figure 1. A snapshot of an animation of the earthquakes recorded in southwest WA from November 2022 to June 2023. This highlights notable local earthquakes from this time including the mainshocks of the Arthur River swam and the largest event of the period at Gnowangerup.*

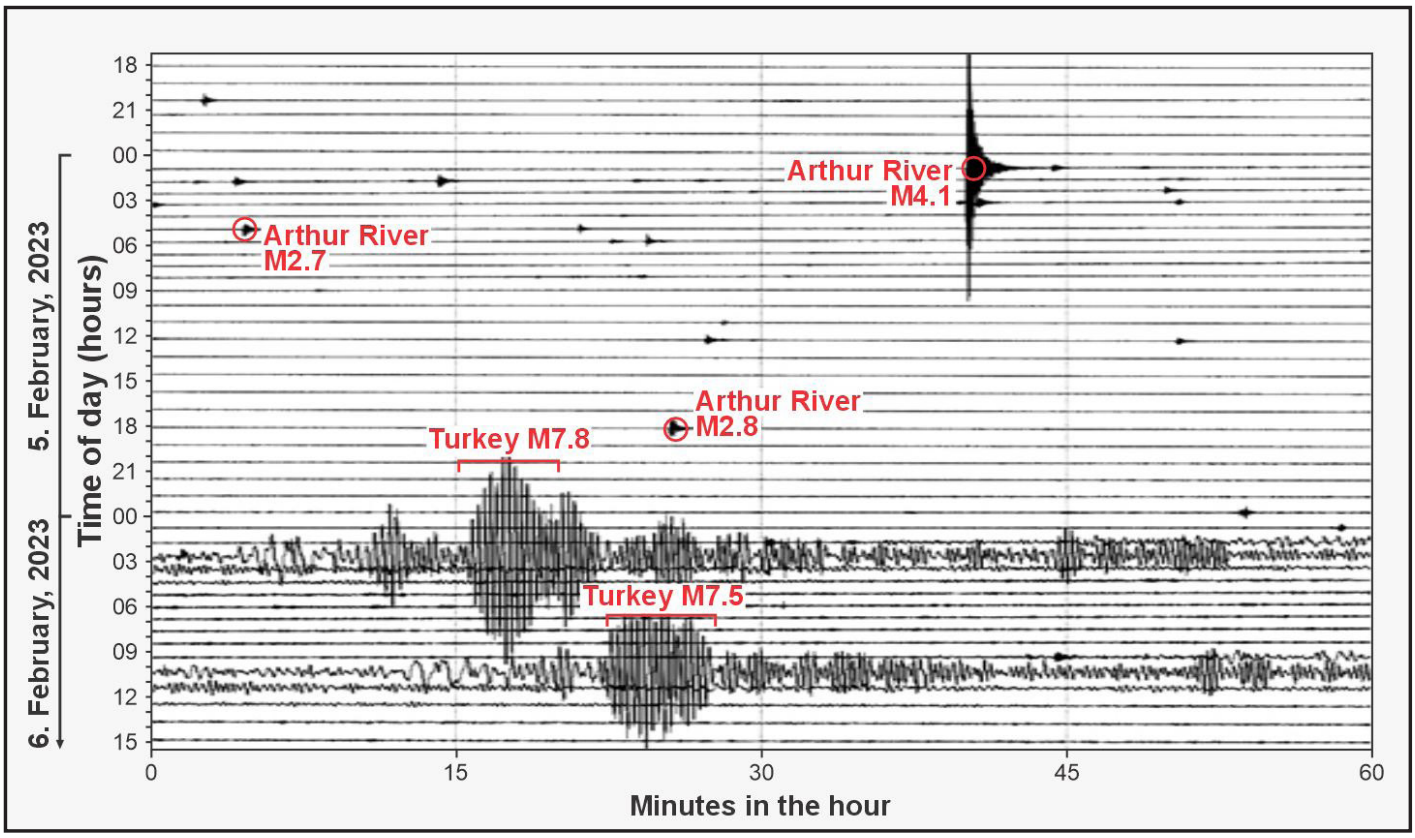



*Figure 2. Seismic traces from two days in February 2023 from a WA Array station which recorded one of the mainshocks and several aftershocks of the Arthur River swam which can be compared to the energy which travelled half way round the globe from the two devastating events in Turkey a day later*

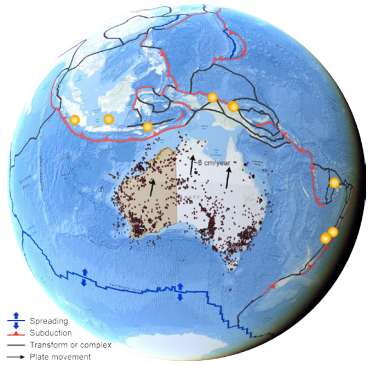



*Plate boundaries enclosing the Australian tectonic plate with locations of major earthquakes in the complex collision zone north of Australia (large orange dots) during the week 19–25 March 2024*

*WA Array field team meet the helicopter pilot to begin the day's work*

## WA Array: listening to the Earth

This StoryMap is the newest release in the series published by the Geological Survey of Western Australia (GSWA). It illustrates how we use earthquakes to explore Western Australia's geology.

The StoryMap contains the following sections:

- Western Australia shaken
- Earthquakes Australia-wide
- WA Array
- What is a seismometer?
- WA Array is listening
- Putting it together
- Monitoring the pulse

WA Array

GSWA has launched a long-term program of earthquake monitoring called **WA Array**. This ambitious project is mapping the state's seismic activity in greater detail than ever before. It is one of the largest high-resolution passive-seismic experiments carried out anywhere.

The program is funded by the State Government as part of its ongoing program of providing the public with data and information about the geoscience of Western Australia.

### WA Array: listening to the Earth

Enquiries to publications@dmirs.wa.gov.au
Free (online): https://storymaps.arcgis.com/stories/aac96da6c12f431f95463d1f16aa7bdf

Department of Energy, Mines, Industry Regulation and Safety

Geological Survey of Western Australia

# Father of Geology in PNG leaves lasting legacy

Hugh Lucius Davies, widely regarded as the Father of Geology in Papua New Guinea (PNG), passed away on Friday 26 April 2024 at the age of 89. He leaves a lasting legacy for the Earth Sciences, through his significant contributions to our knowledge of the geology of PNG, his influence on that nation's minerals and energy sectors, and his training and mentorship of hundreds of PNG geologists.

Hugh was born on 8 April 1935 in Perth, Western Australia, growing up in Cottesloe and studying Geology at The University of Western Australia (UWA), graduating with a BSc in 1956. In that year he joined the Australian Bureau of Mineral Resources (BMR) and was shortly afterwards seconded to the territorial Geological Survey office in what was then the Australian Territory of Papua and New Guinea, to contribute to the systematic geological mapping of the country and unravel its tectonic and volcanic history.

Hugh's early work mapping the geology of the Papuan Ultramafic Belt in the southeast of PNG, subsequently formed the basis of a MSc degree, also awarded by UWA, in 1964. Hugh then commenced a PhD at Stanford University, studying the thrust emplacement of the ophiolitic Papuan Ultramafic Belt over the northern margin of the Australian continental plate, testing the still relatively new theory of plate tectonics.

It was at Stanford that Hugh met and married his beloved wife Connie Lou in 1964, a union that lasted nearly 60 years. The pair returned to PNG between 1965 and 1968, where Hugh did geological mapping in the country's southeast, accompanied where possible by Connie Lou. Hugh returned to Stanford in 1968 with Connie and their young family, to complete his doctorate. He was awarded his PhD in 1970, and the Davies clan returned again to PNG. In 1971 and 1972, Hugh led geological mapping in the country's western central ranges around Telefomin, which included the Ok Tedi, Porgera, and Frieda River mineral prospects and the high country of the Star Mountains.

In 1973, shortly after the country was granted self-determination by Australia, Hugh was appointed Chief Government Geologist in the newly formed Geological Survey of PNG, a position he held until 1981. During this time, he was heavily involved in negotiations to develop the Ok Tedi copper mine, initially as Executive Secretary of the Ok Tedi Steering Committee and then as Managing Director of the government-owned Ok Tedi Development Company (OTDC). When initial lease-holder Kennecott Copper Cooperation withdrew from negotiations in 1975, the OTDC continued exploration, proving it to be a larger, higher-grade copper resource. This led BHP Billiton to agree to develop the mine in 1977.

The Davies family returned to Australia in 1981, and for the next eight years Hugh was based at BMR in Canberra, focussing on marine geology studies that included research cruises to the Solomon Sea (1983–84) and the Southern Ocean (1985–86). He briefly revisited PNG in 1984 as volcanology liaison officer, to provide scientific advice and information to the public when a large eruption threatened Rabaul. This proved to be a false alarm, but was a dress rehearsal for 1994, when he stepped into the same role during the Rabaul eruption which displaced 50 000 people and destroyed Rabaul town.

In 1989, Hugh returned with Connie Lou to PNG, to become Professor and Head of Geology at the University of PNG (UPNG). He restructured the Geology Department to offer an internationally competitive degree program that would prepare local Papua New Guineans to compete for international jobs and encouraged the education of many female PNG geologists, who have subsequently flourished in jobs at home and abroad. Over his 29 years as Professor of Geology at UPNG he improved the lives of hundreds of students, supporting them as a mentor and teacher, and assisting them to find jobs and opportunities for further higher degree studies and research all over the world.

Hugh's contribution to the understanding of PNG's geology was outstanding. He wrote over 100 academic papers on the geology of PNG, and a number of books, including *Earth Tok* in 2014, an introductory geology textbook about the processes and hazards from a PNG perspective, and *Aitape Story: The Great New Guinea Tsunami of 1998*. He was author or co-author of 11 of the 22 published 1:250 000 scale geological maps of PNG.

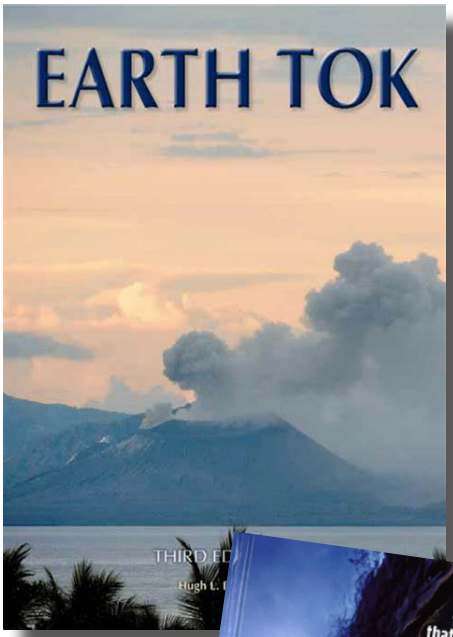
Hugh's commitment to practical geology was underscored by the many other leadership roles he had in government and the community. From 2007 to 2009 he was Executive Manager of the Geological Survey Division at the newly-formed Mineral Resources Authority. He was instrumental in providing critical on-ground disaster relief following the 1998 Aitape tsunami, and from 1999 to 2007 was Chairman of the National Disaster Awareness and Preparedness Committee. His in-depth research on the

Aitape disaster and its historical precedents led to him establishing and becoming inaugural Director of the Centre for Disaster Reduction at UPNG in 2001, which continues to offer crucial information to at-risk populations. As a PNG resident, he also sponsored and organized the logistics for countless international colleagues visiting the country to study its scientific wonders.

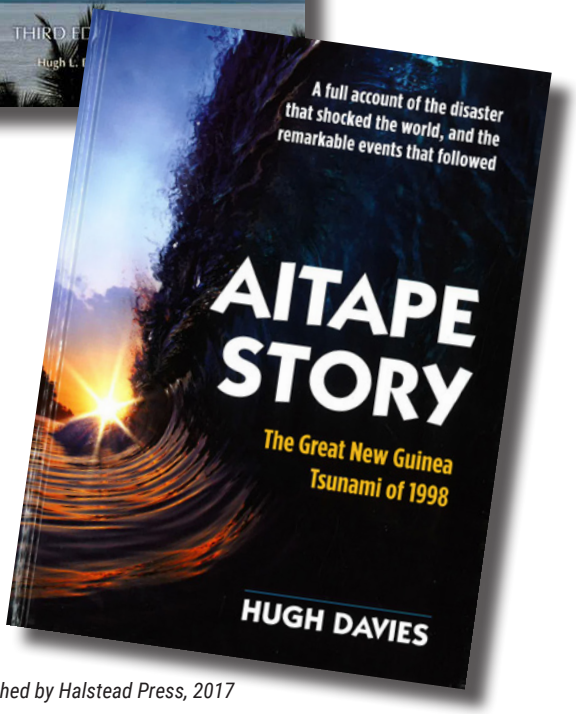
Hugh was a humble and dedicated man and a quiet achiever, only late in his career receiving formal recognition for his work. In 2005, Papua New Guinea, the country he considered his home, bestowed on him the Order of the Logohu for 'services to geological education and disaster relief'. In 2006, he received the Michael T Halbouty Outstanding Leadership Award from the American Association of Petroleum Geologists, for 'outstanding and exceptional leadership in petroleum geosciences', and in 2018, he received an Officer of the Order of Australia for 'distinguished services to Australia–Papua New Guinea relations in the area of geological sciences and to education as an academic, author and researcher'. He was awarded Emeritus Professor status at UPNG in 2018, the highest honour yet bestowed on any academic at that institution.

Hugh 'retired' from research and teaching at the University of Papua New Guinea in 2018 and returned to Canberra, Australia with Connie Lou. His retirement then consisted of working as an Honorary Visiting Professor at Australian National University's Research School of Earth Sciences, continuing his research on PNG geology, speaking with colleagues and former students from PNG and other countries, and mentoring students, helping them with research, and further study opportunities. This continued up until two days before his death.

Hugh was an example to others, living according to his mantra of giving oneself to help others, and to making the world a better place through ongoing service. He was exceptional both as an Australian and an adopted Papua New Guinean, showing that significant contributions can come from single-mindedly applying continuous effort over a long period of time.




*Published by Alan Caudell and Associates, 2014*




*Published by Halstead Press, 2017*

He is survived by wife Connie Lou, his children Martin, Kendi, Rondi and Jocey, his grandchildren Lara, Kaia, Marin and Aries, and his beloved border collie, Brave Dog.

*Trevor Beardsmore*

*Adapted largely from an article by the* ***Development Policy Centre.***

# Product releases

## • PUBLICATIONS •

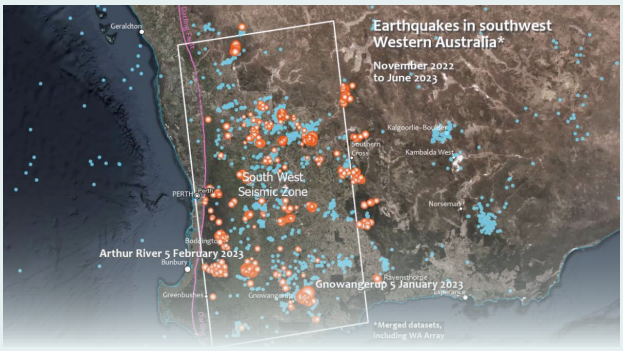
**Report 250 In situ mica Rb–Sr geochronology from the Rudall Province: searching for Miles**
*Kelsey, D, Ribeiro, BV and Kirkland, CL*

**Record 2023/9 6IAS: Redefining Archean terrane boundaries, a radical update within the Yilgarn Craton – a field guide**
*Quentin De Gromard, R and Ivanic, TJ*

**Record 2024/3 The Chittering metamorphic belt, Yilgarn Craton: structural setting and quartz crystallographic preferred orientation**
*Zibra, I and Peternell, M*


## • STORYMAPS •

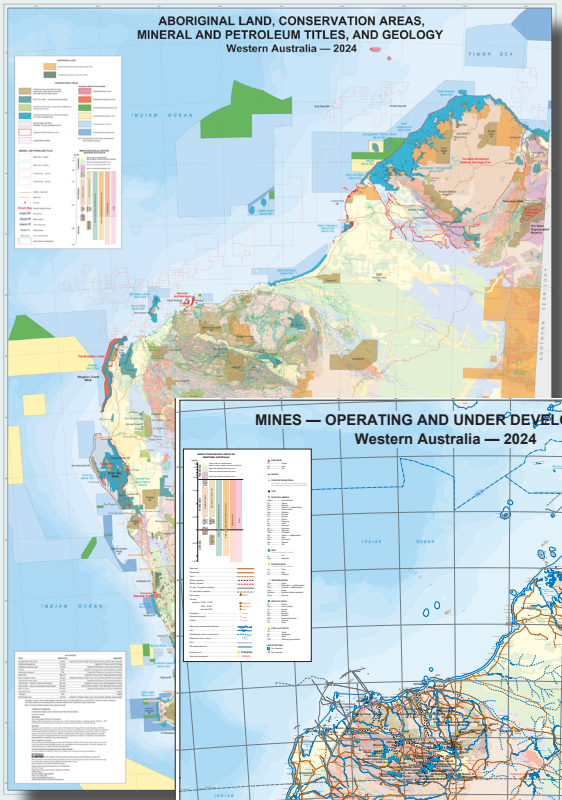
**WA Array: listening to the Earth**
*White, SR*




## • MAPS •

**Mines — Operating and Under Development Western Australia — 2024**
*Johnston, A, Pal, T, D'Ercole, C, Murray, SI and Mathrubhavan Sasi, R*

**Aboriginal land, conservation areas, mineral and petroleum titles, and geology, Western Australia – 2024**
*RIdge, K*





## • FLYERS •

**Petroleum Titles by Nominees and Applicants – April 2024**
*Brooks, D*

**Nickel–Cobalt: investment opportunities, Western Australia**
*D'Ercole, C*

**Vanadium: investment opportunities, Western Australia**
*D'Ercole, C and Pal, T*